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Does Good Project Management Ensure Successful Software Development?

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DOES GOOD PROJECT MANAGEMENT ENSURE SUCCESSFUL SOFTWARE DEVELOPMENT?

By

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Sue Jones and Stuart Hope

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Julie Eldridge - February 1997

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ABSTRACT

For many years the development of computer software has been plagued by poor customer satisfaction caused by missed schedules, underestimated budgets and the development of products which do not meet requirements. The ever increasing reliance on computers, as reported by Sommerville "the result of the proliferation of computer systems into all aspects of life and business is that personal, corporate, national and international economies are [becoming] increasingly dependant on computers and software systems" (1992, p.2), calls for more stable software which can be developed within time and budget constraints.

To achieve this, software development activities must be analysed and ways to improve the success of projects suggested. This study investigates the software development process in an attempt to reveal the importance of project management to the process and establish which activities contribute most to project success. It is

these activities which should receive the most attention when seeking to improve the software development process.

Data was gathered through a series of questionnaires and interviews with software engineering students during their third year software engineering project at Edith Cowan University. This was analysed and conclusions drawn about the project management activities of the teams.

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Chapter 1

INTRODUCTION

Software engineering is a discipline which to date, has been unstructured and ad hoc. This is highlighted by the great number of documented software development project failures (appendix A). If software development is to be seriously considered as an engineering discipline a greater understanding of the process is needed. Also, rigorous practices for its development which ensure quality and success, must be researched. As Pressman explains "managers and practitioners alike recognize the need for a more disciplined approach to software development" (1992, p.xix). The International Standards Organisation's SPICE Project endeavours to do this by outlining practices to follow for successful software development and by measuring the ability of organisations to develop quality software as outlined in the Software Process Improvement and Capability Determination model (Dorling, 1993). The Software Engineering Institute's (SEI) Capability Determination Model (Paulk, Curtis, Chrissis & Weber, 1995 & Saiedian & Kuzara, 1995) has the same objectives. In addition to this the Body of Knowledge for software engineering is currently being defined by the IEEE Computer Society and the ACM.

Other research: Mullin and Hope (1996); Perry, Studenmayer and Votta (1994); Phan, Vogel and Nunamaker (1995); van Genuchten (1991) and Azuma and Mole

(1993) has been conducted to gain a greater understanding of the software development process and how it can be improved.

This research focuses on the management of software development. It attempts to report on the importance of project management to project success as well as identify which project management activities are the most important. Research also suggests that the project manager is important to project success; this study reports on the leadership styles of project managers on both successful and non-successful projects, which will aid in the selection of future managers.

Chapter 2

THE PROBLEM

2.1 Background to the Study

For many years software engineering has been suffering the problems of missed schedules, underestimated resource usage and the development of products which do not meet requirements. Pressman (1992, p.17) refers to this as a "software crisis" or "software affliction", stating that the " 'crisis' has been with us for more than 30 years". Pressman, together with Snyder and Shumate, believes that sound software engineering processes, in particular software project management, are an important factor in solving these problems. "Software project management is ... important to the success of a project" (Pressman, 1992, p.42). "Success in our industry [software engineering] requires continuous, unending, relentless improvement in the process of managing software development" (Snyder and Shumate, 1992, p.12).

The Project Management Institute (1996, p.6) define project management as "the application of skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations for a project". Pressman (1992, p.42) states that project management provides an understanding of the "scope of work to be

done, the risks to be incurred, the milestones to be tracked, the effort (cost) to be expected and the schedule to be followed" he continues referring to project management as a "layer" which "overlays the entire development process from beginning to end". This research attempts to investigate the processes of project management during software development projects and to observe the effect of project management on projects.

2.2 Significance of the Study

This research aims to provide an overview of the leadership styles of project managers on successful projects, the importance of project management to project success and which project management activities provide the most benefit to software development. When identified these activities can become the focus for project managers endeavouring to improve software development outcomes. Future research into methods to improve the key processes of software development should target the activities highlighted by this study.

It is anticipated that the results of this research will aid in the understanding of how to select appropriate project leaders for software development projects as well as identifying which of the software engineering and project management processes should receive most attention to ensure a successful project.

2.3 Statement of the Problem to be Investigated

The extensive list of project failures, outlined in appendix A, prompts the question: What is being done/going wrong? Sommerville (1992, p.480) believes that software failure can be attributed, not to the lack of technical skill of the people on the project, but to the "management techniques used". Personnel are important to software development, "we [have] learned that the key to success in information systems development [is] in managing people, not technology" (Thomsett, 1993, p.xi). The selection of appropriate project leaders and the use of appropriate "management techniques" will contribute greatly to project success.

Stuckenbruck (n.d., p.66) believes that "the method of choosing project managers has been approached rather casually in industry". It is anticipated that documenting the leadership characteristics of managers on successful projects will aid in the selection of personnel for management positions in the future, eliminating the "casual approach" described by Stuckenbruck. Investigation is required into the project management activities undertaken throughout software development in order to determine how they affect a project and identify those most crucial for success.

2.4 Statement of the Research Questions

This study will attempt to answer the following research questions:

- What contribution does project management make to the success of a software development project?
- Which project management activities contribute most to the success of a software development project?
- What leadership styles are associated with project managers on successful software projects?

2.5 Theoretical Framework

2.5.1. Identification of Theoretical And Philosophical Assumptions Underpinning The Study

- The Project Management Body of Knowledge as defined by the Project Management Institute (1996) provides the foundation for this research. This study does not attempt to redefine the processes or activities of management simply to investigate and report on them in line with existing knowledge.

- It is assumed that the data gathered during the study is a true reflection of the actual activities undertaken during the project, who undertook them and the length of time they took to complete. Reassurance that the information gathered during the questionnaires and interview was strictly confidential and did not in any way affect the marks obtained by the students, should have helped to eliminate false or misleading responses.

- Although research inherently alters any study environment to some degree it is assumed that this did not dramatically alter the results obtained. Assurance that the study was intended only to gather information about project managers and management activities not to judge them as correct or incorrect, should have reduced the effect the research had on normal working practices. As Perry, Staudenmayer and Votta (1994, p.37) explain, if participants are apprehensive about providing information it is important to remind them "that there are no right and wrong ways to work; [the] purpose [is] not to judge but to understand behaviour within a given environment".

2.5.2 Variables Impacting On The Research Questions And Their Inter-Relationships

There were several factors which affected the outcome of the research and had to be considered when analysing the data gathered. These are outlined below.

- The level of software engineering experience of the individuals in the teams. Some students in the Computer Science undergraduate degree were part-time students currently working in the information technology profession, some in similar positions to that which they filled in the student project team.

- The level of previous project management experience of project leaders and team members.

- The intellectual capability of individuals within each team. Although each team was formed to have the same average intellectual ability, based on individual course averages over the previous two years of study, some teams consisted of individuals all with similar course averages, while others consisted of members with greatly differing course averages which totaled to meet the average intellectual ability set for all teams.

- The average number of individuals in each team was six. The number of members in the teams varied for some teams through the life of the project, with some teams dropping from six to four members by project completion.

2.6 Limitations on the Study

The following limitations of this study have been identified and were considered when reviewing the results of the study where necessary.

Several limitations exist when using student projects as opposed to real life projects. These are listed below:

- Deadlines in the academic situation are almost totally inflexible whereas the ability to negotiate and alter deadlines usually exists for real projects.

- Most project managers in a student setting have no previous management or software development experience; this would be extremely rare for real projects, where first time project managers normally would have had experience working in a development environment with other project managers.

Apart from these differences anecdotal evidence collected during the prototype data gathering exercise suggests that the student project was very similar to a 'real world' project, with one part-time student, employed full-time as a programmer/analyst commenting that the complexity of the problem and stress levels experienced by team members was similar to those which exist for real projects. In their ongoing research the academic supervisors of the student project teams conclude that "there are many similarities, and some differences between the student environment and the

IT industry". They "consider the differences to be negligible in comparison with the similiarities, and are of the opinion that the results [of their research] translate in the main to the 'real world'". (Mullin & Hope, 1996, p.128).

Chapter 3

REVIEW OF RELEVANT LITERATURE

A large amount of literature exists on project management. One useful discussion is that by Datz and Wilby (n.d., p.27) who describe factors which contribute to 'good project management' including the manager's job, task delegation and decision making. They discuss also the use of different management tools and different types of project managers. However, the focus is on project management in the construction industry. Although not irrelevant to a study on project management in software engineering, the software industry faces a range of management problems which differ from those faced in other professions, as Binder and Phillips (1992, p.28) state "unlike ships, aircraft, computers, or buildings nearly all important structural aspects of software are abstract and invisible".

For this reason the general section of this literature review is divided into non-software engineering project management and software engineering project management specific sections. Section three of the general literature section is dedicated to software engineering education literature. Following section 3.1 is literature on previous finding and/or specific studies similar to the current study. Finally literature on the research methodology is presented.

3.1 General Literature

3.1.1 Non-Software Engineering Specific Literature

The following section begins with a number of general project management journal articles.

A series of useful articles came from the publication "A decade of project management". One such article is that mentioned above by Datz and Wilby entitled "What is good project management". A second article, "Managing the most valuable resource: People" written by Buck describes some of the aspects of managing people. It presents five tasks that an effective project manager must perform in order to balance the schedule, budget and requirements of a project and manage "the people who are to accomplish the work". He highlights that self-motivation of the personnel working under the project manager is important, and spends some time describing how this can be achieved. Buck discusses team work and believes that "the absolute requirement for a good project manager is integrity".

The final article from the publication "A decade of project management" is "The effective project manager" by Stuckenbruck. It describes how "the method of choosing project managers has been approached rather casually in industry" to date. Stuckenbruck discusses briefly the tasks of a project manager including a list of

factors necessary for effective project management. Stuckenbruck suggests that these should be sought when selecting project managers in the future.

A stimulating article by Robinson (1992) provides an insight into the motivation of others by project managers. Robinson first defines management as "getting things done through others", then states that "people cannot be motivated by others, they can find motivation only from within themselves". The article focuses on how to get people to be self motivated and consequently complete the work required by the project manager.

Along similar lines is an article by Cocco (1995), "Using performance goals to motivate workers: a practical guide for project managers". Cocco believes that worker motivation is highly important for project success, stating that "the success of a project manager depends in part upon how well the manager motivates those employees under his or her supervision. Overall, the ability to motivate is at least as important as technical ability".

The article discusses the use of financial bonuses as a motivational tool but explains how these are not always available to project managers. Cocco explains that failing the availability of financial bonuses project managers can use either a positive approach where team members are encouraged to improve their performance and "not to let the team down" or "threats and intimidations as motivational tools". He then outlines the disadvantages of both of these methods, before highlighting how the use of ***performance goals*** is one "obvious but easily overlooked option ... that is not

based on financial incentives, and is positive in nature without undermining the authority of the manager". Cocco explains that goals can be used "as objective measuring sticks to assess performance".

Cocco discusses three fundamental questions which must be addressed if project managers are to use goals as a motivational tool:

1. How difficult should the goals be to obtain?
2. Should the project manager set the goals or let the subordinates set the goals, or should the goals be set together?
3. Perhaps most importantly, are there any techniques available to increase goal commitment?

In conclusion, Cocco states that "the purpose of this article is to suggest to project managers that goal-setting is an effective motivational technique, and to provide a concise, practical review of the findings of the psychology literature regarding ways to make goal-setting more effective".

3.1.2 Software Engineering Specific Literature

Focussing more on software engineering is an article by Binder and Phillips, (1992) "Software teams: issues, analysis & action". They discuss software teams, firstly reviewing what a software team is, then discussing several of the pertinent issues affecting software teams including team management, structure and vision. The

article discusses the personal characteristics of team leaders and states how, quite interestingly, "our profession develops leaders with the *opposite* personality to the one that we really would like them to have!". They present a model they developed for organising the issues and components effective software teams must consider and "suggests how team building problems are related". The model "System development dynamics model - a framework for analysis" is discussed in detail. Binder and Phillips conclude with nine "prescriptions for building effective software teams". The article highlights some interesting points regarding software teams and expands the author's knowledge of software team dynamics and the issues which affect software teams. This knowledge was extremely useful when observing the operation of the software project teams during this study.

Tippett and Peters (1995) continue the discussion on software teams, discussing research undertaken into the current state of project team building. They state that "top project managers have long known that building a cohesive, motivated project team is a key step towards the ultimate accomplishment of project goals" and that "team building is an essential project management skill".

The article outlines the results of a 26 question survey distributed to 88 companies in the United States which was designed to test for the presence of Robert P Hagen's six elements of most successful team-building plans. The survey found that:

> "the majority of project managers assumed their roles without ever receiving any formal project management training, receiving all their preparation in the form of uncoached on-the-job training. Furthermore, only about half of the

respondents indicated that their project managers had any type of management training prior to taking on their management responsibilities" (Tippett & Peters, 1995, p.32).

The survey also revealed that the state of project management team building varied greatly from company to company and within companies in some cases. Tippett and Peters explain how this might be justified by the above findings. They discuss how the research highlights that "companies did not accurately measure their group's progress towards becoming cohesive, motivated project teams [and how] project management evaluation continues to be centred upon the three traditional project management measures: budget, schedule, performance". Companies identified teamwork as an important organisational goal, but because many have no measures in place to evaluate progress it is "difficult to know if headway is being made".

Concluding Tippett and Peters (1995) state that "factors such as company age, size, organizational structure, project orientation, and industry type appear to have a relationship to the state of team building in organizations" and that in general it seems that "companies are doing a poor job of team building".

Kliem and Anderson (1996) continue the team building theme emphasising its importance for successful project management and software development. They state that a project may have "all the necessary disciplines for good project execution - a meaningful statement of work, detailed schedules, and change management for

example - and still end in failure". They explain how "applying the tools, techniques, and knowledge of project management does not guarantee success. It only affects the likelihood of success, depending on the environment and the degree that the basic functions of project management are applied".

They state that "only recently the influence of the project manager's personality on project performance received recognition ... How project managers perceive their environment, respond to events, process information, and interact with others influence the outcome of projects".

They introduce Decide-X, a tool which "provides insights for project managers to develop team structures and processes to improve project management". They explain in detail the Decide-X tool claiming that using a 24 question survey an "individual's approach to any team building situation" can be determined and categorised as one of four "primary styles [relating to] how a person approaches relevant work situations". The four primary styles, "reactive stimulator, logical processor, hypothetical analyser and relational innovator" are described in detail. Briefly, reactive stimulators "react immediately to situations. They are highly focussed on the immediate task and typically seek quick results. *Now!* Is their usual target". Logical processors "work best in situations involving assignments that are clear, precise, and have well-defined expectations ... they may resist change and are generally skeptical in their approach to work" Hypothetical analyzers are "problem solvers ... they are natural teachers leveraging their tendency to decompose problems and processes into more easily understood components. They see the 'big picture'

and maintain perspective". Finally relational innovators "typically deal in ideas and see the 'big picture'. [They] are innovative and like to explore alternative ways of doing tasks".

The article explains the four areas where the maior differences in styles are evident as: "information planning, planning and action, change versus stability and style interactions".

Kliem and Anderson present PMAT - a Project Management Application Typology which groups into four quadrants different project environments according to their level of change and structure. PMAT describes which style of individual best fits into which environment grouping, based on their style attributes and the project environment attributes. Within each quadrant are the four functions of project management: planning; organising; controlling and leading, and the related activities specific to that quadrant.

In conclusion they claim that "knowing the type of environment and the team building style of the project manager increases the opportunities for selecting the right project management practices to increase the likelihood of completing projects cost-effectively".

Another relevant paper is by Tullett (1995) "The adaptive-innovative (A-I) cognitive styles of male and female project managers: Some implications for the management of change". This paper reports on "the results of a study of the adaptive-innovative

cognitive style of the managers of change projects", explaining that "the cognitive style of individuals can be located on a personality continuum which ranges between adaption and innovation". Tullett explains that a person's position on this continuum is determined by the way they process information and data. "This in turn impacts upon his or her preferred way of making decisions, solving problems and construing change".

Tullett outlines the difference between high adaptors who "prefer to work by improving consensually agreed methods, products and practices, suggesting changes which can be accommodated without upsetting existing systems" and high innovators who "tend to reassess and redefine problems and the context within which they have arisen, thereby proposing change initiatives which are sometimes unexpected and, initially, difficult to accept".

He describes the measure of the adaptive-innovative style of individuals developed by Kirton, "the Kirton Adaption-Innovation Inventory (KAI)", before explaining the research undertaken "to measure the A-I cognitive style of those responsible for managing change projects". The study clearly indicates that "the preferred cognitive style of managers of change projects is more innovative ...".

Tullett identified several studies including Lindsay (1985), McHale & Flegg (1985 and 1986), and Rickards & Moger (1994) which "have reported that clashes and conflicts between individuals can be explained, in part, in terms of differences in A-I cognitive style". Tullett continues saying that "when a difference in cognitive style

leads to conflict the situation cannot be resolved by the individuals changing their cognitive style". Studies have shown that individuals with different cognitive styles who work together over a long period of time may change their "expressed behaviours but [their] preferred cognitive style remains constant".

Still on the personal attributes of project managers is an article by Valentine and Price (1994), "The leadership attributes and strengths of female project managers". Valentine and Price review the "current status of women performing responsible and meaningful leadership roles [where] the focus is on the project management environment, [which is] where some of the greatest opportunities for women to exercise their particular style of leadership" exist.

