THE KNOWLEDGE AND COMPETENCY LEVEL OF MANAGEMENT SCIENCE TECHNIQUES AMONGST MANAGERS IN A LEADING SOUTH AFRICAN TEXTILES COMPANY

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The knowledge and competency level of Management Science techniques amongst managers in a leading South African Textiles Company

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Dissertation submitted in partial fulfillment of the requirements for the degree Masters of Technology in Business Administration in the Faculty of Business at the Cape Peninsula University of Technology.

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DECLARATION

I, the undersigned hereby declare that the work contained in this thesis is my own original work and has not previously, in its entirety or in part, been submitted at any university for a degree.

Signed: .... Date: 24/10/2010

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Brackenfell, South Africa Leon Erasmus
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ABBREVIATIONS AND ACRONYMS

SAP	–	An integrated enterprise resource planning (ERP) software manufactured by SAP AG.
ERP	–	Electronic Resource Planning
IS	–	Information Systems
DS	–	Decision Science
MS	–	Management Science
OR	–	Operations Research
SS	–	Success Science
ESS	–	Executive Support Systems
MIS	–	Management Information Systems
DSS	–	Decision Support Systems
KWS	–	Knowledge Work Systems
OAS	–	Office Automation Systems
TPS	–	Transaction Processing Systems
LP	–	Linear Programming
PERT	–	Program Evaluation and Review Technique
CPM	–	Critical Path Method
MCDA	–	Multi-Criteria Decision Analysis
MCDM	–	Multi-Criteria Decision Making
NLP	–	Non-Linear Programming
SPC	–	Statistical Process Control

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1 CHAPTER 1 - INTRODUCTION

1.1 Introduction and structure of the company

The company studied is a privately owned textile company, which is part of the CAP Germany Group of companies. It is one of the leading textile knitting mills in Southern Africa and has won several awards in this regard, whilst it has also been subject to quite a few changes over the last few years.

The company recently appointed a new Chief Executive Officer to lead the textile mill into the technical market, and extend the range of the fashion apparel, which it focuses on as its main product.

With the aim of keeping the company in the forefront of new development, it has become important to keep its management team well informed and for them to make strategic decisions with much focus on analysis of the information that is available to them.

The textile mill has a SAP ERP system, which was implemented as to provide a source of information, hence management can analyse this information that is available to aid them in their decision-making.

1.2 Background to problem statement

Although the SAP system delivers an increasing amount of information to managers of the organisation, capacity planning has to be performed manually. With the ever changing needs of fashion conscious consumers, the managers need to make far reaching decisions based on the information that is available. They also have to bear in mind that mistakes can and do cost the company.

1.3 *Problem Statement*

A lack of mathematical literacy on the part of managers often leads to poor decision-making. Business has become increasingly complex owing to information overload, and proof of this is the amount of information which is available on the Internet. However company managers expect to be able to make sound decisions, which are based on all available information. Management Science competencies, which assist in the analysis of information for decision-making, seem to be lacking amongst managers within South African companies. Competencies include among others, Mathematical Modelling, Operations Research and Mathematical Science.

1.4 Research objectives and design

The main objective of this research was to discover whether the textile mill's management team had competencies that are required to apply Management Science tools and techniques; if not, why not? If yes, what procedure do they follow and what positive results, if any, have they obtained?

Key objectives of the research were to:

- Identify if personnel in the textile manufacturing organisation utilises Management Science techniques to assist in the decision-making process;
- Determine if Management Science techniques are utilised within the textile manufacturing organisation;
- Identify which techniques are utilised by management and why; and
- Determine the procedures, which are utilised by the textile manufacturing organisation to facilitate the decision-making process.

1.5 Research methodology

For purposes of this research the researcher has taken a qualitative approach to determine the level of management science competency that exists amongst managers at the textile mill. This was done to determine a) the competency; b) the techniques applied; and c) the decision-making process.

The case study which was conducted on the textile mill was undertaken to determine the real time application of management science in their business. The research was based on a structure, which first determined the availability of MIS to management, and then the level of formal education management had received, to determine formal mathematical literacy, as defined by Steen (2001: online).

Once the literacy levels were established, the decision-making process followed, which was identified and defined in line with the available published literature, and, finally, the techniques utilised by these managers were identified.

Data pertaining to the research was obtained from in-depth interviews with the management team.

The case study results were compared with pertinent literature, together with previous work, which has been done in the field of operations research (management science).

In order to remain focused on the goal of this research, namely Management Science competency, it was necessary to define a specific field within the vast management science sphere.

The main focus objectives were determining firstly the ability of the managers to follow a structured approach to decision-making and secondly to determine techniques they were using. The field of management science has its fair share of opinions, which cannot necessarily be validated. Thus, the researcher used well-known printed (published) media as the core of the theoretical research base. Other sources of literature were consulted as a calibration of the theory.

The following research questions were answered:

- Does the organisation have formal management systems in place to supply data which facilitates management decisions?

- What level of Information Systems (IS) does the organisation make available?

- Do they have Management Science competencies?

- If the manager does have Management Science competencies, which techniques does he/she apply?

- What procedure do they follow to facilitate decision-making?

1.6 Background of Management Science

It is generally accepted that an increasing number of companies in South Africa are moving towards the use of information systems (IS). However, the level of effectiveness and application of this management information is rarely measured, and information outflows, such as reports and masses of figures, are not necessarily utilised to their full potential.

Studies have been conducted regarding the application of management science to specific problem cases. However, according to library research, little research has been conducted on competency levels of management personnel in management science within the South African business sector.

According to Arsham (2003: online), the Industrial Revolution of the 19th century probably did more to shape life in the modern industrialised world than any other event in history. Large factories, which engaged in mass production created the need for them to be managed effectively and efficiently.

The field of Decision Science (DS), also known as Management Science (MS), or Operations Research (OR) in a more general sense, began with the publication of *The Principles of Scientific Management* (Taylor, 1911: online). His approach relied on the measurement of industrial productivity and on (time and motion) studies within factories. The goal of his scientific management was to determine the best method to perform tasks in the least amount of time. His measurement tool was a stopwatch tool.

During World War II this discipline acquired names such as quantitative decision-making (analysis), operations research and management science, although the principals of the scientific approach to management were pioneered by Taylor (1911: online). Followers include Lee, Moore and Taylor (1981:3); Gordon, Pressman and Cohen (1990:2); Render and Stair (1994:3); Winston (1994:1); and Walker (1999:1).

"This analytical approach is known by several different names: Operations Research (OR), Operational Research (a UK-ism), Decision Sciences (DS), Systems Science, Mathematical Modelling, Industrial Engineering, Critical Systems Strategic Thinking, Success Science (SS), and Systems Analysis and Design. Analytical methods are applied to planning and management problems in areas such as production and operations, inventory management, and scheduling. Techniques, which often use powerful computer programs are available to solve problems ranging from real-time control of specific businesses, industrial, agricultural, and administrative operations, to long-term planning models for corporations and public sector agencies" (Arsham, 2003: online).

1.7 Management Science and decision-making

Management Science (MS) often takes an analytical view of a potential decision before a decision is made. This means that there is reflection before action. A Chinese proverb states: "To chop a tree quickly, spend twice the time sharpening the axe," while carpenters have a saying: "Measure twice, cut once." Hence, there is no delay to time lost to sharpening the tool (Arsham, 2003).

Arsham (2003) concludes that the Management Science approach to decision-making includes the diagnosis of current decision-making and the specification of changes in the decision process. Diagnosis refers to the identification of problems (or opportunities for improvement) in current decision-making behaviours; it involves determining how decisions are currently made, and specifies how decisions should be made, whilst understanding why decisions are not made the way they should be. The specification of changes in decision-making processes involves choosing what specific improvements in decision-making behaviour should be achieved and this defines objectives.

In the past management information could be summerised in a Lotus 123 spreadsheet. At present, decisions are no longer made without sound information on which to base them. Turban (1993:7–9) states that managers had begun to consider decision-making as an art, which is acquired over years and is honed through trial and error. He attributes the change of attitude in the business environment, to the rapid growth and complexity of decision-making.

According to Turban (1996:8), "it is now more difficult to make decisions than in the past for two reasons. Firstly, the number of available alternatives is much larger today than ever before owing to improved technology and communication systems. Secondly, the cost of making errors can be very large owing to the complexity and magnitude of operations, automation, and the chain reaction that an error can cause in many parts of the organisation. By the same token, the benefits can be extremely large if correct decisions are being made".

Gordon, Pressman and Cohen (1990:2) followed the link from the growth in the accounting discipline to arrive at "better" scientifically based decisions. The development of systematic procedures for "accounting" for monetary operations has emerged within an organisation in order that administrators may develop a clearer picture of qualitative analysis. One can consider accounting statements as the "model" of the organisation.

Gordon, Pressman and Cohen (1990:2) assert that the logical next step after providing information for making decisions is to develop decision-making aids, which facilitate the investigation of these problems. Turpin and Marais (2004:20(2)) list models of decision-making which are based on views, supporting theories and models of categorisations that are provided by Keen and Scott Morten (1978), Huber (1981) and Das and Teng (1999).

1.8 Chapter Summary

This chapter introduced the textile manufacturing company, which was the subject of this case study. The research problem and objectives were outlined in Sections 2 and 3, while a summary of the literature looked at was also documented.

Chapter 2 gives a detailed record of the literature that was reviewed as part of this study and also considers the Management Science publications and competencies, which are available.

2 CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction to literature review

It is generally accepted that an increasing number of companies in South Africa are moving towards the use of information systems (IS). Information and data will lead to nothing but mass confusion if data and information are not analysed, and the outputs of the analysis are not acted upon. However, the level of effectiveness and application of this management information is rarely measured and the information outflows, such as reports and masses of figures, are not necessarily utilized to their full potential.