The article is divided into three sections. The first "addresses differences between masculine and feminine leadership styles, as noted by several contemporary management writers and scholars". The second discusses some of the difficulties experienced by managers using more feminine styles of management in "traditional male oriented, hierarchical organizations" and the third section "explores the strengths and intrinsic value of the more feminine styles of leadership and management, together with an overview of the types of organizations which could benefit most from those attributes".

Moving away from software teams and team leader attributes to a more general project management discussion, well known software engineering author Barry Boehm together with Ross (1989) present a theory for effective project management.

The article "Theory-W software project management: Principles and examples" explains how the theory works on the following two principles: "Plan the flight and fly the plan; and identify and plan your risks". It suggests that all parties involved in the software development project should be "made to be winners".

Boehm and Ross (1989) explain that project management is the skilful integration of "software technology, economics and human relations in the specific context of a software project [which] is not an easy task". They state that "a software project needs to simultaneously satisfy a variety of constituencies: the users, the customers, the development team, the maintenance team, the management" and refers to the conflicts of trying to meet the three general objectives of successful projects: budget, schedule and functionality. Theory-W as suggested by Boehm and Ross (1989) should help "project managers navigate through these difficulties".

They explain that Theory-W doesn't "characterize a manager as an autocrat (Theory X), a coach (Theory Y), or a facilitator (Theory Z), [rather] characterizes a manager's primary role as a negotiator between his various constituencies, and a packager of project solutions with win conditions for all parties". Beyond this the manager is a goal setter, a monitor of progress towards goals, and an activist in seeking out day-to-day win-lose project conflicts, confronting them and changing them into win-win situations.

The article explains Theory-W in detail including each of the principles and also outlines the steps project managers should follow to "make situations win-win" for all involved.

In summary Boehm and Ross claim that "establishing a realistic process plan is crucial to the success of the project" but explain how "developing a plan which satisfies everyone's win conditions is not enough to make everyone a winner. You also need to use the plan to manage the project. This involves making a particular effort to monitor the project's progress with respect to the plan". They state that "applying corrective action is [extremely important in ensuring] the 'make everyone a winner' principle".

Phillips (1996) believes that software development is a "people-intensive endeavour" and states that "our major problems lie with how people interact and communicate". In the article "Project management: Filling in the gaps", Phillips discusses how configuration management helps to control communication between personnel on a project as well as software complexity and change saying that "configuration management allows us to trace the effects of the suggestion [of change] through the work already completed. Tracing is the process of going back to a previous activity to justify our current activity".

Phillips concludes by stating that "an effective configuration management process empowers project managers to control changes that affect system requirements and in doing so lets these managers gain control over their projects" (1996, p.18).

Configuration management is just one of the many activities which are the responsibility of project managers. Conflict resolution is another. Pinto and Kharbanda (1995) in the article "Project management and conflict resolution" quote statistics from a study by Thomas and Schmist which estimates that "the average manager spends 20% of his or her time dealing with conflict". In this article, conflict and its "various components ... the stages that conflict often follows, and the wide variety of means for dealing with conflict in containing it and even making it work for the project manager and team" are explored. They outline a "model of conflict behaviour" and provide the reader with an "understanding of some of the most common methods for de-escalating conflict".

Pinto and Kharbanda (1995) explain that "many conflicts develop out of a basic lack of or unwillingness to understand another party's interests". They state that if project managers are aware of the solution options they can employ then conflict may be able to be defused and opportunities to learn from the exercise highlighted.

Pinto & Kharbanda highlight that not all conflict is negative. They explain that if a team argues the merits of a particular development strategy "it is likely that in the course of their deliberations, it will uncover more information than they would if they came to an immediate agreement". Regardless of the positive aspects of conflict it is the general opinion of the authors that project managers "tend to regard conflict as unnecessarily debilitating and wasteful of time and resources".

Pinto and Kharbanda state that "because of the inevitability of project team conflict, project managers need to be aware of the basic conflict process and understand how to deal with conflicts once they have begun". The authors propose a "model of the conflict process" claiming that if project managers understand how conflicts arise "they will be in a better position to defuse the conflict or use it constructively to further the project's goals". In conclusion, Pinto and Kharbanda believe that the level of conflict knowledge project managers have or endeavour to gain determines to a great deal the impact that conflict will have on the project.

In the article "Management-aided software engineering" Brady and DeMarco (1994) present "some management best-practice candidates from a small sample of health organizations [as well as try to] envision how software management might mature over the next few decades to produce best practices". The article is structured as a dialogue, "thus preserving our individual voices while neatly avoiding the necessity that each of us sign on to the other's more preposterous idea of what a best practice is". It discusses such things as the software engineering industry's poor scheduling and budgeting record, leadership styles, the importance of the physical location of the software development team and the changes the manager's role undergoes as the project completion date approaches.

Snyder and Shumate (1992) present some of the software engineering processes used by the software engineering division of the Hughes Aircraft Company. The article, "KAIZER Project Management", discusses "some of the general aspects of the KAIZER approach to project management, its connections to the SEI maturity levels,

and how the related measurement and continuous improvement philosophy affects the day-to-day operations of a software project".

There are many project management texts available, although few of which focus on project management during software development. One text is that by Rob Thomsett "Third wave project management: A handbook for managing the complex information systems for the 1990s". Another useful text is "The software factory managing software development and maintenance" by James Johnson. A third text is by Simpson entitled "New techniques in software project management". A study on project management and the dynamics of software development would not be complete without reference to Gerald Weinberg's text "The psychology of computer programming". Although published in 1971, the text focuses on the psychology behind software development, rather than technological issues and so is still relevant today. The opening sentence of the preface summarises the text "this book has only one major purpose to trigger the beginning of a new field of study: computer programming as a ***human activity***, or, in short, the psychology of computer programming" (Weinberg, 1971, p.vii).

3.1.3 Software Engineering Education Projects Literature

The following articles discuss the method of teaching software engineering in other universities, focusing on articles which incorporate software development projects into the curriculum. These articles are relevant to this study as third year students

undertaking a software development project are the subjects for this research. It is interesting to compare the software development projects in the following articles with the Edith Cowan University software development project being observed in this research.

The first article entitled "A recursive student project to reinforce the principles of software engineering" by Hope and Terry (1996) describes in detail the software engineering project undertaken by third year students at Edith Cowan University which is the project under review in this study. The paper provides the rationale for the student software engineering project and how the project has been developed to meet the synthesis class of Bloom's taxonomy of educational objectives.

> "Our objective is to meet the synthesis class whereby students are able to combine elements or parts of their learning experience in such a way as to produce a structure that was clearly not there before. That is the students take a definition and outline of a problem espoused by an external client which has no existing solution and produce a software product".

Hope and Terry explain that the lectures and project "aim to give the students an understanding and practice in the processes that an organisation at level two on the SEI capability maturity model would have in place". Accordingly the project together with the accompanying lectures place heavy emphasis on "project management and control, team working, requirements management, quality management and configuration management".

The maintenance phase of the system life cycle, identified as one of the largest, is not often addressed in student software projects where the product for development is always new or students start afresh at the start of the project. The ECU project addresses this by having students correct and extend the product developed by students from the previous year. The best product is chosen each year to become the "definitive system" for the following year's students. "The following year's students must then integrate their subject area into this system" (Hope & Terry, 1996).

The paper explains in detail the working environment for the project, the formation of the student teams and the team structure, academic supervision, the client, deliverables and project marking.

The paper discusses two ongoing studies which stem from the student project. One which observes, reviews and reports on the processes and practices that student teams undertake during the project to "evaluate and characterise the components in a software development project that influence its effectiveness and productivity. It also attempts to validate assertions generally held in industry" (Hope & Terry, 1996). The second is a long term study which attempts to review how graduates from the ECU software engineering course perform in their first three years in industry. Employers are being questioned about whether they believe graduates of the ECU software engineering project perform better than previous ECU students and those from other universities.

The authors state that "the project is not structured to have a defined solution and is of sufficient complexity that the students experience a real world situation. This is attested to by the supervisors and from anecdotal evidence given by mature age students working in the software industry that the project is not a 'toy'" (Hope & Terry, 1996).

In conclusion Hope and Terry outline the benefits of the student project over other software engineering project models and how "in the future it is planned that the efficacy of the [ECU] undergraduate program be determined by using the project as an objective measure of the program".

The second article by Dawson-Howe (1996) describes the organisation of final year projects at the Department of Computer Science, Trinity College, Dublin, Ireland. The model proposed for the project sees "the student initially work in a group, co-operatively developing a basic platform on which they can then individually develop their projects". Using this model students get all the experience of working in a group situation "while at the same time fulfill the objective of working on a complex problem independently".

Dawson-Howe outlines some of the problems which seem to affect the projects as follows:

1. Getting started: students often delay starting their project which happens with all course work units but is more serious due to the nature of the final year project.

2. The learning curves: "generally, in order to address their final year projects, the students will require knowledge above that which has been taught to them". This point holds true for the Edith Cowan project being used in the author's research, especially in the area of project management, where students have no prior experience coming into the project and often attend the lectures on the important project management topics after they have had to deal with them in the project.
3. Time to solve the problem and to build a proper system/interface. Due to the complex nature of the problems assigned to students, often a great deal of the available time is used to solve the problem and only a small amount remains to actual build the product.

How the model proposed in this article attempts to address these problems is described in detail.

In conclusion, the authors quote the students involved with the project stating that the group work followed by individual work in the project is "a very useful and rewarding experience" (Dawson-Howe, 1996). "In summary, it seems that this approach to the organization of final year projects yields significant benefits for students, particularly in terms of a faster start-up time, support from the group members, and experience of a reasonably realistic group project".

In the third article Ohlsson and Johansson (1995) describe a two year software engineering program offered as a "complement to the four and half year Masters degree programs at the traditional engineering schools" offered by Swedish

universities. The curriculum focuses on "designing a practice driven education program where the students are trained to learn by themselves rather than being taught canned knowledge from books and lectures" this helps to overcome the problem of teaching students things which become out of date quickly with the rapid changes that occur in software engineering. It teaches them to solve problems rather than respond to them with text book answers.

The curriculum is designed around three project units. The first aims to "introduce a professional attitude" (Ohlsson & Johansson, 1995) to the student whereby they are expected to estimate the time and cost to perform given tasks, deliver the assigned product within these and deal with the events that sometimes arise and prohibit this from happening.

The goal of the second project unit is to "informally introduce project planning as a refinement to making commitments" (Ohlsson & Johansson, 1995). The need for strict project organisation becomes evident to the students during these introductory group projects due to the nature of working in small groups and "more strict organization ... is introduced in the final project course".

Similar to the Edith Cowan University's third year software engineering group project being used by the author in this research, maintenance is not ignored as a phase in the development process. They state that "the problems of maintenance are made realistic and very concrete by having the groups switch systems so that

everybody is confronted with the code and documentation developed by someone else".

The third and final project course runs for 15 weeks. Students work in groups of 12-15 and, similar again to the Edith Cowan University third year software engineering project being used by the author in this research, the project is divided into two major sections. A pre-project phase constitutes approximately one third of the total course time and sees the students clearly define the problem and determine and outline the requirements. A quality plan must be developed in the pre-project phase "starting from a quality standard in accordance to the principles of ISO9000. The quality plan defines procedures for configuration management, quality assurance, and the various kinds of documentation" (Ohlsson & Johansson, 1995). The product is developed in the second phase of the project.

The course has no formal project management lectures, which "created some initial difficulties for the students in dividing the work among themselves and at the same time maintaining sufficient communication about the various parts of the system" (Ohlsson & Johansson, 1995). The authors of the paper state this as one of the areas for improvement in future years.

In concluding Ohlsson & Johansson reflect on the conduct of the course over the first year outlining successful areas as well as those which need improvement. They present some results from follow-up feedback received from graduated students' employers, who generally comment that their "students needed less time on internal

training to become productive compared to students who had gone to ordinary engineering schools .... One employer explicitly said he preferred hiring people with this background. In particular the project experience was highly valued". The project provided the students with an appreciation of the roles within a team environment and allowed them to easily adapt when placed in a team situation.

3.2 Literature on Previous Findings / Specific Studies Similar to the Current Study

Five papers have been found which describe studies similar in design or findings to this study. The first reports on a study conducted at Edith Cowan University using the same project group as that used in this study. The second describes two experiments in a series which investigates software development processes, focussing on the importance of social or behavioural factors in software development. The third addresses the "issues of management and control in large development projects and presents the results of a study on the development of the OS/400 R.1 development project" (Phan, Vogel & Nunamaker, 1995, p.279). The fourth article investigate the reasons for delay in software development projects in an attempt to identify areas for improvement. The fifth concentrates on the managerial factors which are effective in designing software and compares the management practices in Japan with those used in Europe.

For several years the student project under investigation in this study has been part of the assessment for the third year software engineering unit of the Computer Science degree at Edith Cowan University. The Unit Coordinator and a colleague have been collecting data from the project via a questionnaire for the past two years. Their paper, "An application of quantitative techniques to the question of what contributes to a successful software development project", presents the results of these questionnaires and provided valuable information for this study. The paper attempts to objectively answer the question of "what contributes to a successful software development project" (Mullin and Hope, 1996). Mullin and Hope state that the purpose of the study was to:

> "evaluate and characterise the components in a software development project that influence it's effectiveness and productivity. It also attempts to validate assertions generally held in industry that have little empirical data or evidence to support the effectiveness of a particular view".
> (Mullin and Hope, 1996).

The paper outlines the Edith Cowan University software engineering project from which the data for the study was obtained incorporating a discussion on the software engineering units for which the project is the major assessment. It discusses the formation of project teams and the project development environment. The authors describe how the data was gathered and analysed using Spearman's Rank Correlation Coefficient method.

Mullin and Hope (1996) then present the findings from the first and second year projects in detail, concluding with a summary of the findings for the two years. In summary the results provided clear evidence of a feel-good factor, although this "did not necessarily lead to good software products". The authors report that "from the statistics, the teams who produced the good products tended to have good project management, appropriate to the team and "put in the hours". Two other factors were observed as contributing to a good software product in both years, but neither showed up in the statistics:-

The depth of understanding of the processes.

The degree of competition between teams.

It appears that a large unmanageable scope was all that resulted from excess time spent on analysis and design. "Both years showed clear evidence that too much time spent on analysis and design phases resulted in poorer products" (Mullin & Hope, 1996).

An important discussion in this article is that on the similarities and differences between student projects and "real world" software engineering developments. Mullin and Hope, who between them have over 35 years of IT experience feel that "the differences [between student and real world projects] are negligible in comparison with the similarities" and they are of the opinion that the results of research conducted using the student development group "translate in the main to the 'real world' ".

Team management is a significant component of project management. When investigating the activities that contribute to a successful project it is important to consider team dynamics; that is, how the team works together, how change, risk and conflict affect the team and how they relate socially. Therefore, it is essential, to quantify these activities. Perry, Staudenmayer and Votta (1994) in the article entitled "People, organizations, and process improvement" state that to "genuinely understand development processes" social as well as technological aspects must be considered. They continue to state that without that understanding "we cannot hope to significantly improve these processes and justify their improvement".

The article describes two studies from a series expected to "enhance understanding of the structure of software-development processes". The article provides useful guidelines for collecting social or behavioural data which is similar to that gathered in this study. It highlights an important trade-off between "minimizing the possible variance and maximising the ability to generalize a study's findings" (Perry, Staudenmayer and Votta, 1994). The author's study minimises possible variance by investigating student projects where the platforms, design objectives and completion date are consistent.

The purpose of the research outlined in the third article in this section was to "gain insights regarding the factors that contribute to the successful delivery of large projects". Phan, Vogel and Nunamaker (1995) report and compare the results from and a case study of the development efforts of the OS/400 development project and a

field survey sent to 827 "randomly selected members of the Association of the Institute for Certification of Computer Professionals", regarding the "planning, control, and management of medium and large scale software projects".

The study had three goals one of which was to investigate "what major problems and opportunities in the development of large, complex software projects need more attention" (Phan, Vogel & Nunamaker, 1995). The author of this research is endeavouring to identify which project management activities contribute most to the success of software development projects, thus, identifying which activities need most attention during software projects. Hence, this article was of particular relevance to the author's research.

As a result of their survey Phan, Vogel & Nunamaker were able to collate a list of "common project characteristics and/or factors" for project failure and "actions to improve project success in terms of meeting schedule, budget and user expectations" as reported by the survey respondents.

The participant response rate from the field survey was 17%. Responses were analysed using the ANOVA and Spearman's rank correlation and were "tested for a correlation with the project success indicators (i.e. meeting user requirements, suffering cost overruns, and suffering late delivery) using the Spearman Rank Correlation test at 95 percent significance level" (Phan, Vogel, & Nunamaker, 1995).

"Although software project management historically has been notorious for cost overruns, late deliveries, and failure to meet user expectations, the results of this survey indicated that progress had been made. A significant sign of improvement was the high proportion, nearly three fourths, of projects that were considered to have met user requirements".

(Phan, Vogel, & Nunamaker, 1995).

The article discusses the design of the OS/400 case study at length before presenting the findings and a comparison of these with those from the field survey. The article concludes listing the ***key success factors*** for successful software development obtained from the survey and the study of the OS/400 project as follows:

- The provision for user feedback mechanisms. "End-users should be involved in the entire development process"
- A "good inventory of reusable code and designs, [which] help to reduce the development time"
- Thorough and enforced project management techniques and quality control standards. Including reviews, inspections and tests and close monitoring of project changes and identified defects.
- Sound configuration management. Importantly "software versions must be well-managed to minimise impacts of design changes during development". CM is also required to control resources and ensure requirements are fulfilled.