Studies have been conducted regarding the application of management science (in) specific problem cases. However according to the literature, little research has been conducted on Management Science competency levels in the South African business sector. This may be due *to a lack of understanding on the part of managers in South African companies.

2.2 Background of Management Science

It is stated that the simplest decision model that comprises two alternatives, is known as Manicheanism, which was adapted by Zarathustra (B.C. 628-551). Manicheanism is a duality concept, which divides everything in the world into either discrete or its opposite polar, such as good and evil, black and white, night and day, mind and body, and so on. In the past this duality concept was (previously) a good enough model of reality for decision-makers to use in order to make their world manageable and calculable.

"Nowadays we know very well that everything is becoming less well defined and problems and their solutions cover a wide continuous spectrum. There are no real opposites in nature. We have to see the world through our colourful mind's eyes; otherwise we do not understand complex ideas well." (Arsham, 2003-online).

2.2.1 History of Management Science

The Industrial Revolution of the 19^{th} century probably did more to shape life in the modern industrialised world than any other event in history. Large factories, which engaged in mass production, created a need (to manage them effectively and efficiently) for effective and efficient management. The field of Decision Science (DS), also known as Management Science (MS), and Operations Research (OR) in a more general sense, began with the publication of *The Principles of Scientific Management* (Taylor, 1911). Taylor's approach relied on the measurement of industrial productivity as well as time and motion studies within factories. The goal of his scientific management was to determine the best method of perform tasks in the least amount of time. His measuring tool was a stopwatch. The application and principle of the scientific approach to management was pioneered by Fredrick W. Taylor as early as 1911 (Taylor, 1911). Fredrick Taylor is known as the father of scientific management and his work may be seen as constituting the very beginning of the management science field. This view is supported in the work of Lee, Moore and Taylor (1981:3); Gordon, Pressman and Cohen (1990:2). Render and Stair (1994:3); Winston (1994:1); and Walker (1999:1).

In its infancy this discipline bore names such as quantitative decision-making (analysis), operations research and management science. This occurred during World War II (Lee, Moore and Taylor, 1981:3, Gordon, Pressman and Cohen, 1990:2; Render and Stair, 1994:3; Winston, 1994:1; Walker, 1999:1), although the application and principles of the scientific approach to management had been pioneered by Fredrick W. Taylor in 1911. During the war military leaders had to make critical decisions regarding war strategy and troop deployment with a fair amount of accuracy in as little time as possible, taking into consideration that there should be as few casualties as possible. It is said that because of the application of management science competencies by the Allies, German forces were defeated on the shores of Normandy on D-day during the Second World War.

2.2.2 Definition of Management Science

The analytical approach to Management Science is known by several different names: Operations Research, Operational Research, Decision Sciences, Systems Science, Mathematical Modelling, Industrial Engineering, Critical Systems Strategic Thinking, Success Science, Systems Analysis and Design Research. Analytical methods are applied to planning and management problems in areas such as production and operations, inventory management and scheduling. Techniques (competencies), which often use powerful computer programs are available to solve problems that range from real-time control of specific business, industrial, agricultural and administrative operations, to long-term planning models for organisations and the public sector (Manson, 2006: ORiON 22:2:160).

Operations Research(OR) or Quantitative Management, as it is termed in the USA, Canada, South Africa and Australia, and Operational Research, as it is termed in Europe, is defined as an interdisciplinary branch of Applied Mathematics, which uses methods such as mathematical modelling, statistics, and algorithms to arrive at optimal or near optimal solutions to complex problems. OR is typically concerned with determining the maxima (of profit, assembly line performance, crop yield, bandwidth, and so on) or the minima (of loss, risk, and so on) of some objective function. Operations research helps management to achieve its goals by using scientific methods.

Management Science (MS) is an interdisciplinary branch of Applied Mathematics, Engineering and Sciences, that uses various scientific research-based principles, strategies, and analytical methods, which include mathematical modelling, statistics and algorithms to improve an organisation's ability to enact rational and meaningful management decisions by arriving at optimal or near optimal solutions to complex business problems. The discipline is typically concerned with determining the maxima (of profit, assembly line performance, crop yield, bandwidth, and so on) or minima (of loss, risk, and so on) of some objective function. In short, management sciences help businesses to achieve goals by using various scientific methods.

For the purposes of this research, Operations Research, Management Science, Decision Science and Success Science will be referred to as Management Science.

2.2.3 Management Science basics

The approach to decision-making includes diagnosis of current decision-making and the specification of changes in the decision process. Diagnosis is identification of opportunities for improvement in current decision behavior. This involves determining how decisions are currently made, specifying how decisions should be made, and understanding why decisions are not being made as they should be. Specification of changes in the decision process involves choosing what specific improvements in decision behavior should be achieved; this defines the objectives. Applied Management Science is a science, which solves business problems. A major reason why Management Science has evolved as quickly as it has is owing to evolution in computing power, and this research will test the role of Management Information Quality.

The foundation of a good decision-making process is when it includes historical, psychological and logical aspects of the subject. The foundation of Management Science is built on the philosophy of knowledge, science, logic and, above all, creativity. It is this fact that academic and technical universities miss when they teach students that the decision "problem" refers to pre-fabricated exercises or puzzles such as the problem of finding a solution to a system of equations. These exercises fail by not giving any motivation for the need-to-know that originally caused the problem (Arsham, *et al.*, 2009-online).

The website of the OR society states that Operational Research (OR) and, for that matter Management Science, is the discipline of applying appropriate analytical methods to help make better decisions. Problem structuring methods are sometimes known as 'Soft O.R.' and are a basis of most Management Science applications. However, it should be stressed that this "soft OR/ MS" should include the philosophy of knowledge, science, logic and creativity in order to ensure that the entire system is analysed, and not merely the mathematical equation (OR Society, online).

There are several examples and case studies, which are available where management science has enhanced organisations and experiences. These examples include better scheduling of airline crews, and the design of queues at banks; two-person start-ups and multi-million blue chip organisations; global resource planning decisions the optimisation of hundreds of local delivery routes and the deployment of troops in military operations (www.theorsociety.com, online). The samples and case studies are ample proof that this is an important competency. Hence, it can be asked, is Management Science correctly presented by academic institutions? This may be a field that can be considered for future research.

It is, however, necessary to have a clear view of the role of Management Science in decision-making, keeping in mind that Management Science is more than mere mathematical equations. Management Science is also concerned with the application of systematic structuring of managerial decision-making. As in a mathematical equation it concerns ordering variables within a model.

2.3 Management Science and decision-making

The work (that steers the course of society and its economic and governmental organisations) of managers, scientists, engineers and lawyers is largely concerned with making decisions and solving problems. Their task and focus is to decide which issues require attention, before setting goals, finding or designing suitable solutions and/or choosing the best solution among alternative actions, for the organisation.

The setting of goals and objectives, finding the root causes and designing actions are usually referred to as *problem solving.* Evaluating and deciding on the best alternative is usually called decision-making (Simon, Dantzig, Hogarth, Plott, Raiffa, Schelling, Shepsle, Thaler, Tverski, Winter 1986:11).

Because some decision problems are complicated and important, individuals who analyse the problem are not necessarily the same individuals as those who are responsible for making the final decision. Therefore, it is important to distinguish between *management scientists* who are someone who studies what decisions have to be made and may also be seen as the problem solver; while *a decision-maker* is someone who is responsible for making the decision (Simon, *et al,* 1986:11). It is the opinion of this author that, within a South African business environment, these two functions are likely to be carried out by the same person. South African managers are expected to be both scientist and decision-maker, thus taking responsibility for both problem solving and decision-making. This has not been tested by any published research to date.

In the past management information could be summerised on a spreadsheet. However, decisions are no longer made without recourse to a wealth of sound information on which to base them. Turban (1993:7 –9) states that managers have for years considered decision-making as an art, which is acquired over years and which is honed through trial and error. He attributes changes in the business environment to the rapid growth and complexity of decision-making. Managers are expected more than ever before to make decisions in as short a time as possible and without the help of management scientists. It would therefore be wise to ensure that they have the competency to apply Management Science to problems that they experience, by analysing the information and data to which they have access.

Gordon, Pressman and Cohen (1990:2) followed the link from the growth in the accounting discipline to arrive at "better" scientifically based decisions. Development has occurred of systematic procedures for "accounting" monetary operations of an organisation in order that administrators may have access to a clearer perspective of qualitative analysis. Accounting statements can be considered as the "model" of the organisation. This "model" however is a reactive view looking at events that have already past. Management Science as an operational "model", and thus is a proactive view taking into consideration the current events and moulding the future. (Erasmus 2005)

From the information supplied by the above mentioned authors, it is safe to say that management requires information to make decisions. Management is frequently required to act, not only as problem solver but also as decision-maker. Thus a manager requires information in a structured and manageable format, which should be made available by Information Systems.

2.4 Information Systems

The abilities and skills that determine the quality of managerial decision-making and problem solving are stored not only in more than 200 million human heads, but also in tools and machines, and these machines are referred to as computers. Data in unprocessed format is stored in these computers and transformed into information by means of tools and applications.

Kotler (1997:110) states that a marketing information system consists of people, equipment and procedures, which gather, sort, analyse, evaluate and distribute needed, timely and accurate information to marketing decision-makers.

In the phases of information management systems, in businesses and other organisations, internal reporting was provided manually and only periodically as a by-product of the accounting system, and with little or no additional statistics. Internal reporting provided limited and delayed information on management performance, and was merely a raw data supply rather than useable information.