(Phan, Vogel & Nunamaker, 1995)

A fourth study by van Genuchten (1991) describes a "study of the reasons for delay in software development that was carried out in 1988 and 1989". The aim of the study was to gain an insight into the reasons for differences between plans and reality in development activities in order to be able to take actions for improvement".

Van Genuchten used Basili, Selby and Hutchens framework of experimentation to define the study. Accordingly the definition of the study contains six components. The motivation, object, purpose, perspective, domain and scope. He aimed to answer several questions regarding the delays which affect software development projects as follows:

- what are the predominant reasons for delay?
- what is the distribution of the reasons for delay?
- how is the delay distributed over the phases of a project?
- which actions for improvement can prevent delay in future projects?

The article outlined the data collection and analysis processes including the three principles for data collection. Data was interpreted "during a meeting attended by the project leaders taking part, the department manager and the researcher. In van Genuchten's opinion, data of this kind should, in the first place, be analyzed together with the people involved in data collection". Six reasons for this are outlined in the paper.

The important results of the study were presented in four figures.

1. The frequency distribution of the difference between the planned and actual durations. (Bar graph).
2. The frequency distribution of the relative difference between the planned and actual effort. (Bar graph).
3. The distribution of reasons for differences between the actual and planned starting date. (Pie chart).
4. The distribution of the reasons for differences between the actual and planned durations. (Pie chart).

In conclusion, van Genuchten compares the results of his study to those of other studies identified in the literature.

A fifth study by Azuma & Mole (1993) investigates the management practices of software developers in Japan. It compares these with the practices used by European software developers. Data was gathered using a questionnaire which was circulated to software managers in both countries. The data was entered into a spreadsheet and analysed. The article discusses in depth the results of the survey paying particular attention to management practices, including the "use of metrics, standards, and process management". This article provided information on some important issues to be considered when conducting research using questionnaires.

3.3 Literature on the Research Methodology

Three articles were found which discuss research in software engineering. The first is a paper by Basili, Selby and Hutchens (1986) which describes "a framework for experimentation", and discusses problems and issues which arise when experimenting in software engineering. It also provides "useful recommendations for the application of the experimental process in software engineering". The article presents a range of experiments using the framework stating that it can be used to "analyze most of the experimental work that has been performed in software engineering over the past several years". Although the exact framework outlined in the article was not used in this study many of its component parts were.

Fenton, Lawrence Pfleeger and Glass (1994) in the article "Science and substance: A challenge to software engineers", suggest ways to make research in software engineering more scientific by examining and comparing "good experiments with flawed ones". As this study endeavours to use the scientific method this literature was invaluable.

"The software research crisis" by Glass (1994) is an interesting article set in twenty-first century with the author reflecting on software engineering and software engineering research through the 1980's and 1990's. It explains how a lack of

experimentation using a scientific approach during the 80's and 90's lead to a research crisis. "Almost no computing research to that time [until this time, remember the article is written in the future] had used the scientific method (it begins with 'observe the real world.' No one was doing even that first step, let alone formulating and validating hypotheses)". The article provided some valuable guidelines on the use of the scientific method when conducting software engineering research.

Chapter 4

RESEARCH DESIGN

4.1 Design of the Study

This study observed, monitored and collected data about the team leaders and software engineering processes undertaken by third year computer science student project teams at Edith Cowan University, Mount Lawley campus and Joondalup campus, in 1996, during the software engineering development project. This project forms the assessment for the third year software engineering units of the computer science degree. A prototype data gathering exercise on similar student projects in 1995 clarified the design method for this study.

The following activities were undertaken during the study:

- A literature search to identify relevant literature and similar studies which may be used to compare against the results of this study.

- Data collection via:

1. An initial interview with each student involved with the third year software engineering project.
2. Four questionnaires completed by each student involved with the third year software engineering project.
   - These were completed at the start and end of first semester and the middle and end of second semester.
   - The questions were kept as similar as possible for all four questionnaires although small refinements were required as the project progressed.

- Assessment of project success. Project success or failure was decided by an expert judging panel, including the Academic Project Supervisors of the project and a industry expert who represented the "client". This occurred on completion of second semester.

- Analysis of data and discussion of results addressing the research questions.

4.2 Research Subjects

The subjects for this research were third year students studying computer science at an undergraduate level at Edith Cowan University. Students were grouped into teams of four to six individuals. The project teams were formed by the Academic Project Coordinator using each student's average course score, achieved over the first

two years of the course, in an attempt to ensure each team had the same average level of intellectual ability. The distribution of gender, race and age was completely random. Eleven teams were formed, seven consisting of students from the Mount Lawley campus, three from the Joondalup campus and one from the Bunbury campus. For logistical reasons only the Mount Lawley and Joondalup teams were used in this research. During the project one of the Mount Lawley and one of the Joondalup teams disbanded, with the remaining members merging into other teams. Hence, at the completion of the research there were eight teams, six from the Mount Lawley campus and two from the Joondalup campus.

4.3 Data Collection

Data was collected in four stages: at the beginning and end of first semester and at the middle and end of second semester. In the first stage, data was collected via an initial interview and a simplified questionnaire for approximately half the research subjects. The other half completed a detailed questionnaire only. A standard questionnaire was used for the remaining three stages of data collection.

During data collection it was important to ensure that the normal operation of the team was not altered as Perry, Studenmayer and Votta (1994, p.36) explain "you must ensure that the study does not interfere with normal work". Interference with

normal working patterns may have hindered the learning of the team members and could have affected the data collected. For this reason questionnaires were conducted during normal lecture time for the first and third questionnaire and after the completion and submission of the half year and final project for the second and fourth questionnaire.

When collating responses for questions using a Likert scale, a standard measuring tool was used to gauge the position the participant indicated on the scale. This ensured all results were recorded using a similar method.

4.4 Description of Instruments Used

The instruments used to collect data included an initial interview and four questionnaires. Each of these instruments were designed following guidelines from questionnaire/survey design text books mainly "Designing sensible surveys" by Orlich (1978) and "Constructing questions for interviews and questionnaires" by Foddy (1993). The questionnaires consisted of a standard set of questions which were refined after each stage of data collection and structured so as to discover the software engineering processes being used by each group. Also a range of questions regarding the project leader were asked. As suggested by Orlich (1978, p.19) the

questions related to the "purpose or objectives" of the research and endeavoured to elicit data which would enable the author to address the research questions.

The first detailed questionnaire (appendix B) included both forced-response and open-ended questions. The first introductory questionnaire (appendix B) and questionnaires two, three and four (appendix C, D and E) included only forced-response questions. Orlich (1978, p.46) states that from his experiences the response rate to open-ended questions is usually "rather low", this was the case for the first detailed questionnaire, hence the open-ended questions were eliminated from questionnaires two, three and four.

The open-ended questions in the first detailed questionnaire were in the form of a 'please comment' request after a forced-response question. Following Orlich's (1978, p.45) guidelines "questions that could be answered 'yes' or 'no' or by degrees of agreement or disagreement were in a forced-response format" primarily using Likert scales with a range of zero to five or zero to ten. Questions which provided a list of options from which participant's chose a response were another common question type along with 'yes' or 'no' questions.

All questionnaires asked for the respondents name, gender and study mode together with the date the questionnaire was completed, the respondents team number, team size and role/responsibility in the team. Respondents names were included on the questionnaires so that responses from one questionnaire could be compared with

those from others on a participant to participant basis. As students could change study mode, teams, roles and responsibilities during the project, this information needed to be recorded on each questionnaire.

It was anticipated that interviews would be conducted after each questionnaire but after only a 30% participation rate for the first round of interviews it became evident that time constraints on the students were going to make interviews for all impossible. Hence, only questionnaires were used to collect data after the initial interview.

4.3.1 Interview and Questionnaire One

For the first stage of data collection respondents either completed an introductory questionnaire (appendix B) and attended an interview or just completed a detailed questionnaire (appendix B). The questions were similar for both methods of data collection. During the interview respondents were asked to comment on their responses to the questions in the introductory questionnaire, where as the detailed questionnaire simply asked the respondents to record their comments on the questionnaire. The first stage of data collection was to record the current knowledge level of the participant's and discover how they felt about their team, their team leader and the project.

The combined introductory and detailed questionnaire and interview consisted of the following question types:

- Six questions used a Likert scale on which participants marked their response. The scale ranged from zero to ten, where zero was the lowest response and ten the highest.
- Five questions provided a list of options from which participants selected a response.
- Four questions asked the respondents to provide a rank between zero and ten, where zero was the lowest or negative response and ten was the highest or positive response.
- There were four questions which required a 'yes' or 'no' response.
- One question asked respondents to list as many activities as they could and another asked them to list the number of occurrences of an event.
- There were eight 'please comment' questions, which required the participant to comment on a response they had made to a question using one of the above methods. For instance participants were asked to rate their team leaders' management of the people in their team from 0 to 10 and then comment. On the simplified questionnaire participant's were asked to rank the project leader only. In the interview they were asked to comment or elaborate on their response.

The questions are outlined below.

How important do you believe project management is to a successful project?

This question was trying to establish whether the respondents believed that project management was an important activity for software development. Participant's were asked to rank the importance of project management from 0 not important, to 10 very important.

What activities do you understand project management entails?

This question was endeavouring to discover the respondents level of understanding of project management and project management activities. The level of participant knowledge had to be considered when reviewing the results of the research and drawing conclusions. It would be unlikely that a project manager on a real world project would have no understanding of project management, where as this was the case for the student project leaders.

What effect do you think the use of these activities has on the overall project?

This question was trying to establish what effect the participant believed project management activities had on software development projects. For example "project management has a positive effect on the success of a project" or "a project will fail without project management". This was an interview question, participant's were

prompted to reflect on the project management activities discussed in the last question and consider the effect performing or not performing these activities might have on the project.

What activity(ies) do you think will be the most important for a successful project?

This question was trying to establish which of the range of software development activities undertaken during a project the respondents perceived to be the most important to the success of the project. For example "analysis and design", "coding", "testing", "management". This was also an interview question.

What planning has your team done so far?

This question gave participant's an opportunity to discuss their team's planning up to the first stage of data collection. It provided an insight into the activities respondents considered to come under the planning umbrella. Participant's were given a list from which they selected the planning activities their group had completed. The options for this question were:

1. none;
2. set date for first meeting;
3. allocated roles/responsibilities;
4. formed project plan;

5. allocated tasks and
6. other.

Who decided on the allocation of roles/responsibilities? Were you happy with this?

This question established who and how the roles and responsibilities of the team members were decided. It provided some insight into the management styles of the team members and the team leader, and identified if there was any conflict or discontent early in the project.

During the interview participant's were asked to explain how the team leader had been selected and if the participant was happy with this process and the person selected. In the detailed questionnaire three separate questions were used to obtain this information. These were:

1. Who decided on the allocation of roles and responsibilities of the team members?

a) Project leader b) Group c) Other (please specify)

2. How was this done?
3. Were you happy with this process? Y/N Why? (please comment)

Who formed the project plan? Were you happy with this?

For this question participant's were asked to choose between:

a) the group b) the team leader c) other (please specify)

Also participant's were asked if they were happy with the way the plan had been formed. This question gave some insight into the style of management of the team leader.

How important do you believe the project plan is in the success of your project?

This question established whether the participant's believed that the project plan was important to a project. Participant's were asked to rank the importance of the project plan from 0, not important, to 10, very important.

What is the composition of your team?

This question clarified the information provided by individual team members with regard to the size and composition, that is, the number of males/females and/or full/part-time students in their team. The members of some teams changed considerably in the early stages of the project and because the first round of data collection took place over a three week period the change in team composition was evident from this question.

How well do you know the other members in your team? Please comment.

A Likert scale was used to record how well participant's knew other members in their team. The scale ranged from 'not know at all' to 'know well'. Respondents were asked to elaborate on their response, for example, did they know some team members well and others not at all or all the team members well, not at all etc.

A) Do you associate with any members of your team socially? B) If yes, do you discuss university when out socially? C) If yes, will you discuss the project?

For part A of this question a Likert scale was used ranging from 'not at all' to 'frequently'. The question endeavoured to uncover how well participant's knew and related to other members in their team and whether the project was discussed outside the formal team meetings and university setting.

Do you feel uncomfortable working with any members in your team? Please comment.

This question endeavoured to establish if participant's felt uncomfortable working with other members in their team and if so why. The study sample included a

diverse range of participant's from varying nationalities and of varying ages. 15% of participant's were female. The question prompted participant's to elaborate on what or why they felt uncomfortable with some members of their team. In the detailed questionnaire two separate Likert scale questions were used to establish this information:

1. Are you happy with your team mix? (Age, gender, nationality, study mode). Please comment.
2. Do you feel uncomfortable working with any members in your team? Please comment.

This information allowed the researcher to report on the effect initial unrest within the team had on the project.

Have you had any major conflicts in your team so far? If yes, what effect has this had on the project?

This question was used to highlight if any problems had arisen within the team and also recorded how the team members thought these affected the project. It was not anticipated that teams would have incurred much conflict at that point in the project, although some of the decisions which teams make early in the project, such as roles and responsibilities of team members, may have caused friction and exposed potential conflict areas.

How was this conflict handled?

This question allowed the respondents to elaborate on their answer to the forced response question: "Who handled the conflicts that had arisen to that point in the project", where participant's chose between:

a) handled by the project manager;

b) handled by the people involved; or

c) has not been handled yet.

How would you rate the project leaders' management of the people in your team?

AND

How would you rate the project leaders' management of the project management activities?

Respondents were asked to rate from 0 poor, to 10 outstanding, their team leaders management of the people in their team and the project management activities at that point in the project. In the interview and on the detailed questionnaire respondents were asked to elaborated and justify their ratings. These two questions were asked in all four questionnaires.

After seeing the requirements for the project how many hours do you think it will take per week?

Respondents were requested to estimate the total time they believed the project was going to take for the entire project.

4.3.2 Questionnaires Two, Three and Four

As mentioned earlier in this section questionnaires two three and four included only forced response questions. The questions were kept reasonably similar for all three questionnaires although small refinements were required as the project progressed.

Questionnaire two included the following question types:

- There were 14 Likert scale questions where 0 was the lowest or negative response and 10 was the highest or positive response.
- Two questions asked respondents to provide a percentage of time they had been spending on a list of software engineering and project management activities.

- Two questions asked respondents to provide the number of hours for a particular event.

- There was one 'yes'/'no' question.

- One question asked participant's to select from a list of responses.

Questionnaire three included similar question types, although the 'yes'/'no' question was replaced by a Likert scale question. Also the questions on conflict were altered slightly as is outlined in the discussion on the questions below.

In ***questionnaire four*** additional questions were included asking the respondents to rank the importance of a list of software engineering and project management activities in addition to providing the percentage of time their team had been spending on these activities. Also the questions which asked the respondents to estimate the number of hours they were spending on the project were eliminated.

For both questionnaire two and three respondents were asked to respond to the questions at the time of completing the questionnaire. This differed for questionnaire four where respondents were asked to reflect on the entire project when responding to the questions.

As the questions for questionnaire two, three and four (appendix C, D and E) were reasonably similar they will be discussed together. The questions on each questionnaire were grouped into sections. Initially the questions related to the software engineering and project management activities being used by the teams. The next questions focussed on some of the dynamics of the teams and these were followed by questions focussing on the team leader. Questionnaire two and three concluded with general project questions.

Software Engineering and Project Management Processes Questions

The first question on all three questionnaires asked participant's to record the percentage of time they had been spending on a given list of software engineering activities. The list varied slightly for each questionnaire, for example in questionnaires three and four the activities were divided into engineering and support activities as outlined below.

Table 1. List of the software engineering activities presented in questionnaires two, three and four.

Questionnaire Two	Questionnaire Three	Questionnaire Four
Analysis Design Scope definition Team meetings Programming Oracle Risk avoidance/management Testing Project progress monitoring Configuration management Project management	**Engineering** Analysis Design Programming/Oracle Testing Implementation Quality Monitoring **Support** Configuration management Project management Other	**Engineering** Analysis Design Programming/Oracle Testing Implementation Quality Monitoring **Support** Configuration management Project management Other

The question endeavoured to record on what software engineering activities project teams were spending their time.

Questionnaire four asked respondents to rank from one to nine the importance of each of the activities given in the list of software engineering activities in question one. This was not asked in questionnaires two or three.

Next participant's were asked to provide the percentage of time they had been spending on a given list of project management activities. Again the list varied slightly from one questionnaire to the next.

Table 2. List of the project management activities presented in questionnaires two, three and four.

Questionnaire Two	Questionnaire Three	Questionnaire Four
Planning Estimation Scheduling/task allocation Risk avoidance/management Conflict management Team member management Project progress monitoring Team meetings General administration/organisation tasks	Planning Estimation Scheduling/task allocation Risk avoidance/management Conflict resolution Individual team member communication Group communication Project progress monitoring Other	Planning Estimation Scheduling/task allocation Risk avoidance/management Conflict resolution Individual team member communication Group communication Project progress monitoring Other

Only the team leader was required to complete this question for questionnaires three and four.

Questionnaire four then asked participant's to rank from one to nine the importance of the project management activities listed.

Team Dynamics Questions

All three questionnaires asked participant's to rate on a Likert scale their comfort level working with the members in their team. Then the number of conflicts, if any, was recorded. In questionnaire two this was done using a yes/no response to the question: "Have you had any major conflicts in your team so far?", if the response was yes, a request to state the number of conflicts. In questionnaires three and four a

Likert scale was used to record the number of conflicts with a range from 'none' to 'many'. Each questionnaire asked the respondents to select the person or people who had handled the conflict from the list below.

1. the project leader
2. the people involved
3. the group
4. some haven't been resolved yet (questionnaire two) OR no-one (questionnaires three and four)
5. supervisor (added for questionnaires three and four)

Finally, each questionnaire asked the respondents to rate, on a Likert scale, the effect of the conflict. Questionnaire two used a 'little' to 'great' range on the Likert scale. Questionnaires three and four asked if the conflict had had a positive or negative effect using '-ve' to '+ve' on the Likert scale.

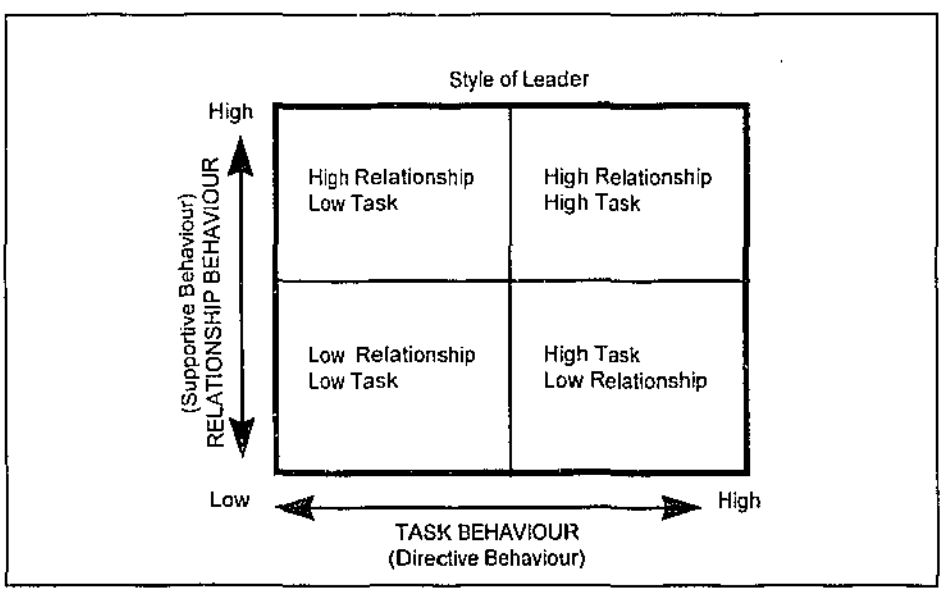
Project Leader Questions

These questions focussed on the project leader using twelve Likert scale questions. Firstly participant's were asked to rate their team leaders' management of the people in their team from 'poor' to 'outstanding'. Next they were asked to rate their team leaders' management of the project management activities from 'poor' to 'outstanding'.

The Hersey and Blanchard (Hodgetts, 1985, p.403) "Situational Leadership Model" was used as a basis for the investigation of the leadership styles of the team leaders. Ten questions taken from the 1993 British Airways Training Manual for the "Managing Winners Quality Workshop" were used to determine the leadership behaviours of the team leaders. Five questions focussed on the supportive/relationship behaviour and five on the task/directive behaviour exhibited by the team leader. Hodgetts (1985, p.406) explains that "*Task behaviour* relates to the extent to which a leader provides direction for subordinates, such as by telling them what to do, when, where, and how. *Relationship behaviour* relates to the extent to which the leader engages in two-way or multi-way communication by providing assistance, advice and socioemotional support". Hodgetts continues explaining that these "two types of behaviour combine to provide four basis leadership styles 1) high task and low relationship, 2) high task and high relationship, 3) high relationship and low task, 4) low relationship and low task" as is presented in figure 1.

Figure 1. Hersey and Blanchard's "Situational Leadership Model"

(Taken from Hodgetts, 1985, p.406).



After each team member had responded to the questions, the *teams'* responses were averaged and a team rank was obtain for the level of supportive/relationship and task/directive behaviour exhibited by the team leader. These ranks were then plotted onto the model in figure 1, with the task/directive behaviour on the x axis and the level of supportive/relationship behaviour on the y axis.

The team leaders responses to these questions were collated separately. It was interesting to compare the team leaders perception of their leadership/management attributes with the teams.

The ten questions used to determine the team leaders behaviour ratings are outlined below.

How often does your project leader:

1. Listen to team members opinions, ideas, information and concerns?
2. Test to make sure team members have a good understanding of what is to be achieved?
3. Offer reassurance, help or guidance as necessary and appropriate?
4. Provide permission to act and protection/backup as necessary?
5. Consider others' needs and point of view when offering suggestions or support?

How often does your project leader:

1. Express views clearly and emphatically?
2. Set high expectations?
3. State the actions or results your team is striving to achieve?
4. Indicate positive and negative consequences of not meeting expectations?
5. Offer alternative views and options?

Each question used a Likert scale ranging from 'never' to 'always' to record the response.

General Project Question

Questionnaires two and three included two final questions regarding the project in general. Questionnaire two asked participant's to state the average number of hours they had been spending on the project per week and the number they anticipated they would spend for the rest of the project. Questionnaire three simply asked the respondents to state the minimum and maximum number of hours they had been spending on the project.

4.5 Data Analysis

For each stage of data collection the questionnaire responses were grouped according to project teams and entered into an Excel spreadsheet. The responses from all team members were averaged to give a team response to each of the questions for each questionnaire. Each of these team responses were then ranked from lowest to highest. A Pearson's function between the team's response to the questions and the team's final project mark provided a Spearman's Rank Coefficient Correlation score for each question. This Spearman's rank score highlighted correlations between the questions and the success of the project as determined by the team's final project mark. The Excel spreadsheets containing the team responses to all questions and the corresponding Spearman's correlation for each stage of data collected are presented in Chapter 5 for questionnaire one and appendix F, G and H for questionnaires two, three and four respectively.

The Spearman's Rank Coefficient method was chosen for two reasons: firstly, it is a robust measure which is preferred because "... most software measurements are not normally-distributed and usually contain atypical values ..." (Fenton, 1991, p.102). "The rank correlation coefficient method is not easily influenced by either abnormal values or any non-linearity of the underlying relationship" (Mullin & Hope, 1996). Secondly, Spearman's rank coefficient method is "considered better for 'behavioural' data" (Mullin & Hope, 1996) which best describes the data gathered in this study.

Chapter 5

RESULTS

5.1 Analysis of Interview and Questionnaire One

Data from the first stage of data collection was gathered in two different ways, via an introductory questionnaire and interview for approximately half the respondents and via a detailed questionnaire for the other half as described in section 4.3. Both these collection methods are presented in appendix B. As outlined in section 4.3.1 the detailed questionnaire asked respondents to comment on their answers to forced-response questions. Those who completed the introductory questionnaire and were interviewed were asked to comment or elaborate on their questionnaire responses in the interview. The author found that the detailed questionnaire using the 'please comment' request instead of a participant interview was not as successful in obtaining data as the interview. This response is similar to that experienced by Orlich (1978, p.46) who states that "when open-ended questions are used in some surveys, the rate of return tends to be rather low".

The responses from both collection methods were collated and entered into a Microsoft Excel spreadsheet which is presented in figure two.

Figure 2. Questionnaire and Interview One Spreadsheet

	ML1	ML2	ML3	ML4	ML5	ML6	ML7	JO1	JO3	Spearman's Correlation
Team Size	6	6	5	5	6	6	4	5	7	0.85
No partic in quest	3	4	4	3	4	2	3	4	5	
% partic in quest	50%	67%	80%	60%	67%	33%	75%	80%	71%	
Females	1	1	0	2	0	1	1	1	0	-0.39
% Females	17%	17%	0%	40%	0%	17%	25%	20%	0%	
Part Timers	0	0	1	2	0	1	3	0	0	-0.54
% Part Timers	0	0%	25%	67%	0%	50%	100%	0%	0%	
Importance of PM	8.67	8.5	9.25	9.33	8.5	10	9	9	9.2	-0.37
Importance of Plan	9	8	6.75	9	8.75	10	9	9.5	9.2	0.24
Familiarity with team members	3	3.25	3.75	2	3.13	2	1.33	3.25	3.8	0.02
Socialising within team	2.67	2.75	3.13	1	2	2	1	2.63	1.8	-0.32
Happy with team mix	4.33	4	4.25	4.67	3.38	3.5	4.33	4.5	4.4	-0.52
Comfort level working with team members	2.67	1.25	2	2.33	1.75	2	1	1	1.2	-0.29
Number of conflict as at 1st questionnaire	0	0	0	0.33	0	0	0	0	0	-0.41
PM's handling of team	7	7.5	7	3.5	8.33	-	8	5	5	0.53
PM's handling of PM activities	6.67	8.25	7	5	7.67	-	7.67	5.5	5.4	0.30
Anticipated num of hours for project	15.5	10.25	10.75	12	10.5	11	12.33	10.5	14.5	-0.01
Project Mark	**254**	**258**	**205**	**234**	**373**	**365**	**-**	**237**	**267**	

This spreadsheet presents the combination of data collected via the introductory questionnaire and interview and the detailed questionnaire as outlined in appendix B. In addition to this material other information was gathered during the first stage of data collection via the open-ended questions. Responses from these questions were categorised and the information presented in the tables which follow.

What activities do you understand project management entails?

Most participant's understood that project management was managing the project but were unable to list specific project management activities. Common responses were "to organise the project" and "to organise and control team meetings".

Table 3. Project management activities listed by the respondents.

Common Responses	Number	Percent
Organising	4	12.5%
Planning	5	15.6%
Managing Human Resources	3	9.4%
Scheduling Tasks	9	28.1%
Monitoring Project	9	28.1%
Risk Management	0	0%
Configuration Management	0	0%
Controlling Project	2	6.2%
Leading and Motivating Team	7	21.9%
Estimating	2	6.2%
Overseeing project	3	9.4%
Conflict Resolution	3	9.4%
Other	5	15.6%

Other responses included: time management; quality assurance, liaise with client, administration tasks and decision making.

What effect do you think the use of these activities has on the overall project?

Generally respondents believed that project management did affect project success, although they were not confident in describing the effect.

Table 4. Effect of using project management activities.

Common Responses	Number	Percent
Substantial positive effect	2	6.2%
Make or break project	3	9.4%
Very Important	3	9.4%
If done well project will run smoothly	5	15.6%
Keep things on track	3	9.4%
Minimise panic near project completion date	2	6.2%
Other	3	9.4%

Other responses included: should make other tasks easier, decrease problems and increase amount of quality work completed.

What activity(ies) do you think will be the most important for a successful project?

The design activity scored highest of all activities for this question. This may be because the major focus for participant's at this time in the project development was

the software design, that is, in first semester participant's had to design the software product, in second semester they had to develop the product.

Table 5. List of importance of software engineering activity for project success.

Common Responses	Number	Percent
Analysis	4	12.5%
Requirements specification / understanding	2	6.2%
Design	7	21.9%
Scope definition	4	12.5%
Planning	1	3.1%
Project management	3	9.4%
Monitoring Tracking	0	0%
Coding Programming	0	0%
Testing	1	3.1%
Configuration / change management	0	0%
Other	0	0%

What planning has your team done so far?

Most teams had not formally defined the tasks to be completed during the initial set up and planning phase of the project. Generally teams had decided on who was going to lead the team but had not clearly identified other roles/responsibilities of team members and therefore had not allocated these to specific team members.

Table 6. Teams planning at first stage of data collection.

Common Responses	Number	Percent
Research and reading activities	3	9.4%
Allocated only some, major roles eg. PM	6	18.7%
Allocated team member role & responsibilities	2	6.2%
Discussed project plan informally	5	15.6%
Formed informal project plan	2	6.2%
Form formal documented project plan	1	3.1%
Other	1	3.1%

Other responses included: developed documentation standards.

Who formed the project plan? Were you happy with this?

This question gave some insight into the style of management of the team leader, although most teams had not yet formed the plan at the time of the first round of data collection. Of those respondents whose team had formed a project plan all were happy with the way this had been done.

Table 7. Who formed the project plan.

Common Responses	Number	Percent
Group members	5	15.6%
Project leader / manager	3	9.4%
Have not formed plan	8	25%
Other	0	0%

Who decided on the allocation of roles/responsibilities? Were you happy with this?

This question gave further insight into the management styles of the team leaders. Only one respondent was not happy with this process, explaining how their group looked at the skills of team members to decide on roles. They stated that some team members said they did not have skills so they did not have to do certain tasks.

Table 8. Who decided on the allocation of roles and responsibilities?

Common Responses	Number	Percent
Group members	6	31.6%
Project leader / manager had final choice	2	10.5%
Looked at skills and allocated tasks accordingly	7	36.8%
Team members volunteered for jobs they wished to do	4	21%
Other	0	0%

Have you had any major conflicts in your team so far?

This question was used to highlight if any problems have arisen to date within the team.

Table 9. Team conflicts

Common Responses	Number
No	15
Yes	
Just teething problems	2
Other	

If yes, how has this affected the project?

This question was used to establish if the team members felt the conflict was affecting the project, either positively or negatively.

Table 10. Effect of conflict on project.

Common Responses	Number
Hasn't	1
Negatively	
Decreased productivity	
Decreased team cohesion	
Positively	
Increased productivity	
Increased team cohesion and motivation	
Other	

How was this conflict handled?

This questions allowed the participant to elaborate on an answer in the questionnaire where they chose between:

a) handled by the project manager;

b) handled by the people involved; or

c) has not been handled yet.

Table 11. How has conflict been handled?

Common Responses	Number
By project leader	
By all group members	
By people involved	1
Hasn't been yet	
Other	

Do you believe the project leader is managing the team well and all the responsibilities they have?

This questions allowed the participant to elaborate on an answer in the questionnaire where they ranked the team leaders' management of the people in their team and the project management processes.

Table 12. Project leaders management of the team and the processes.

Common Responses	Number
Yes	4
No	
OK	6
Not bad	2
Hard to tell as hasn't done much	2
Too early to tell	5
Other	

What is the composition of your team?

Table 13. Team composition.

Common Responses	Number
All males	10
Mixed sex	5
Mixed study mode	1
Mixed Nationality	3
Other	

After seeing the requirements for the project how many hours do you think it will take per week?

This question asked the respondent to estimate the average hours per week they believed the project would take for the year.

Table 14. Amount of time project will take over the entire year.

Common Responses	Number
8 hrs	4
10 hrs	4
12 hrs	4
15 hrs	2
18 hrs	1
20 hrs	1
25 hrs	1

5.2 Analysis of Questionnaire Two, Three and Four

As discussed in section 4.4 information was recorded during the second, third and fourth stages of data collection via three separate questionnaires using forced response questions only. The responses from each of these questionnaires were entered into three separate Microsoft Excel spreadsheets. The spreadsheets, including the Spearman's rank correlation as discussed in section 4.5, are presented in appendix F, G and H respectively.

In order to facilitate easier analysis of the data from each spreadsheet the results have been collated and presented in a combined format below. Question responses from each questionnaire have been presented in one table. It is important to note that the fourth questionnaire requested respondents to reflect on the entire project when answering the questions, hence the results of the forth questionnaire should, to a degree, reflect the combined results for questionnaire two and three.

As outlined in section 4.3.2, the questions on each questionnaire were grouped into sections. Initially the questions related to the software engineering and project management activities being used by the teams. These were followed by questions focussing on some of the dynamics of the teams, followed by a series of questions

regarding the project leader. Questionnaires two and three concluded with general project questions.

Software Engineering Processes Questions

The first group of tables presents the data from the questions which focussed on the software engineering activities undertaken by the teams.

What percentage of time has your group been spending on analysis?

Table 15. Percentage of time teams spent on analysis.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	22	19	12	12	14	19	18	15
3	13	14	6	13	8	7		
4	16	10	15	11	9	11	18	16

What percentage of time has your group been spending on design?

Table 16. Percentage of time teams spent on design.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	23	18	11	21	22	28	23	20
3	18	25	14	17	9	31		
4	23	20	15	19	21	20	19	20

What percentage of time has your group been spending on programming/Oracle activities?

Table 17. Percentage of time teams spent on programming/Oracle activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	4	1	8	10	2	2	3	8
3	33	21	40	25	50	36		
4	27	41	28	31	28	30	38	27

What percentage of time has your group been spending on testing activities?

Table 18. Percentage of time teams spent on testing activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	4	10	7	8	11	6	7	5
3	15	11	5	7	12	12		
4	9	11	11	9	16	27	7	8

What percentage of time has your group been spending on quality monitoring activities? (In questionnaire two this question asked for project progress monitoring only).

Table 19. Percentage of time teams spent on quality monitoring activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	5	6	8	9	11	8	6	6
3	8	7	9	3	6	7		
4	7	4	9	9	8	12	4	8

What percentage of time has your group been spending on configuration management activities?

Table 20. Percentage of time teams spent on configuration management activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	4	6	4	9	8	5	6	7
3	8	11	6	12	6	2		
4	6	6	7	11	8	3	4	6

What percentage of time has your group been spending on project management activities?

Table 21. Percentage of time teams spent on project management activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	8	16	17	8	12	8	13	18
3	8	12	14	17	9	5		
4	8	9	11	10	13	4	7	15

What percentage of time has your group been spending on other unlisted activities? (This question was only asked in questionnaire 3 & 4).

Table 22. Percentage of time teams spent on other activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2								
3	0	0	8	7	1	1		
4	3	0	2	0	0	0	4	1

Although respondents were asked to list other activities none were recorded.