In their infancy, business computers were used for practical business such as computing the payroll and keeping track of accounts payable and accounts receivable. As applications were developed, which provided managers with information regarding sales, inventories and other data that would help to manage the enterprise, the term "MIS" (Management

Information Systems) arose to describe these kinds of applications. The term Management Information Systems is used broadly in a number of contexts and includes (but is not limited to) Decision Support Systems (DSS).

Management Information Systems are planned systems, which involve collecting, processing, storing and disseminating data in the form that is necessary and appropriate for management to carry out functions. In a way it is a documented report of activities that were planned and have been executed.

According to Render and Stair (1994:2), Management Science (quantitative analysis, operations research) is a scientific approach to managerial decision-making. As the authors state, this approach begins with data. Like raw material for a factory, this data is manipulated or processed into information, which is valuable to people who have to make decisions. This processing and manipulation of raw data into meaningful information is the heart of Management Science. Computers have been instrumental in increasing the use of Management Science. The present author asserts that decisions, which are based on insufficient or badly presented data, will impact negatively on the quality of decisions that are made.

Decision quality is thus greatly influenced by the quality of the data that is made available to the decision-maker. Availability of data accompanied the introduction of computers and vice versa. An overwhelming amount of data is available on a daily basis. This is received by managers in an organisation, and used to make decisions.

Hence, it is important to manage this large quantity of information that is available to management. Information and data are at the centre of decision-making and Management Science should be managed. The fundamentals of management are defined by four components, namely Planning, Organising, Leading and Controlling (Smit & Cronje; 1992:13).

- **Planning**: the conscious determination of future courses of action. This Includes application of all necessary resources to achieve the organisation's goals. Thus, planning includes determination of specific objectives, determining projects and programs, setting policies and strategies, setting rules and procedures and preparing budgets.

- **Organising** (implementation): making optimum use of resources that are required to enable the successful carrying out of plans.

- **Leading**: determining what should be done in a situation and getting people to do it.

- **Controlling**: monitoring and checking progress against plans, which may require modification based on feedback.

Management of information and data should also comply with these criteria:

- Planning information requirements so that the managers can act on their action plans;

- Organising information so that it is made available at the right time and packaged in such a way that the manager can use it with little manipulation required;

- Leading the decision-making process by making complex problems flow; and

- Controlling: monitoring and checking the quality of decisions based on information that is made available by information systems.

Information Systems (IS) have been defined by Laudon and Laudon (1996:9) and O'Brien (1996:41-55) as inter-related components that collect, process, store and distribute information to support decision-making and technically assist in the control of an organisation. It is important to look at what Information Systems organisations employ to process data that their business processes generate. Organisations process information by means of information systems to group and filter through the information and thus package it in manageable data packets or clusters. Having been processed and packaged, information is stored in what has become known as databases. The packaged data is then distributed to all concerned. It is critical that this packaged data should reach managers. It is this information on which they will base their operational decisions.

By using techniques such as problem structuring methods and mathematical modelling to analyse complex situations, Management Science provides executives with power to make more effective decisions and to build more productive systems, which are based on:

- More complete information;

- Consideration of all available options;

- Careful predictions of outcomes and estimates of risk; and

- The latest decision tools and techniques.

The terms Management Information Systems (MIS) and information systems (IS) are often confused. Information systems (IS) include systems that are not intended for decision-making. Management Information Systems (MIS) supply pertinent information to management to facilitate decision-making.

Naylor 1999:751 states that information is the sum of data and meaning, and information systems give meaning to data by grouping data in meaningful systems. Systems give information structure so that it can be applied for management information systems to facilitate knowledgeable allocation for decision-making.

The definition of a system is summerised as (from Latin systēma, in turn from Greek σύστημα systēma) a set of interacting or interdependent entities, which form an integrated whole. These systems can be divided into levels of information systems.

2.4.1 Levels of Information Systems

Laudon and Laudon (1996:16-17) divide IS into four kinds of systems, namely (Figure 2.1):

- Operational Level IS;

- Knowledge Level IS;

- Management Level IS; and

- Strategic Level IS.

This is illustrated and linked to levels, which are described by Laudon and Laudon.