Project Management Processes Questions

The following group of questions focussed on the project management activities undertaken by the teams.

What percentage of time has your group been spending on planning activities?

(For questionnaires three and four, only the project leaders were required to respond to this question. The response rate was not 100% for all questionnaires).

Table 23. Percentage of time teams spent on planning activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	17	14	14	10	11	19	15	14
3			20	10	20	50		
4	10	15	20	20	20	30	10	20

What percentage of time has your group been spending on estimation activities?

Table 24. Percentage of time teams spent on estimation activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	9	13	14	20	19	5	16	11
3			10	15	5	10		
4	5	10	5	10	10	5	15	5

What percentage of time has your group been spending on scheduling/task allocation activities?

Table 25. Percentage of time teams spent on scheduling/task allocation activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	11	12	9	6	7	8	11	15
3			20	35	8	20		
4	10	15	20	20	10	10	5	10

What percentage of time has your group been spending on risk management activities?

Table 26. Percentage of time teams spent on risk management activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	4	4	6	4	8	10	8	3
3			10	10	12	5		
4	10	10	13	10	5	10	10	10

What percentage of time has your group been spending on conflict resolution activities?

Table 27. Percentage of time teams spent on conflict resolution activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	4	4	5	9	7	3	0	4
3			5	0	0	0		
4	10	10	2	10	5	5	10	5

What percentage of time has your group been spending on individual team member communication? (In questionnaire two this question asked respondents to report on team member management).

Table 28a. Percentage of time teams spent on individual team member communication.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	5	7	5	7	5	7	8	6
3			10	0	20	5		
4	25	15	20	5	15	10	10	20

What percentage of time spent has your group been spending on group communication? (In questionnaire two respondents were asked to report on time spent on/in team meetings).

Table 28b. Percentage of time teams spent on group communication.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	27	14	20	12	14	14	9	15
3			10	10	25	5		
4	20	10	15	10	10	15	15	20

What percentage of time spent has your group been spending on project progress monitoring?

Table 29. Percentage of time teams spent on project progress monitoring.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	6	11	9	8	12	10	8	11
3			15	20	10	5		
4	10	15	10	15	25	15	5	10

What percentage of time spent has your group been spending on other/general administration activities.

Table 30. Percentage of time teams spent on other general administrative activities.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	12	8	10	17	6	7	14	14
3			0	0	0	0		
4	0	15	0	0	0	0	20	0

Team Dynamics Questions

The following tables present the results of the questions which focussed on the team dynamics.

Please rate your level of comfort with the members of your team? (0 very uncomfortable - 10 very comfortable).

Table 31. Team members level of comfort with other team members.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	5.3	2	3.5	3.3	1.9	1	3	2
3	4	6	6	8	8	6		
4	8	7	7	8	7	7	6	9

How many conflicts has your team had to date? (Questionnaire two asked for an exact number of conflicts, where as questionnaire three and four asked respondents to rate the number of conflicts on a Likert scale between none (0) and many (10).

Table 32. Number of conflicts teams experienced during the project.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	0	0	0.5	40	0	0	0	2
3	6	3	1	5	4	1		
4	3	3	4	2	4	2	5	2

What effect (positive or negative) have these conflicts had on the project? (Questionnaire two asked respondents to rank the effect of the conflict on a Likert scale between little (0) and a great deal (10). Questionnaire three and four asked respondents to rank the conflict between -ve and +ve).

Table 33. Effect of conflict (positive or negative) on the project.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	5.3	2	3.5	3.3	1.9	1	3	2
3	4	6	6	8	8	6		
4	8	7	7	8	7	7	6	9

Project Leader Questions

The following tables present the information from those questions which focussed on the teams project leader.

How would you rate your team leaders' management of the people in your team? (0 poor - 10 outstanding).

Table 34. Teams rating of project leaders' management of the people in the team.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7	8	6	4	8	6	9	5
3	1	6	7	3	7	7		
4	5	6	7	1	7	8	7	8

How would you rate your team leaders' management of the project management activities? (0 poor - 10 outstanding).

Table 35. Teams rating of project leaders' management of the people in the team.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	5	8	6	4	7	7	8	5
3	1	6	7	3	7	7		
4	6	6	6	0	8	8	7	9

The following 10 tables present the results from a series of questions used to establish a support and challenge ranking for each team leader, as discussed in section 4.3.2. under the "Project Leader Questions".

How often does your project leader listen to team members' opinions, ideas, information and concerns? (O poor - 10 outstanding).

Table 36. Team leader relationship behaviour - question one.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	9.2	8.4	9.2	4.3	9.4	8	9.8	8.2
3	3	6.1	9.3	2.6	6.5	9.4		
4	9.7	7	8.1	2	6.9	9.8	9.6	9.3

How often does your project leader test to make sure team members have a good understanding of what is to be achieved? (O poor - 10 outstanding).

Table 37. Team leader relationship behaviour - question two.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	8.4	7	3.4	4.3	8.9	4.7	8.3	4.4
3	4.3	6.2	6.4	4.3	7.2	7.7		
4	7.8	5.7	6.9	1	6.8	5.6	6.7	6.3

How often does your project leader offer reassurance, help, or guidance as necessary and appropriate? (O poor - 10 outstanding).

Table 38. Team leader relationship behaviour - question three.

Team Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	8.4	8.3	6.3	1.3	8.4	4.3	7.5	4.9
3	5.8	5.22	7.5	2.5	6.6	7.8		
4	8.8	7	7.1	0.3	6.1	6.6	6.1	8.6

How often does your project leader provide permission to act and protection/backup as necessary? (O poor - 10 outstanding).

Table 39. Team leader relationship behaviour - question four.

Team Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	6.7	8.4	5	4.3	8.4	4.3	9.3	4.4
3	9.7	6.1	8.23	4.6	7	7.77		
4	8.7	6.5	6.7	4.3	6.2	8.2	4.9	8

How often does your project leader consider others' needs and points of view when offering suggestions or support? (O poor - 10 outstanding).

Table 40. Team leader relationship behaviour - question five.

Team Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7.4	8.8	6.7	4.3	8.2	5.3	9	8
3	7.7	6.6	7.3	3.4	6.9	7.7		
4	9	6.7	7.6	3	6.6	9.7	9.5	9.2

How often does your project leader express view clearly and emphatically? (O poor - 10 outstanding).

Table 41. Team leader task behaviour - question one.

Team Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7.1	8.4	6.3	4.7	9	4.3	6.7	6.9
3	2.3	6.2	7	3.1	8.2	6.1		
4	5.2	5.5	8.7	2	7.5	9.3	7.9	8.7

How often does your project leader set high expectations? (O poor - 10 outstanding).

Table 42. Team leader task behaviour - question two.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7.1	8.6	4.3	8.5	10	4.2	6.3	6.2
3	5.4	8.6	6.5	5.2	8.9	7.5		
4	6.7	7.3	8.5	3	8.7	5.6	6.6	6.7

How often does your project leader state the actions or results the team is trying to achieve? (O poor - 10 outstanding).

Table 43. Team leader task behaviour - question three.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	6.4	7.9	4.3	5.3	6.6	3.5	8	5.6
3	4.4	7.4	6.4	1.1	7.4	7.3		
4	5.7	6.3	7	1.5	9.3	8.3	6	8.9

How often does your project leader indicate the positive and negative consequences of not meeting expectations? (O poor - 10 outstanding).

Table 44. Team leader task behaviour - question four.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	6.5	7	5	6.2	7.6	4.2	7.2	6
3	6.9	7.7	7.7	4.8	8.3	8		
4	7.5	6.2	6.4	3	9	6.5	5.9	9.3

How often does your project leader offer alternative views and options? (O poor - 10 outstanding).

Table 45. Team leader task behaviour - question five.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	8.9	7.9	5.2	3	7.1	3	9.3	5.4
3	5.3	6.4	6.4	3.5	5.9	8		
4	7.5	7	6.5	0.83	9	6.7	8.6	9.2

The project leaders' final relationship (supportive) / task (directive) behaviour ranking's are presented in the following two tables.

Level of relationship (supportive) behaviour of the project leaders as determined by the team members.

Table 46. Level of relationship (supportive) behaviour of the project leaders as determined by the team members.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	8	8.2	6.2	3.7	8.6	5.3	8.8	5
3	6.1	6.1	7.7	3.5	6.8	8.1		
4	8.8	6.6	7.3	2.1	6.5	7.8	7.4	8.3

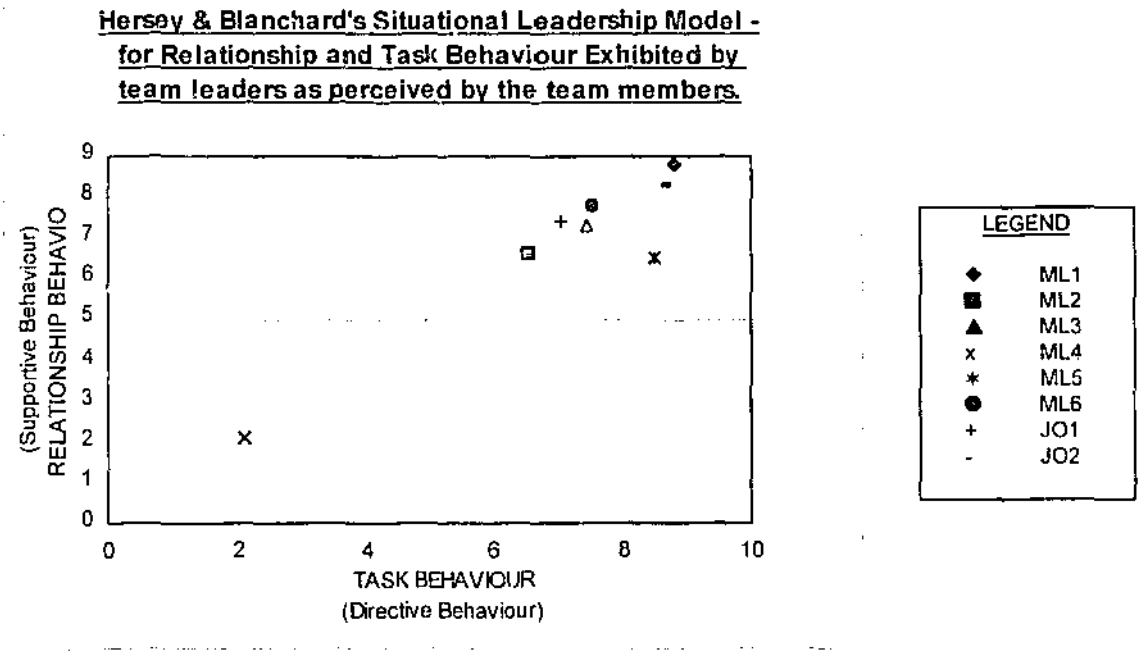
Level of task (directive) behaviour of the project leaders as determined by the team members.

Table 47. Level of task (directive) behaviour of the project leaders as determined by the team members.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7.2	7.9	5	5.5	8.5	3.8	7.5	5
3	4.9	7.3	6.4	3.5	7.8	7.4		
4	8.8	6.5	7.4	2.1	8.5	7.5	7	8.6

Figure 3 presents the rank for the level of relationship and task behaviour of the project leaders as perceived by the team members plotted on Hersey and Blanchard's Situational Leadership Model. exhibited

Figure 3. Rank for the level of relationship and task behaviour of the project leaders as perceived by the team members plotted on Hersey and Blanchard's "Situational Leadership Model".



When collating the responses from the relationship and task questions the team member responses were separated from the project leaders'. The following two tables present the project leaders perception of the level of relationship and task directive behaviour they perceive they exhibited.

Level of relationship (supportive) behaviour of the project leaders as perceived by the project leaders.

Table 48. Level of relationship (supportive) behaviour of the project leaders as perceived by the project leaders.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	7.1	7.4	9.6	8	5.4	10	7.9	6
3			9.4	7	5.5	6.5		
4	6.5	9.8	9.8	8	5.3	8	4.5	6.8

Level of task (directive) behaviour of the project leaders as determined by the team leaders.

Table 49. Level of task (directive) behaviour of the project leaders as determined by the team leaders.

Team / Questionnaire	ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2
2	3.2	9.3	9.4	5	9	9	6.3	6
3			9.4	5	9	5.8		
4	2.5	8.8	9.9	4	9.5	7.3	7	7.2

5.4 Project Success Evaluation

As discussed in section 4.1 the student projects were marked by an expert judging panel consisting of the Academic Project Supervisors and the "client" who was an external industry representative. Project success was determined by the final project mark achieved by the teams. Projects were marked in a number of areas as outlined below.

Project File

- Project plans
- Timesheets
- Meetings
- Project reports
- Roles & responsibilities
- Management of the process
- Configuration management
- Standards
- Risk management

Quality of Testing

- Test plan
- Scope of testing
- Test environment
- Test results
- Completeness of other aspects (Security, auditing, tests tested etc.)

Maintenance Documentation

- Design updates
- Data dictionary
- Code
- Maintainability
- Completeness of other aspects (hardware software environment, conversion, manual methods)

User Documentation

- Usage guidelines
- Reference/help

Application of standards
Document readability
Document format and style

Presentation

Statement of the problem
Explanation of the approach taken
System functionality
System quality
Overall presentation

Marks were allocated against each of these criteria for each team and this information was entered into a spreadsheet. A Spearman's Rank Correlation was calculated and is included on this spreadsheet which is present in appendix I.

Chapter 6

DISCUSSION

6.1 Discussion of Results and Findings

The main objective of this research was to observe, record and report on:

- the software engineering and project management processes undertaken during software development
- the leadership/management styles of team leaders of software development projects.

Analysis of the data collected during the research highlighted several significant correlations together with other interesting findings. This discussion focuses primarily on questionnaire four as this reflects the practices and processes undertaken over the entire project. Results from questionnaires one, two and three are included where relevant. As discussed in section 4.3.2 the data collection questions were grouped into several topic areas: questions relating to the software engineering and project management activities used by the teams; questions focussing on some of the

dynamics of the teams; and questions focussing on the team leader. This discussion of results and findings will be presented under these question groupings, similar to the results of the research in section 5.2.

Software Engineering Processes Questions

When reviewing the software development activities undertaken by the student software engineering teams, the most significant correlation was between the percentage of time teams spent on the design of the software product and the final project mark. This supports the common theory that the initial design of software products is of crucial importance to the success of the development project, as Sommerville (1992, p.172) states "good design is the key to effective engineering".

In similar research conducted using the same subjects as this research Mullin and Hope (1996, p.129) conclude that "the most consistently significant contributor to a good product is the proportion of time spent testing". In this research the percentage of time spent on testing produced the second highest correlation with project success behind design activities. In the analysis of questionnaire three the percentage of time spent testing correlated the highest with project success. Testing is the process of reviewing a software product with the objective to highlight errors. "We test a program in order to demonstrate the *existence* of an error" (Lawrence Pfleeger, 1987,

p.270). Those teams which spent considerable time on testing activities were rewarded with a more successful project than those that did not.

Interestingly there was a negative correlation between the percentage of time teams spent on programming and project success, suggesting that large quantities of time spent on coding does not increase project success. The negative correlation with the percentage of time spent coding and the positive correlation with the percentage of time spent on design suggests that time spent developing a clear, thorough design leads to a decrease in the coding effort required, primarily due to the minimisation of re-work. This ultimately leads to a more successful project.

Project Management Processes Questions

When reviewing the project management activities undertaken by the software development project team leaders there were no highly significant positive correlations between specific activities and project success, although the responses to questionnaire two showed a significant positive correlation with the time teams spent on project progress monitoring activities. Also in the analysis of questionnaire four, progress monitoring was the highest ranking project management activity. Sallis, Tate and MacDonell (1995, p.81) explain that "the establishment of process management principles is only worthwhile in the long term if assessment of the

effectiveness is undertaken". This can be done only if the project is accurately tracked and project plans and schedules are constantly reviewed and updated to reflect project changes.

This research suggests that tracking and monitoring activities does have a positive effect on project success. In addition tracking and monitoring provide the software industry with much needed historical data on development projects which allows software engineering professionals to review the software development process and investigate improvement opportunities, as Sallis, Tate and MacDonell (1995, p.81) outline "project progress must be tracked and documented so that ... the software process (including process management) can be analysed and improved".

There was one significant negative correlation between the percentage of time teams spent on risk management activities and the success of the project, suggesting that time spent on risk management had a negative effect on project success. This strongly conflicts with existing beliefs that risk management increases the likelihood of project success, by eliminating un-managed risk elements. Boehm states how (1989, vi) "the problems widely associated with software project disasters can be avoided or strongly reduced if there is an explicit early concern with identifying and resolving high risk elements". The results of this research show that the team with the highest project mark actually spent the least percentage of time on risk management 5%, though in real time this was actually 85 hours. The team with the

lowest final project mark, who spent the most percentage of time on risk management, 13%, actually only spent 60 real hours of time. Hence this finding may be misleading due to the use of percentages of time rather than real hours.

Project Leader Questions

The results showed a significant positive correlation between the team members rating of the effectiveness of the leaders' management of their project management responsibilities and the success of the project. This suggests that effective management of the processes of project management has a positive effect on the project success as Sommerville (1992, p.492) states "good software project management is essential if software engineering projects are to be developed on schedule and within budget". Sallis, Tate and MacDonell (195, p.46) agree saying that "the likelihood of a successful outcome in a development project is influenced greatly by the management methods used".

When analysing the data collected on the team leaders it was evident that a high level of task/directive behaviour exhibited by the team leader was important for success. Directive behaviour is described in section 4.3.2 under the project leader questions

heading. Of the five questions relating to the task or directive behaviour of the team leader three correlated highly with the final project mark.

Hodgetts (1985, p.407) writing on Hersey and Blanchard's "Situational Leadership Model" explains how different leadership styles should be used for different teams of individuals depending on their "maturity level" and knowledge in the project area. Hodgetts states that a "selling" leadership style where "the leader provides both directive and relationship behaviour" is most appropriate for "individuals of low to moderate maturity" which best describes the subjects in this study. Seven of the eight team leaders in this research exhibited both directive and relationship leadership behaviour see figure 3.

6.2 Addressing Research Questions

- ***What contribution does project management make to the success of a software development project?***

The importance of project management to successful projects has been well documented by authors such as Sallis, Tate and MacDonell (1995, p.46), Sommerville (1992, p.492), Pressman (1992, p.42) and Snyder and Shumate (1992, p.12). Although no significant correlations between the percentage of time

teams spent on project management activities and the success of the project were identified by this research, the author is of the belief the project management activities undertaken by the team leaders was an important contributor in the success of the software development projects. Anecdotal evidence gathered during the completion of the fourth questionnaire by the author suggests that the respondents, third year students, did not identify some of the tasks they were undertaking as project management activities. Hence they under estimated, both the percentage of time and the importance of the activities.

It could be argued also that more successful teams spent less time on project management activities, hence the lack of correlation between time spent on project management and project success, because they completed the activities more efficiently than less successful teams.

- ***Which project management activities contribute most to the success of a software development project?***

The effectiveness with which all project management activities are carried out is of vital importance to project success as stated by Sallis, Tate and MacDonell (1995, p.46), Sommerville (1992, p.492), Pressman (1992, p.42) and Snyder and Shumate (1992, p.12). Of the software development project management activities completed during this software development project, time spent on project progress monitoring was identified as one of the most important

contributors to success. Planning was the second highest correlating activity. Badiru and Pulat (1995, p.39) claim that "the key to a successful project is good planning".

- ***What leadership styles are associated with project managers on successful software projects?***

When endeavouring to select leaders it is imperative to consider the many factors such as: the working environment, the project and the skills and personal traits of the human resources that can influence the effectiveness of the leadership, as Robbins (1988, p.384) outlines "a manager can be unsuccessful in one leadership situation and quite successful in another".

The significant Spearman's correlations identified in this research highlight that directive behaviour seems to be the major leadership style associated with project managers on successful projects when dealing with team members with a "low to moderate level of maturity" (Hodgetts, 1985, p.407). Anecdotal evidence, collected by the author and the academic project supervisors, of the firm assertive leadership displayed by the leader of the most successful student software development team support this finding.

Chapter 7

IMPLICATIONS AND CONCLUSION

7.1 Implications

This study confirms the established belief in the value of both software design and testing activities. It has established also that ongoing project progress monitoring has a positive effect on project success and thus should be a focus for project leaders.

"Good leadership is an essential component of project management". . (Badiru & Pulat, 1995, p.27). Selecting a project manager requires careful consideration because they are responsible for some of the most crucial activities undertaken during the project. The selection should be done taking into consideration the numerous varying factors which can influence leadership, including: the work environment, the project, and the skills and personal traits of the human resources.

Findings from this research suggest that managers on projects with individuals with "low to moderate maturity levels" (Hodgetts, 1985, p.405) should have sound

technical knowledge and the ability to challenge and direct team members, but most importantly they must have the ability to be flexible in their leadership styles to accommodate a range of environments, projects and most importantly human resources.

7.3 Enhancements to the Study

As the student project at Edith Cowan is ongoing the opportunity exists to repeat and refine the research. A number of areas requiring improvement were highlighted during the research which would substantially improve future research and consequently the results. These include:

- a clearer explanation to ALL research subjects of the reason and importance of the research which would help to ensure a 100% participation from the subjects;
- removal of the initial questionnaire and interview which, although they were of general interest, did not serve to provide any data useful in answering the research questions;
- closer attention to the creation of the research instruments, especially the language used to ensure questions are clear and unambiguous;

- analysis of the design of the research is required to investigate if other techniques can be used to elicit data which is more useful in answering the research questions;

- finally psychometric tests of the team leaders should be conducted by an professional.

7.4 Thesis Conclusion

The main objective of this research was to observe and report on the software engineering and project management processes undertaken during software development and the leadership of the software development teams involved. The subjects were software engineering students completing a software development project as part of their assessment for the Computer Science degree at Edith Cowan University. All teams had the same development objectives, development environment and access to resources. This provided a rich research environment, rarely available using 'real world' software development projects. Data was collected in four stages via an initial interview and questionnaire for the first stage and via three questionnaires for the remaining stages.

Data from each of the four data collection stages were entered into separate spreadsheets and a Spearman's Rank Correlation Coefficient calculated. Analysis and discussion of the data collected allowed the research questions to be addressed and implications to be drawn from the research.

The author believes that this research is of significant value to the software engineering profession. It adds to the existing Body Of Knowledge on project management and endeavours to address the "Research Crisis" discussed by Glass by observing, recording and, to a degree, quantifying software development processes.

Chapter 8

BIBLIOGRAPHY

Azuma, M., & Mole, D. (1993). Software management practice and metrics in the European Community and Japan: Some results of a survey. *Proceedings 2nd International Conference on Achieving Quality in Software* (pp.5-18). Italy: IEI-CNR.

Badiru, A.B. & Pulat, P.S. (1995). *Comprehensive project management* USA: Prentice Hall.

Basili, V.R., Selby, R.W., & Hutchens, D.H. (1986). Experimentation in software engineering. *Transaction on Software Engineering SE-12, 7 July* 733-743.

Binder, R.V., & Phillips, J.E. (1992). Software teams issues, analysis & action. *American Programmer. June*, 28-41.

Boehm, B. & Ross, R. (1989). Theory-W software project management: Principles and examples. *IEEE Transactions on Software Engineering, 15*(7), 902-915.

Boehm, B (1989). *Software risk management.* USA: IEEE Computer Society Press.

Brady, S., & DeMarco, T. (1994). Management-aided software engineering. *IEEE Software. November* 25-32.

Buck, C.L. (n.d.). The effective project manager. In J. Adams & N. Kirchof (Eds.), *A decade of project management* (pp. 92-95). USA: Project Management Institute.

Cocco, A.F. (1995). Using performance goals to motivate workers: A practical guide for project managers. *Project Management Journal, June,* 53-56.

Datz, A., & Wilby, L.R. (n.d.). The effective project manager. In J. Adams & N. Kirchof (Eds.), *A decade of project management* (pp. 27-31). USA: Project Management Institute.

Dawson-Howe, K.M. (1996). Organization of final year projects. *SIGSCE Bulletin, 28*(3), 2-4.

Dorling, A. (1993). SPICE: Software Process Improvement and Capability dEtermination. *Information and Software Technology, 5*(6/7), 404-406.

Fenton, N., Lawrence, S. & Glass, R.L. (1994). Science and substance: A challenge to software engineers. *IEEE Software. July* 86-95.

Foddy. (1993). *Constructing questions for interviews and questionnaires.* United Kingdom: Cambridge University Press.

Glass, R., L. (1994). The software-research crisis. *IEEE Software. November* 42-47.

Hodgetts, R.M. (1985). *Management international edition.* UK: Academic Press, Inc.

Hope, S. & Terry, J.E. (1996). A recursive student project to reinforce the principles of software engineering. In *Software Engineering Education and Practice Proceedings.* (68-75) USA: IEEE Computer Press.

Johnson, J.R. (1991). *The software factory managing software development and maintenance.* (2nd Ed.) USA: QED Information Sciences, Inc.

Kliem, R.L. & Anderson, H.B. (1996). Teambuilding styles and their impact on project management results. *Project Management Journal, 27*(1), 41-50.

Lawrence Pfleeger, S. (1987). *Software engineering. The production of quality software.* USA: Macmillian Publishing Company.

Leveson, N.G. (1995). *Safeware: System safety and computers.* USA: Addison-Wesley Publishing Company.

Mullin, K. & Hope, S. (1996). An application of quantitative techniques to the question of what contributed to a successful software development project. *1996 Australian Software Engineering Conference Proceedings.* (118-130) USA: IEEE Computer Press.

Ohlsson, L. & Johansson, C. (1995). A practice driven approach to software engineering education. *IEEE Transactions on Education, 38*(3), 291-295.

Orlich, D.C. (1978). *Designing sensible surveys.* USA: Redgrave Publishing Company.

Paulk, M.C., Curtis, B., Chrissis, M.B. & Weber, C.V. (1993). Capability maturity model, version 1.1. *IEEE Software, July,* 18-27.

Perry, D.E., Staudenmayer, N.A. & Votta, L.G. (1994). People, organizations, and process improvement. *IEEE Software, July 1994,* 36-45.

Phan, D., Vogel, D. & Nunamaker, J. (1995). Empirical studies on software development projects: Field survey and OS/400 study. *Information & Management, 28,* 271-280.

Phillips, Dwayne. (1996). Project management: Filling in the gaps. *IEEE Software, July,* 17-18.

Pinto, J.K. & Kharbanda, O.P. (1995). Project Management and conflict resolution. *Project Management Journal, December,* 45-53.

Pressman, R.S. (1992). *Software engineering: A practitioners approach.* Singapore: McGraw-Hill Book Co-Singapore.

Project Management in Japan. (1991). *American Programmer. June* 41-48.

Robbins, S.P. (1988). *Management concepts and applications.* USA: Prentice Hall, Inc.

Robinson, G. (1992). Motivation. In *Proceedings of the Project Management Institutes Annual Seminar/Symposium* (pp. 522-526) USA: Project Management Institute.

Saiedian, H. & Kuzara, R. (1995). SEI Capability maturity model's impact on contractors. *IEEE Computer, January,* 16-26.

Sallis, P., Tate, G. & MacDonell, S. (1995). *Software engineering: Practice, management and improvement.* Addison-Wesley Publishing Company.

Simpson, W.D. (1987). *New techniques in software project management.* Canada: John Wiley & Sons, Inc.

Snyder, T., & Shumate, K. (1992). KAIZEN project management. In *American Programmer. December* 12-20.

Sommerville, I. (1992). *Software Engineering.* USA: Addison-Wesley Publishing Company, Inc.

Stuckenbruck, L.C. (n.d.). The effective project manager. In J. Adams & N. Kirchof (Eds.), *A decade of project management* (pp. 66-67). USA: Project Management Institute.

Thomsett, R. (1993). *Third wave project management A handbook for managing complex information systems for the 1990s.* USA: Prentice Hall, Inc.

Tippet, D. & Peters, J. (1995). Team building and project management: How are we doing? *Project Management Journal, December,* 29-36.

Tullet, A. (1995). The adaptive-innovative (A-I) cognitive styles of male and female project managers: Some implications for the management of change. *Journal of Occupational and Organizational Psychology, 68,* 359-365.

Valentine, M. & Price, J.E. (1994). The leadership attributes and strengths of female project managers. *PMNETwork, March,* 27-29.

van Genuchten, M. (1991). Why is software late? An empirical study of reasons for delay in software development. *IEEE Transactions on Software Engineering, 17*(6), 582-590.

Weinberg, G., M. (1971). *The psychology of computer programming.* USA: Van Nostrand Reinhold Company Inc.

Appendix A

SOFTWARE ENGINEERING FAILURES

Appendix A presents a list of documented project failures. The first was taken from "Risk to the Public in Computer and Related Systems" by Peter Neumann published in the ACM SIGSOFT September 1996. The second was compiled by Sherer. The third was documented in the article "Incessant Stories of Big Computer Systems" a feature story in the *Nikkei Computer* Journal in June 1990.

Taken from:

Neumann, P.G. (1996). Risks to the public in computers and related systems. *ACM SIGSOFT, 21*(5). 13-19.

Largest computer error in US banking history: US$763.9 billion.

When Jeff Ferrera and Cindy Broadwater checked their checking balance at the First National Bank of Chicago, the automated voice gave it as $924,844,208.32. More than 800 other folks had similar stories to tell. The sum total for all accounts was $763.9 billion, more than six times the total assets of First Chicago NBD Corp. The problem was attributed to a "computer glitch" [Source AP US & World, 18 May 1996, By Mario Fox. Courtesy of Associated Press News via CompuServe's Executive News Service. PGN Abstracting.]

The "glitch" was apparently the result of a programming change intended to support the new out-of-area ATM fees being proposed by various banking groups. When the new transaction messages were introduced to the network, some systems took the strange new codes and transformed them into something they could understand: a posting of a huge credit to one's account.

Ariane 5 failure (John Rushby)

Faulty computer blamed in Ariane 5 rocket failure: Experts studying the moments before the Ariane-5 rocket explosion say faulty computer software may be to blame for the rocket veering off course. Apparently, the rocket was mis fed information that made it think it was not following the right path. The rocket then changed direction causing the upper part to begin to break. (From CNN's web page www.cnn.com).

(Andy Fuller) According to the 24-30 June issue of Space News, the 4 June 1996 explosion of the Ariane 5 rocket was caused by software in the inertial guidance system. Apparently an inertial platform from the Ariane 4 was used aboard the Ariane 5 without proper testing. When subjected to the higher accelerations produced by the Ariane 5 booster, the software (calibrated for an Ariane 4) ordered an "abrupt turn 30 seconds after lift off", causing the airframe to fail.

Massive failure of Washington DC traffic lights (Jeremy J Epstein)

According to *The Washington Post*, 9 May 1996, most traffic lights in downtown Washington D.C. went onto their weekend pattern (typical: 15 seconds of green light

per light), rather than their rush hour pattern (typical: 50 seconds of green light per light). This occurred during the Wednesday (8 May) morning rush hour. The problem was reportedly caused by a new version of software installed in the central system that controls all of the traffic lights, providing timing (so lights turn green in sequence). The result was mile-long traffic jams.

Taken from:

Sherer, S.A. (1992). *Software Failure Risk Measurement and Management.* New York: Plenum Press.

"Software has contributed to some of the most widely publicized computer disasters in the past decade:"

- A software error in the Patriot missile's radar system allowed an Iraqi Scud to penetrate aid defenses and slam into an American Military barracks in Saudi Arabia, killing 28 People during the Gulf war (Schmitt, 1991).

- A software error in the programs that route calls through the AT & T network was blamed for the nine-hour breakdown in 1990 of the long-distance telephone network, dramatizing the vulnerability of complex computer systems everywhere (Elmer-DeWitt, 1990).

- A software error involving the operation of a switch on the Therac-25, a computer-controlled radiation machine, delivered excessive amounts of radiation, killing at least four people (Jacky, 1989).

- A software design error in the Bank of New York's government securities system resulted in the bank's failure to deliver more than $20 billion in securities to purchasers (Juris, 1986).

Examples of the repercussions of reported failures within the last five years illustrate the impact of software failure:

- The Bank of New York had to pay $5 million interest on more than $20 billion it was forced to borrow from the Federal Reserve Bank in order to repay sellers for the securities it had been receiving when its software failed to process incoming credits from those transferred. Moreover, when government securities trading was disrupted, metal traders, believing that a financial crisis had hit the Treasury bond market, bid up the price of platinum futures from $12.40 to $251.20 per ounce - a 29-year record (Juris, 1986).

- A software error allowed winning lottery tickets to be sold after the winning number had been drawn in the Tri-State Megabucks game for Vermont, New

Hampshire, and Maine, resulting in several belated winners collecting up to $5000 (*Software Engineering Notes,* 1991).

- A software error in Washington's Rainier Bank Teller machines permitted unlimited amounts of money to be withdrawn in excess of customer balances. The bank then had to incur the cost of trying to recover the excess money withdrawn (*Software Engineering Notes,* 1985).

In addition to these failures detailed outlines of accidents and disasters attributed to software failure can be found in the text "Safeware: System Safety and Computers" (1995) by Nancy G. Leveson.

Appendix B

QUESTIONNAIRE AND INTERVIEW ONE

& DETAILED QUESTIONNAIRE ONE

INTERVIEW ONE

Name: _____ Sex: M / F

Team: _____ Study Mode: Part time / Full time

Role/Responsibilities in Team: _____

Project Management

What activities do you understand project management entails?

What effect do you think to use of these activities has on the overall project? (Depending on rating in question 1)

What activity(ies) do you think will be the most important for a successful project?

Project Plan

Planning so far?

Who formed the project plan? Were you happy with this

(Depending on answer to 2b)

Who decided on the allocation of roles/responsibilities? Were you happy with this

(Depending on answer to 2c)

Project Team

Do you associate with any members of your team socially?

Do you discuss university etc. when out socially. (Depends on answer to 3b).

If yes So you will discuss the project?

Are you uncomfortable working with any member of your team. Why? (Depending on answer to 3c & 3d.)

Nationality/Age/Study Mode/Sex

Have you had any major conflicts in your team so far?

If yes how has this effected the project? (Depending on answer to 3e.)

How was this conflict handled? Expand on answer to 3f.

Do you believe the project leader is managing the team well and all responsibilities they have? Expand on 3g & h.

The Project

After seeing the requirements for the project how much of your time do you anticipate it will take per week? Expand on 4a.