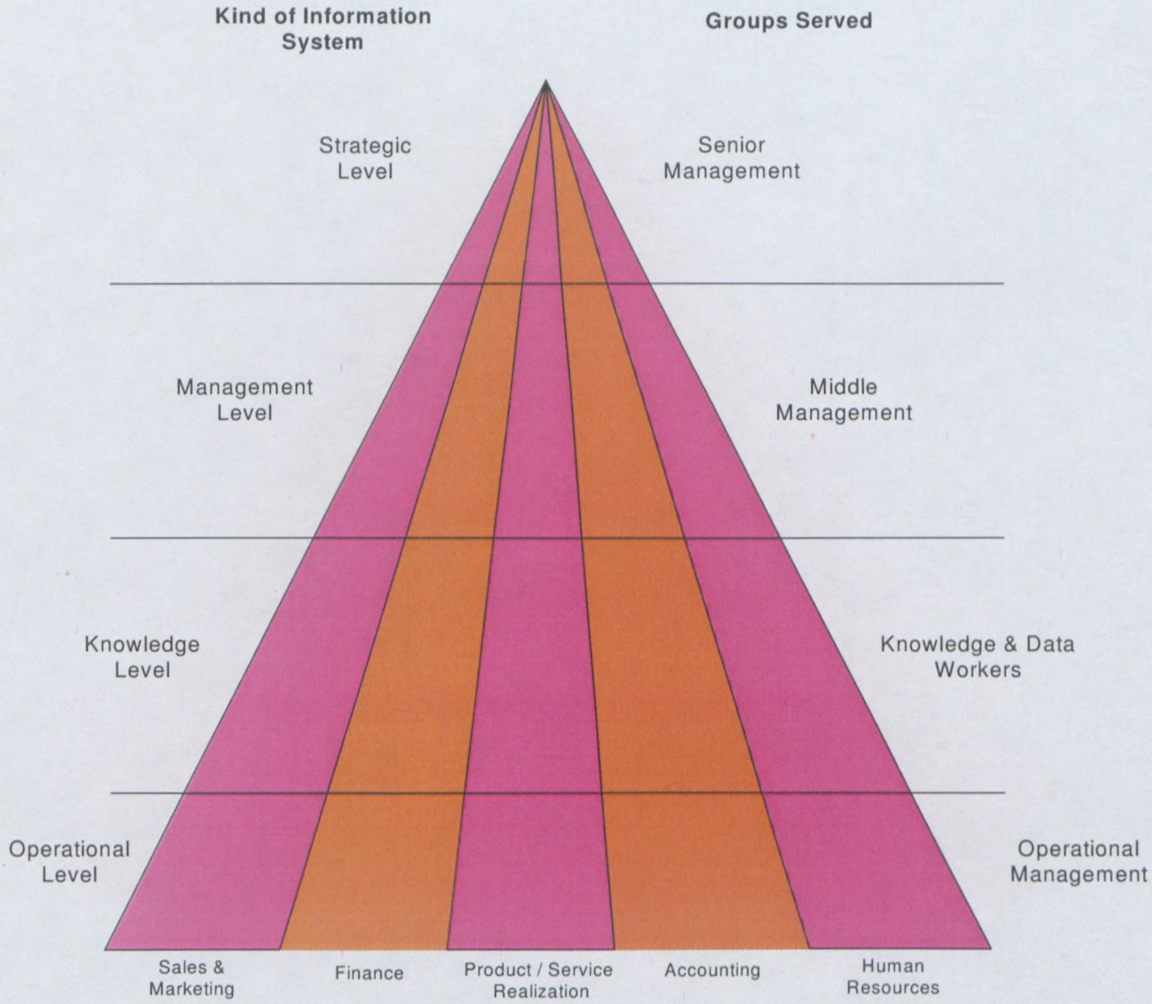

Figure 2.1, Types of information systems (Laudon and Laudon, figure 1.6, 1996:17)

The authors divided the four levels further into different types of systems and their application within the parts of the organisation that employ them.

1. **Strategic Level Information Systems**

   Support systems at this level are known as Executive Support Systems (ESS). Executive Support Systems include all systems that are employed by the top management of an organisation and are used for forecasting and planning

2. **Management Level Information Systems**

   This is known as Management Information Systems (MIS) and Decision Support Systems (DSS) and is utilised for management activities, scheduling, analysis, control, budgeting and costing.

3. Knowledge Level Information Systems

Knowledge Work Systems (KWS) are used by knowledge workers to influence operational strategies and Office Automation Systems (OAS) such as workstations and data processing software.

4. Operational Level Information Systems

Transaction Processing Systems (TPS) are mainly applied for the execution of administration, accounting and record keeping.

For the problem solving phase of Management Science, information is required from Strategic, Management, Knowledge and Operational Level Information Systems. This is because all the information available for problems that are encountered should be gathered and analysed. Sources should be tapped into in order to obtain as much information regarding the problem as possible (Laudon, *et al*: 1996). As for decision-making, Decision Support Systems are utilised to enable decision-makers to filter through data and to assist with collating and analysing it.

With the introduction of computers and suitable software, analyses of data and mathematical decision-making have become easier. The question arises whether managers in leading South African organisations make use of the Management Science tools and techniques, which assist in the analysis of available data, to aid them in the decision-making process.

It is the experience of the present author that every modern business is flooded by an oversupply of information, but that managers do not make use of this information to make their most critical decisions: those related to organisational change.

It has been found that several small and medium sized organisations in South Africa do not make use of totally computerized information systems.

Gordon, Pressman and Cohen (1990:2) assert that the next logical step after providing information for decisions is to develop decision-making aids, which facilitate the investigation of these problems.