QUESTIONNAIRE ONE

5TH MARCH - 12TH MARCH 1996

Date: _____

Name: _____ **Sex:** M / F

Team: _____ **Study Mode:** Part Time / Full Time

Role/Responsibilities in Team: _____

Project Management

1. How important do you believe project management is for a successful project. (0-10) _____

Project Plan

2a. At what stage is your teams planning? (Please circle one)

None — Set date for first meeting
Allocated roles — Allocated Responsibilities
Formed project plan

2b. If you have developed a plan: Who formed the plan? Project Leader / Group / Other

2c Who decided on the allocation of roles/responsibilities? Project Leader / Group / Other

2d. How important do you believe the project plan is in the success of your project. (0-10) _____

Project Team

3a. How well do you know the other members in your team? 1 (Not at all) — 5 (Know well)

3b. Do you associate with any members of your team socially? Not at all — Frequently

3c. Do you feel uncomfortable working with any members in your team? Not at all — Extremely

3d. Are you happy with your team mix? (Age/Sex/Nationality) Not at all — Extremely

3e. Have you had any major conflicts in your team so far? Yes / No If Yes approximate number: _____

3e If you have had conflict what effect has this had on the project so far? Little — A great deal

3f. How was this conflict handled? By project leader / By people involved / Hasn't been yet

3g. How would you rate the project leaders management of the people in your team. (0-10) _____

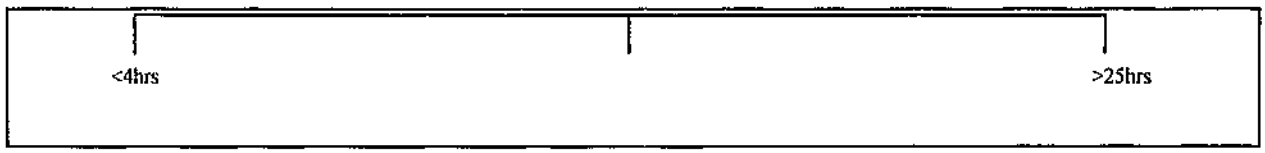
3h. How would you rate the project leaders management of project management activities. (0-10) _____

3i. What skills do you bring with you to the team?

DB Design — 3GL Programming — Technical Writer
Project Management — Oracle

The Project

4a. After seeing the requirements for the project how much of your time do you anticipate it will take per week?



DETAILED QUESTIONNAIRE ONE

Date:
Name: _____ **Sex:** M / F
Team: _____ **Study Mode:** Part Time / Full Time

Role/Responsibilities in Team:
(If you have not been allocated a role or any responsibilities simply write "Team Member").

Project Management

1a. How important do you believe project management is for a successful project. (0 not important -10 very important)

1a. List as many project management activities as you can.

Project Plan

2a. What planning has your team done so far?
(Please circle one)
None — Set date for first meeting
Allocated roles/responsibilities — Formed project plan
Allocated tasks — Other (please specify)

2b. How was the project manager or leader selected? (please comment)

2c. Were/are you happy with this selection? Yes / No (please circle) Why? (please comment)

2d. Who decided on the allocation of roles & responsibilities of the team members? Project Leader Group Other (please specify)

2e. How was this done? (refer question 2d.)

2f. Were you happy with this process? Yes / No (please circle)
(Refer to question 2d and 2e) Why? (please comment)

2g. If your team has developed a project plan:
Who formed the plan? Project Leader Group Other (please specify

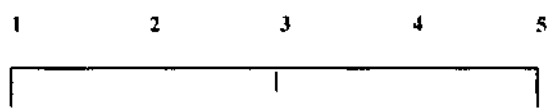
2h. Were you happy with this? Yes / No (please circle)
(refer question 2g) Why (please comment)

2i. How important do you believe the project plan is in the success of your project. (0 not important -10 very important)

Project Team

3a. What is the composition of your team?
Eg. 4 men, 4 men 1 woman

3b. How well do you know the other members in your team?



Please comment:
eg. Do you know some well and others not at all or do you know all your team well or not at all etc.

3c. Do you associate with any members of your team socially?

1 2 3 4 5
Not at all — Frequently

3d. Are you happy with your team mix? (Age/Sex/Nationality/Study Mode)
Please comment:

1 2 3 4 5
Not at all — Extremely

3e. Do you feel uncomfortable working with any members in your team?
Please comment:

1 2 3 4 5
Not at all — Extremely

3f. Have you had any major conflicts in your team so far?
Please comment:

Yes / No If Yes approximate number: _____

3g If you have had conflict what effect has this had on the project?
Please comment:

1 2 3 4 5
Little — A great deal

3h. How was this conflict handled?
Please comment:

By project leader By people involved Hasn't been yet

3i. How would you rate the project leaders management of the people in your team.
Please comment:

(0 poor -10 outstanding) _____

3j. How would you rate the project leaders management of the project management activities.
Please comment:

(0 poor -10 outstanding) _____

3k. What skills/experience do you have?

DB Design 3GL Programming Technical Writer
Project Management Oracle Others (please list)

The Project

4a. After seeing the requirements for the project how much of your time do you anticipate it will take per week?

<4hrs — >25hrs

4b. What is the minimum and maximum number of hours you think you will have to spend on the project per week.

Minimum _____ Maximum _____

Thank you!

Appendix C

QUESTIONNAIRE TWO

QUESTIONNAIRE TWO
27th - 31st May 1996

Name: _____ **Date:**
Team: _____ **Sex:** M / F
Team Size: _____ **Study Mode:** Part Time / Full Time

Role/Responsibilities in Team:

1. Which software engineering activities do you feel your group is/has been spending most time on?

		%
a)	Analysis	
b)	Design	
c)	Scope Definition	
d)	Team Meetings	
e)	Programming/Oracle	
f)	Risk Avoidance/Management	
g)	Testing	
h)	Project Progress Monitoring eg. Reviews, Walkthroughs	
i)	Configuration Management	
j)	Project Management	
	TOTAL	**100%**

2. Which project management activities to you feel your group is/has been spending most time on?

		%
a)	Planning (Project plan reviews & updates)	
b)	Estimation	
c)	Scheduling/Task Allocation	
d)	Risk Avoidance/Management	
e)	Conflict Resolution	
f)	Team member management eg. Motivation	
g)	Configuration Management	
h)	Project Progress Monitoring eg. Reviews, Walkthroughs	
i)	Team Meetings	
j)	General administration/organisation tasks (Please list below)	
	TOTAL	**100%**

Please list any general administration/organisational tasks undertaken.

Project Team

3a. Do you feel uncomfortable working with any members in your team?
Not at all — Extremely

3b. Have you had any major conflicts in your team so far?
Yes / No If yes, how many: _____

3d. If you have had conflicts, what effect have these had on the project?
Little — **A great deal**

3e. Who has handled these conflicts? (Please circle)
Project leader People involved
Group Some haven't been yet

Project Leader
(If you are the project team leader please rate yourself for the following questions)

4a. How would you rate your project leaders management of the people in your team.
Poor — **Outstanding**

4b. How would you rate your project leaders management of project management activities.
Poor — **Outstanding**

How often does your project leader:

4ci. Listen to team members opinions, ideas, information and concerns?
Never — **Always**

4cii. Test to make sure team members have a good understanding of what is to be achieved?
Never — **Always**

4ciii. Offer reassurance, help, or guidance as necessary and appropriate?
Never — **Always**

4civ. Provide permission to act, and protection/backup as necessary?
Never — **Always**

4cv. Consider others needs and point of view when offering suggestions or support?
Never — **Always**

How often does your project leader:

4di. Express views clearly and emphatically?
Never — **Always**

4dii. Set high expectations?
Never — **Always**

4diii. State the actions or results your team is striving to achieve?
Never — **Always**

4div. Indicate positive and negative consequences of not meeting expectations?
Never — **Always**

4dv. Offer alternative views and options?
Never — **Always**

The Project

5a. How much time has the project been taking, on average, per week. _____ hours

5b. How much time do you anticipate the project will take per week during second semester? _____ hours

All responses will be treated in the strictest confidence.
Thank you for your time!

QUESTIONNAIRE THREE

QUESTIONNAIRE THREE
October 1996

Name: _____ **Date:**
Team: _____ **Gender:** Male / Female
Team Size: _____ **Study Mode:** Part Time / Full Time

Role/Responsibilities in Team:

1. Which software engineering activities has your group been spending most time on?

Engineering

a) Analysis.....
b) Design
c) Programming/Oracle.....
d) Testing
e) Implementation.....
f) Quality Monitoring eg. Reviews, Walkthroughs.....

Support

g) Configuration Management.....
h) Project Management.....
i) Other (specify below).....

TOTAL **100%**

Project Manager ONLY to complete question 2.

2. On which project management activities has you/your group been spending most time?

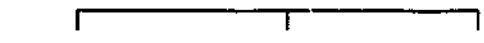
%

a) Planning (Project plan reviews & updates).....
b) Estimation
c) Scheduling/Task Allocation.....
d) Risk Avoidance/Management.....
e) Conflict Resolution.....
f) Individual Team Member Communication.....
g) Group Communication.....
h) Project Progress Monitoring eg. Task completion checking.....
i) Other

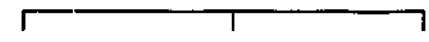
TOTAL **100%**

Project Team

3a. How comfortable are you working with the people in your team?



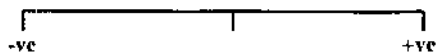
3b. How many conflicts has your team had so far?



3c. Who has handled most of these conflicts? (Please circle **ONE** only)

Project leader People involved Group
No-one Supervisor

3d. Have these been handled positively or negatively

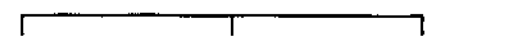


Project Leader

Please rate your team's project leader for the following questions. (If you are the project team leader please rate yourself))

4a. How would you rate your project leaders' management of the people in your team.

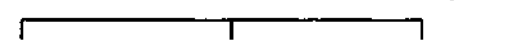
4b. How would you rate your project leaders' management of project management activities.



How often does your project leader:

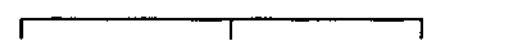
4ci. Listen to team members opinions, ideas, information and concerns?

4cii. Test to make sure team members have a good understanding of what is to be achieved?

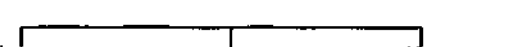


4ciii. Offer reassurance, help, or guidance as necessary and appropriate?

4civ. Provide permission to act and protection/backup as necessary?



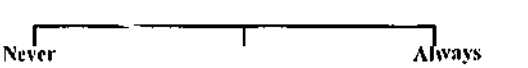
4cv. Consider others needs and point of view when offering suggestions or support?



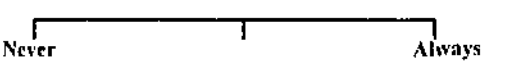
How often does your project leader:

4di. Express views clearly and emphatically?

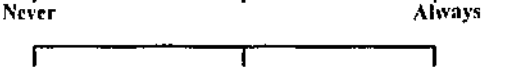
4dii. Set high expectations?



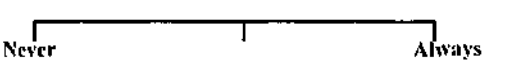
4diii. State the actions or results your team is striving to achieve?



4div. Indicate positive and negative consequences of not meeting expectations?



4dv. Offer alternative views and options?



The Project

5a. How much time have you been spending on the project, on average, per week.

_____ min _____ max

All responses will be treated in the strictest confidence.
Thank you for your time!

Appendix E

QUESTIONNAIRE FOUR

QUESTIONNAIRE FOUR
November 1996

Name: _____ **Date:**
Team: _____ **Gender:** Male / Female
Team Size: _____ **Study Mode:** Part Time / Full Time

What was your main role or responsibility in your team?

Reflecting on the entire project:

1. please provide percentages for the time your group spent on each of the activities listed below.

2. please rank the activities listed below according to their value/importance to the success of your project, where 9 was the most valuable/important activity and 0 was the least valuable/important activity.

		Time %	Value Rank
Engineering			
a)	Analysis		
b)	Design		
c)	Programming/Oracle		
d)	Testing		
e)	Implementation		
f)	Quality Monitoring eg. Reviews, Walkthroughs		
Support			
g)	Configuration Management		
h)	Project Management		
i)	Other (specify below)		
		TOTAL	**100%**

ONLY the Team Leader needs to complete question 2.

Reflecting on the entire project:

3. please provide percentages for the time your group spent on each of the project management activities listed below.

4. please rank the project management activities listed below according to their value/importance to the success of your project, where 9 was the most valuable/important activity and 0 was the least valuable/important activity.

		Time %	Value Rank
a)	Planning (Project plan reviews & updates)		
b)	Estimation		
c)	Scheduling/Task Allocation		
d)	Risk Avoidance/Management		
e)	Conflict Resolution		
f)	Individual Team Member Communication		
g)	Group Communication		
h)	Project Progress Monitoring eg. Task completion checking		
i)	Other		
		TOTAL	**100%**

Project Team

5a. Please rate how comfortable you were working with your team members.

Very Uncomfortable — Very Comfortable

5b. Over the entire project rate the number of major conflicts within your team.

None — Many

5c. Who handled most of these conflicts? **(Please circle ONE only)**

Team leader | People involved | Group | No-one | Supervisor

5d. In general did the conflicts have a positive or negative effect on the project.

-ve — +ve

Project Leader

Please rate your team's leader for the following questions.
(If you are the team leader please rate yourself)

6a. Over the entire project how would you rate your team leaders' overall management of the people in your team.

Poor — Outstanding

6b. Over the entire project how would you rate your team leaders' overall management of project management activities.

Poor — Outstanding

Over the entire project how often did your team leader:

6ci. Listen to team members opinions, ideas, information and concerns?

Never — Always

6cii. Test to make sure team members had a good understanding of what was to be achieved?

Never — Always

6ciii. Offer reassurance, help, or guidance as necessary and appropriate?

Never — Always

6civ. Provide permission to act and protection/backup as necessary?

Never — Always

6cv. Consider others needs and point of view when offering suggestions or support?

Never — Always

How often did your project leader:

6di. Express views clearly and emphatically?

Never — Always

6dii. Set high expectations?

Never — Always

6diii. State the actions or results your team was striving to achieve?

Never — Always

6div. Indicate the positive and negative consequences of not meeting expectations?

Never — Always

6dv. Offer alternative views and options?

Never — Always

All responses will be treated in the strictest confidence.
Thank you for your time!

Appendix F - QUESTIONNAIRE 2 - RESULTS

Key			ML1	ML2	ML3	ML4	ML5	ML6	ML7	JO1	JO2	Total	Spearman's Correlation
		Team Size	6	6	5	5	6	4	4	4	6	46	0.43
		No partic in quest	6	6	4	5	6	4	4	4	6	45	0.00
		% partic in quest	100%	100%	80%	100%	100%	100%	100%	100%	100%	98%	
		Females	1	1	0	2	0	0	1	1	0	6	-0.50
		% Females	17%	17%	0%	40%	0%	0%	25%	25%	0%	13%	
		Part Timers	3	0	1	2	0	2	4	0	1	13	-0.25
		% Part Timers	50%	0%	25%	40%	0%	50%	100%	0%	17%	28%	
	Qus												
% of time	1a	Analysis	22	19	12	12	14	19	21	18	15	16.89	0.28
% of time	1b	Design	23	18	11	21	22	28	30	23	20	21.78	0.28
% of time	1c	Scope Definition	10	7	11	5	7	5	4	13	6	7.56	-0.37
% of time	1d	Team Meetings	16	13	20	11	10	13	13	8	12	12.89	-0.32
% of time	1e	Progrm/Oracle	4	1	8	10	2	2	7	3	8	5.00	-0.52
% of time	1f	RM	2	2	2	4	5	8	2	6	4	3.89	0.39
% of time	1g	Testing	4	10	7	8	11	6	2	7	5	6.67	0.07
% of time	1h	Pj Progress Mon	5	6	8	9	11	8	8	6	6	7.44	0.07
% of time	1i	CM	4	6	4	9	8	5	4	6	7	5.89	0.35
% of time	1j	PM	8	16	17	8	12	8	8	13	18	12.00	0.06
% of time	2b	Planning	17	14	14	10	11	19	16	15	14	14.44	0.06
% of time	2c	Estimation	9	13	14	20	19	5	9	16	11	12.89	-0.28
% of time	2d	Sched/Task All	11	12	9	6	7	8	14	11	15	10.33	0.22
% of time	2e	RM	4	4	6	4	8	10	6	8	3	5.89	0.09
% of time	2f	CR	4	4	5	9	7	3	4	0	4	4.44	-0.13
% of time	2g	Team Mem Man	5	7	5	7	5	7	5	8	6	6.11	-0.13
% of time	2h	CM	5	9	7	16	9	6	13	10	7	9.11	-0.26
% of time	2i	Pj Progress Mon	6	11	9	8	12	10	11	8	11	9.56	0.75
% of time	2j	Team Meetings	27	14	20	12	14	14	18	9	15	15.89	-0.04
% of time	2k	General Admin	12	8	10	17	6	7	6	14	14	10.44	-0.54
		Project Mark	254	258	205	234	373	365		237	267	2193.00	

Key			ML1	ML2	ML3	ML4	ML5	ML6	ML7	JC1	JO2	Total	
0 V Comf - 10 V Uncomf	3a	Uncomf with Tm Mems	5.33	2	3.5	3.3	1.92	1	6	3	2	3.12	0.00
Number of conflicts	3b	Num of Conflicts	0.1	0	0.5	40	0	0	0	0	2	4.73	-0.38
0 little - 10 great	3d	Effect of Conflicts	6.5	0	3	5.5	1.88	1	5	1	2	2.88	0.00
(1=PL, 2=PI, 3=G, 4=SHB)	3e	Conflict Handler	2&3	1&3	2&4	2,3&4	1,2&3	1,2&3	3	3	1,2&3		
0 pr - 10 outstd	4a	Mngmnt of People	6.83	8.13	6.25	4.33	8.5	6	5	9	5	6.56	0.15
0 poor - 10 outstanding	4b	Mngmnt of Activies	5.17	8.38	5.75	4.17	7.13	7	4	8	5	6.07	0.21
0 low - 10 high	4c Tm	Relationship Behaviour	8.02	8.18	6.17	3.73	8.65	5.3	5.85	8.8	4.98	6.63	0.09
0 low - 10 high	4d Tm	Directive Behaviour	7.2	7.94	5.03	5.53	8.48	3.83	6.23	7.5	5.02	6.31	0.16
0 low - 10 high	4c PM	Relationship Behaviour	7.1	7.4	9.6	8	5.4	10		7.9	5.98	6.82	-0.62
0 low - 10 high	4d PM	Directive Behaviour	3.2	9.3	9.4	5	9	9		6.3	6.02	6.36	0.36
Number of hours	5a	No hrs this sem	26	11	8	12	30	14	17	17	10	16.11	0.37
Number of hours	5b	Est hrs next sem	31	18	14	16	19	21	25	22	15	20.11	
		Project mark	254	258	205	234	373	365		237	267	2193.00	

		ML1	ML2	ML3	ML4	ML5	ML6	ML7	JO1	JO2	Total	Spearman's Correlation
	How often did the teams project leader:											
4ci TM	Listen to team members opinions, ideas, information & conems?	9.2	8.4	9.17	4.33	9.38	8	6.5	9.83	8.2		0.10
4cii TM	Test to make sure team members had a good understood what was to be achieved?	8.4	7	3.67	4.33	8.88	4.67	6.25	8.33	4.4		0.50
4ciii TM	Offer reassurance, help, or guidelines	8.4	8.3	6.33	1.33	8.38	4.33	6	7.5	4.9		0.17
4civ TM	Provide permission to act and protection/backup as necessary?	6.7	8.4	5	4.33	8.38	4.33	4.75	9.33	4.4		0.01
4cv TM	Consider others needs and point of view when offering suggestions or support?	7.4	8.8	6.67	4.33	8.25	5.33	5.75	9	8		0.29
4di TM	Express views clearly and emphatically?	7.1	8.4	6.33	4.67	9	4.33	7.33	6.67	6.9		0.52
4dii TM	Set high expectations?	7.1	8.6	4.33	8.5	10	4.17	5.33	6.33	6.2		0.25
4diii TM	State the actions or results your team was striving to achieve	6.4	7.9	4.33	5.33	6.63	3.5	6.5	8	5.6		0.19
4div TM	Indicate the positive and negative consequences of not meeting expectations?	6.5	7	5	6.17	7.63	4.17	5.67	7.17	6		0.25
4dv TM	Offer alternative views and options?	8.9	7.9	5.17	3	7.13	3	6.33	9.33	5.4		0.10
	Project mark	254	258	205	234	373	365		237	267		

Appendix G - QUESTIONNAIRE 3 - RESULTS

Key			ML1	ML2	ML3	ML4	ML5	ML6	Spearman's Correlation
		Team Size	6	6	5	5	6	7	**0.78**
		No partic in quest	2	4	4	3	5	4	
		% partic in quest	33%	67%	80%	60%	83%	57%	
		Females							
		% Females	0%	0%	0%	0%	0%	0%	
		Part Timers							
		% Part Timers	0%	0%	0%	0%	0%	0%	
	Qus								
% of time	1a	Analysis	13	14	6	13	8	7	0.12
% of time	1b	Design	18	25	14	17	9	31	0.14
% of time	1c	Progrm/Oracle	30	18	27	23	47	13	0.03
% of time	1d	Testing	15	11	5	7	12	12	**0.64**
% of time	1e	Implementation	3	3	13	2	3	23	0.15
% of time	1f	Quality Mon	8	7	9	3	6	7	-0.41
% of time	1g	CM	8	11	6	12	6	2	-0.41
% of time	1h	PM	8	12	14	17	9	5	**-0.66**
% of time	ji	Other	0	0	8	7	1	1	-0.50
% of time	2b	Planning			20	10	20	50	0.17
% of time	2c	Estimation			10	15	5	10	**-0.69**
% of time	2d	Sched/Task All			20	35	8	20	**-0.69**
% of time	2e	RM			10	10	12	5	0.17
% of time	2f	CR			5	0	0	0	**-0.70**
% of time	2g	Ind Team Mem Comm			10	0	20	5	0.43
% of time	2h	Group Comm			10	10	25	5	0.17
% of time	2i	Pj Progress Mon			15	20	10	5	**-0.76**
% of time	2k	Other			0	0	0	0	0.00
		Project Mark	254	258	205	234	373	365	1.00

Key			ML1	ML2	ML3	ML4	ML5	ML6	Spearman's Correlation
0 V Uncomf - 10 V Comf	3a	Uncomf with Tm Mems	4	6	6	8	8	6	0.22
Number of conflicts	3b	Num of Conflicts	6	3	1	5	4	1	-0.03
(1=PL, 2=PI, 3=G, 4=SHB)	3c	Conflict Handler	2	2&1	1&4	2&3	1,2,3&4	1,2,3&4	
0 -ve - 10 +ve	3d	-ve or +ve effect of con	4	6	9	7	6	6	-0.58
0 pr - 10 outstd	4a	Mngmnt of People	1	6	7	3	7	7	0.33
0 poor - 10 outstanding	4b	Mngmnt of Activies	1	6	7	3	7	7	0.33
0 low - 10 high	4c Tm	Relationship Behaviour	6.12	6.07	7.73	3.51	6.83	8.07	0.26
0 low - 10 high	4d Tm	Directive Bahaviour	4.88	7.26	6.44	3.54	7.76	7.38	**0.83**
0 low - 10 high	4c PM	Relationship Behaviour			9.4	7	5.48	6.52	**-0.98**
0 low - 10 high	4d PM	Directive Bahaviour			9.38	5	9	5.84	-0.11
Number of hours to date	5a	Min	4	4	5	1	16	8	**0.64**
Number of hours to date	5b	Max	16	19	14	12	32	20	**0.94**
		Project Mark	**254**	**258**	**205**	**234**	**373**	**365**	

		ML1	ML2	ML3	ML4	ML5	ML6	Spearman's Correlation
	How often did the teams project leader:							
4ci TM	Listen to team members opinions, ideas, information & conerns?	3	6.15	9.27	2.65	6.35	9.4	0.31
4cii TM	Test to make sure team members had a good understood what was to be achieved?	4.3	6.23	6.43	4.35	7.25	7.73	**0.54**
4ciii T	Offer reassurance, help, or guidelines	5.8	5.23	7.47	2.5	6.63	7.8	0.26
4civ T	Provide permission to act and protection/backup as necessary?	9.8	6.1	8.23	4.6	7	7.77	-0.14
4cv TM	Consider others needs and point of view when offering suggestions or support?	7.7	6.63	7.27	3.45	6.9	7.67	0.09
4di TM	Express views clearly and emphatically?	2.3	6.25	7	3.1	8.2	6.07	0.31
4dii TM	Set high expectations?	5.45	8.58	6.47	5.2	8.93	7.5	**0.77**
4diii T	State the actions or results your team was striving to achieve	4.4	7.43	6.43	1.1	7.43	7.33	**0.72**
4div T	Indicate the positive and negative consequences of not meeting expectations?	6.9	7.68	7.68	4.8	8.28	8	**0.75**
4dv TM	Offer alternative views and options?	5.35	6.38	6.38	3.5	5.95	8	0.29
	Project Mark	**254**	**258**	**205**	**234**	**373**	**365**	

Appendix H - QUESTIONNAIRE 4 - RESULTS

Key			ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2	Spearman' Rank
		Team Size	4	5	5	4	6	5	6	6	0.53
		No partic in quest	4	4	5	4	6	5	5	5	
		% partic in quest	100%	80%	100%	100%	100%	100%	83%	83%	
		Females	1	1	0	2	0	1	1	0	-0.39
		% Females	25%	20%	0%	50%	0%	20%	17%	0%	
		Part Timers	0	0	2	2	3	4	0	0	0.15
		% Part Timers	0%	0%	40%	50%	50%	80%	0%	0%	
	Qus										
% of time	1a	Analysis	16	10	15	11	9	11	18	16	-0.37
% of time	1b	Design	23	20	15	19	21	20	19	20	**0.72**
% of time	1c	Coding	27	41	28	31	28	30	38	27	-0.27
% of time	1d	Testing	9	11	11	9	16	27	7	8	0.31
	1e	Incorporated into 1c									
% of time	1f	Quality Mon	7	4	9	9	8	12	4	8	-0.07
% of time	1g	CM	6	6	7	11	8	3	4	6	-0.20
% of time	1h	PM	8	9	11	10	13	4	7	15	0.24
% of time	ji	Other	3	0	2	0	0	0	4	1	-0.42
rank of value	2a	Analysis	7.5	5	8	6	8	8.5	4	7.5	0.31
rank of value	2b	Design	9	8	8	9	7	6	7.5	9	-0.32
rank of value	2c	Coding	13	6	7	14	10	10.5	15	9	-0.24
rank of value	2d	Testing	5.5	3	4.5	6	6	6	4	4.5	0.24
	2e	Incorporated into 2c									
rank of value	2f	Quality Mon	3	8	6	2	5	6	7.5	4.5	0.01
rank of value	2g	CM	3	8	2.5	3.5	4	3.5	4	2	0.16
rank of value	2h	PM	3	6	8	3.5	5	3.5	2	7.5	0.10
rank of value	2i	Other	1	1	1	1	1	1	1	1	
		Project Mark	254	258	205	234	373	365	237	267	

Key			ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2	Rank
% of time	3a	Planning	10	15	20	20	20	30	10	20	0.27
% of time	3b	Estimation	5	10	5	10	10	5	15	5	-0.08
% of time	3c	Sched/Task All		15	15	20	10	10	5	10	-0.42
% of time	3d	RM	10	10	13	10	5	10	10	10	**-0.76**
% of time	3e	CR	10	10	2	10	5	5	10	5	-0.18
% of time	3f	Ind Team Mem Comm	25	15	20	5	15	10	10	20	0.12
% of time	3g	Group Comm	20	10	15	10	10	15	15	20	0.01
% of time	3h	Pj Progress Mon	10	15	10	15	25	15	5	10	0.48
% of time	3i	Other	0	15	0	0	0	0	20	0	-0.16
rank of value	4a	Planning	4	6	9	5	3	9	-	9	-0.19
rank of value	4b	Estimation	2	7	4	3	7	2	-	3	0.12
rank of value	4c	Sched/Task All	7	5	8	7	4	8	-	8	-0.28
rank of value	4d	RM	5	8	2	8	8	7	-	4	0.28
rank of value	4e	CR	3	3	3	2	9	3	-	2	0.32
rank of value	4f	Ind Team Mem Comm	9	2	5	4	6	4	-	5	0.15
rank of value	4g	Group Comm	8	4	7	6	5	6	-	6	-0.53
rank of value	4h	Pj Progress Mon	6	9	6	9	2	5	-	7	-0.43
rank of value	4i	Other	1	1	1	1	1	1	-	1	
		Project Mark	254	258	205	234	373	365	237	267	

Key			ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO2	Spearman' Rank
0 V Uncomf - 10 V Comf	5a	Uncomf with Tm Mems	8	7	7	8	7	7	6	9	0.15
Number of conflicts	5b	Num of Conflicts	3	3	4	2	4	2	5	2	-0.22
(1=PL, 2=PI, 3=G, 4=SHB)	5c	Conflict Handler	2&3	2&3	1,2&3	2&3	2&1	2&3	1,2&3	1,2&3	
0 -ve - 10 +ve	5d	-ve or +ve effect of con	6	5	4	7	5	5	4	6	0.19
0 pr - 10 outstd	6a	Mngmnt of People	5	6	7	1	7	8	7	8	0.50
0 poor - 10 outstanding	6b	Mngmnt of Activies	6	6	6	0	8	8	7	9	**0.79**
0 low - 10 high	6c TM	Relationship Behaviour	8.8	6.57	7.3	2.13	6.54	7.79	7.38	8.3	0.17
0 low - 10 high	6d TM	Directive Behaviour	6.5	6.47	7.43	2.07	8.5	7.54	7.01	8.58	0.64
0 low - 10 high	6c PM	Relationship Behaviour	6.5	9.8	9.8	8	5.3	7.98	4.5	6.76	-0.38
0 low - 10 high	6d PM	Directive Behaviour	2.5	8.8	9.9	4	9.5	7.34	6.96	7.2	0.17
		How often did the teams project leader:									
	6ci TM	Listen to team members opinions, ideas, information & conerns?	9.67	7	8.13	2	6.92	9.8	9.65	9.35	0.10
	6cii TM	Test to make sure team members had a good understood what was to be achieved?	7.83	5.67	6.88	1	6.8	5.63	6.7	6.35	-0.07
	6ciii T	Offer reassurance, help, or guidelines	8.83	7	7.13	0.33	6.13	6.58	6.1	8.6	0.14
	6civ T	Provide permission to act and protection/backup as necessary?	8.67	6.5	6.75	4.33	6.25	8.2	4.93	8	0.26
	6cv TM	Consider others needs and point of view when offering suggestions or support?	9	6.67	7.63	3	6.6	9.67	9.5	9.18	0.14
	3di TM	Express views clearly and emphatically?	5.17	5.5	8.75	2	7.5	9.3	7.9	8.7	0.17
	6dii TM	Set high expectations?	6.67	7.33	8.5	3	8.7	5.63	6.58	6.75	0.31
	6diii T	State the actions or results your team was striving to achieve	5.67	6.33	7	1.5	9.3	9.35	6	8.95	0.67
	6div T	Indicate the positive and negative consequences of not meeting expectations?	7.5	6.17	6.38	3	8.98	6.5	5.93	9.3	**0.74**
	6dv TM	Offer alternative views and options?	7.5	7	6.5	0.83	9.02	6.88	8.63	9.2	**0.71**
		Project Mark	254	258	205	234	373	365	237	267	

Appendix I - PROJECT SUCCESS EVALUATION

		ML1	ML2	ML3	ML4	ML5	ML6	JO1	JO3	Spearman's Correlation
Project File	100	45	73	61	64	93	93	55	69	0.73
Project plans (SPMP, Gantt charts, quality plan etc)	20	8	15	11	11	17	18	12	15	0.77
Time sheets	10	6	7	6	5	10	9	6	7	0.91
Meetings	10	2	6	6	6	10	10	5	5	0.51
Project reports	10	5	8	7	6	10	10	5	5	0.63
Roles & Responsibilities	10	3	6	6	5	10	10	5	6	0.63
Management of the process	15	9	12	12	8	14	14	10	14	0.71
Configuration Management	10	3	8	3	5	8	8	5	7	0.80
Standards	5	2	4	3	2	5	5	2	3	0.73
Risk Management	10	7	7	7	6	9	9	5	7	0.74
Quality of Testing	50	24	21	21	20	34	50	16	18	0.67
Test Plar	10	6	5	4	4	6	10	2	5	0.76
Scope of Testing (Functional, Stress, System ..)	10	6	3	3	3	6	10	3	3	0.70
Test Environment (Test bed, test forms)	10	5	5	5	5	9	10	5	5	0.77
Test Results (Actuals vs expected)	10	1	5	6	5	8	10	3	2	0.39
Completeness of other aspects (security, installation, auditing, tests tested etc)	10	6	3	3	3	5	10	3	3	0.63
Maintenance Documentation	100	77	69	49	65	91	81	70	73	0.88
Design Updates	25	18	18	0	0	25	12	15	16	0.76
Data Dictionary	25	20	20	15	22	25	23	20	23	0.80
Code	30	22	20	20	21	26	28	23	20	0.62
Maintainability	10	8	6	8	7	9	10	7	8	0.49
Completeness of other aspects (hardware software environment, conversion, manual methods)	10	9	5	6	5	6	8	5	6	0.29
User Documentation	50	35	23	26	26	44	41	36	32	0.63
Usage Guides (introduction, installation, getting started, manual procedures, error messages, ...)	20	17	11	11	12	18	18	16	13	0.70
Reference/help	10	2	2	2	3	10	5	6	6	0.55
Application of Standards	10	8	3	4	5	8	8	6	6	0.59
Document readability (eg contents, index)	5	4	4	3	4	4	5	4	4	0.60
Document Format & style	5	4	2	3	2	4	5	4	3	0.48
Presentation	100	49.67	48.67	29.67	67.50	77.50	56.00	38.67	50.67	0.72
Statement of the problem	10	4.00	5.83	3.67	5.33	6.67	7.67	6.67	8.00	0.69
Explanation of the approach taken	10	4.00	6.83	2.33	5.00	8.67	7.00	3.33	7.00	0.91
System Functionality	40	24.00	16.00	13.33	22.67	32.00	20.00	13.33	18.67	0.59
System Quality	30	14.00	15.00	8.00	18.50	21.50	24.00	9.00	11.00	0.74
Overall Presentation Delivery	10	3.67	5.00	2.33	6.00	8.67	7.33	6.33	6.00	0.70
Out of 40		25.37	25.81	20.53	23.38	37.35	36.41	23.72	26.69	
Total Project Mark	400	253.73	258.13	205.33	233.75	373.45	364.10	237.23	266.93	