Early management information systems were designed on the assumption that information was a scarce resource. Now, because designers recognize that the scarce resource is managerial attention, a differently designed framework is produced (Simon, *et. al.* 1986:28).

2.5 Management Science methodologies

Turban (1996:8) states that in order to advance, and if they want to survive, managers should become more sophisticated, which involves learning how to use new and current tools and techniques that are available, as well as those that are developed in their field to make decisions. These techniques are mostly based on a quantitative analysis approach and can be grouped under the discipline of Management Science.

(Simon, *et al.* 1986:24-25) claims that the first steps in the problem solving process are the least understood. The question that should be asked is what brings (and should bring) problems to the head of the agenda? And, when a problem is identified, how can it be represented in a way that facilitates its solution?

Management is guilty of wanting the most from their assets, whether it is physical or human, while not enough energy is allocated to the decision-making process.

The task of setting an agenda is of utmost importance because both individual human beings and human institutions have limited capacities to deal with several tasks simultaneously. While some problems receive full attention, others are neglected. When new problems arise, "fire fighting" replaces planning and structured decision-making. The facts of limited attention span for individuals are well known. However, relatively little has been accomplished in the field of analysing or designing effective agenda setting systems. The quality of solutions that are provided by decision-makers has much to do with the way in which problems are represented (OR Society: online).

The Management Science approach has had a number of proponents since the 1980's. Seven authors and lecturers in Management Science are listed below, together with the basic scientific models that they individually present for the process of problem solving and decision-making.

2.5.1 Lee, Moore and Taylor (1981:5)

These authors depict a basic scientific model which comprises the following (See Figure 2.2):

1. **Observation** of, or studying the organisation to gather information on the potential problem or area of improvement.

2. **Definition of the problem** or area of improvement. This should include alternatives (at least 3), objectives for each of the alternatives and the mid- and long-term goals of the potential solution. They conclude that it is also important to specify the measurement criteria to ensure that performance of the proposed solution is evaluated.

3. **Model construction** and the formulation of the hypothesis. Lee *et al.* state that models are abstractions of reality and only components that are relevant to the problem, which is analysed should be included in the model. A model can be a graph, a flow chart, diagram, network, or a set of mathematical equations (also called algorithms by some).

4. **Model validation** ensures that validity of assumptions is checked.

5. **Problem solution** or experimentation using the model.

6. **Implementation** – this is critical to the success of Management Science as an unimplemented or, even worse, badly implemented solution can cause unnecessary losses.

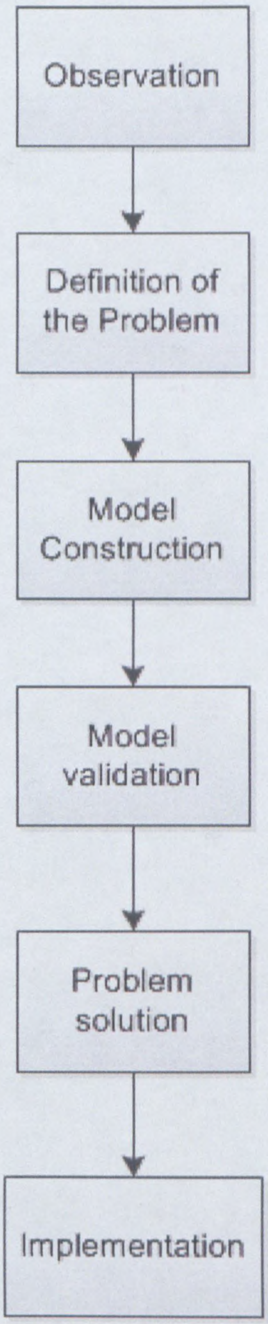

Figure 2.2 Scientific Model (Lee et.al. 1981:5 to 7)

They classified the models into two groups:

- Deterministic models – models developed under conditions of assumed certainty; and
- Probabilistic models – models developed where uncertainty is assumed. This model is generally more difficult to solve.

2.5.2 *Beasley, James (2003)*

Beasley strongly supports the views of Lee *et al.* on phases in the process of problem solving, and this is illustrated in Figure 2.3 below:

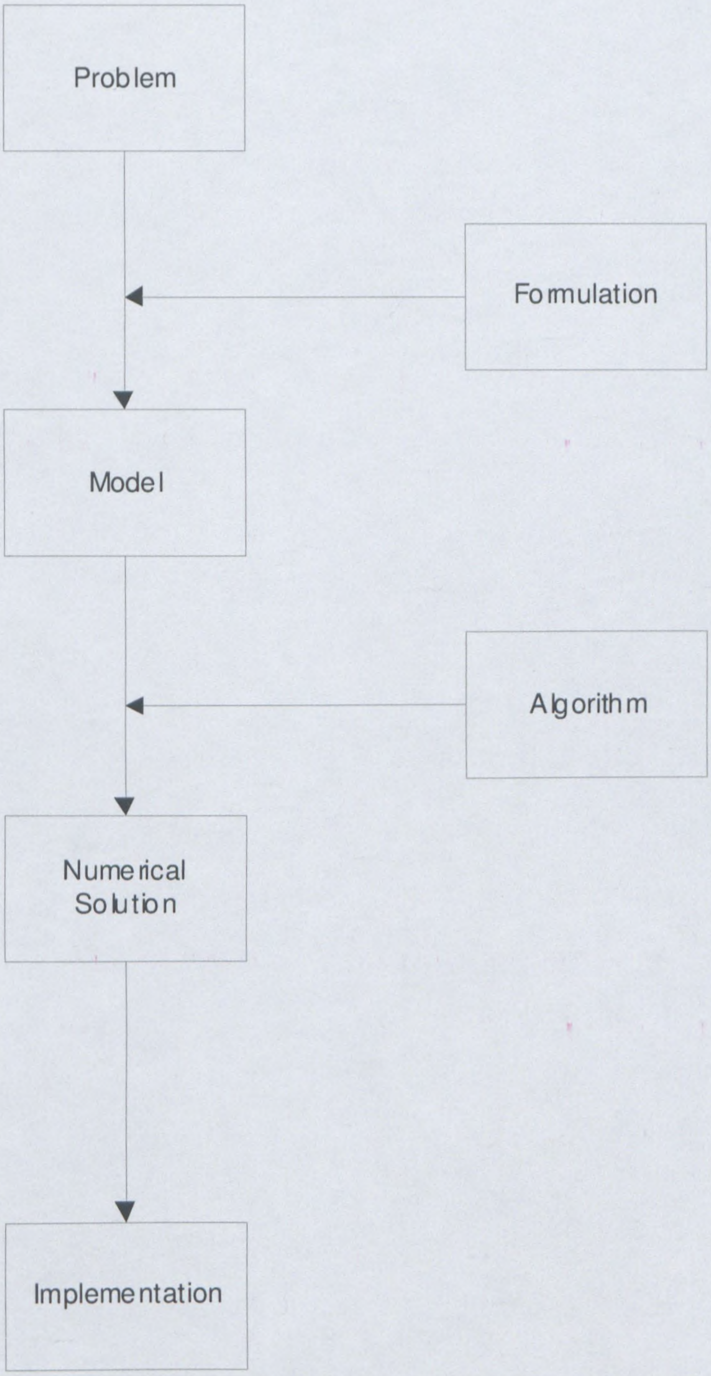

Figure 2.3 Problem Solving Model (Beasley, 2003: online)

His steps can be broken down as follows:

1. **Problem identification** – Beasley states that it is important to diagnose the problem and not merely its symptoms. The purpose is the establishment of objectives, limitations and requirements of set problem areas.

2. **Formulation as a mathematical model** – it is further stated by Beasley that a problem can be modelled in different ways. The choice of the appropriate model is crucial to the success of the Management Science project. In addition to algorithmic considerations for solving the model - in other words, can the model be solved numerically - consideration should also be given to the availability and accuracy of real-world data, which is required as input to the model. In his experience, Beasley found that some business and decision-making environments are naturally data-poor, which means that the data is of poor quality or non-existent. Some environments are naturally data-rich. This issue of the data environment can affect the model that is built or the problem that one intends to solve. There may even be certain data that can never realistically be obtained. The fact of the matter is that in such a case there is little point in building a model that uses such data. This statement supports the research that was conducted by this author on the quality of information systems and data availability.

3. **Model validation** (or algorithm validation) – in the phase of model validation, Beasley states that it involves running the algorithm for the model on the computer in order to ensure that:
    a. the input data is free of errors;
    b. the computer program is bug-free, or at least there are no outstanding bugs;
    c. the computer program correctly represents the model that is being validated; and
    d. the results from the algorithm seem reasonable and the output compares well with the historical result.

   It is on this point that Beasley differs from Lee *et al.* since he does not view "Soft OR" solutions as part of the Management Science field of study. Beasley does not refer to non mathematical solutions in his scientific approach. His view of pure mathematical modelling is not inline with any of the other authors that are reviewed here. The present author believes that his model is not operationally aligned, but is instead a purely theoretical one.

4. **Solution of the model** - Standard computer packages, or specially developed algorithms can be used to solve the model. Because Beasley states that non mathematical models and solutions are not addressed by Management Science most of his models (if not all) can be presented as a mathematical model.

5. **Implementation** - This phase may involve implementation of the results of the study or implementation of the algorithm to solve the model as an operational tool, usually in a computer package. In the first instance, detailed instructions regarding what should be done, including time schedules to implement the results, should be issued. In the second instance, operating manuals and training schemes should be produced for the effective use of the algorithm as an operational tool. It is believed that several Management Science projects, which successfully pass through the first four phases given above, fail at implementation stage. As a result, one topic that has received attention in terms of bringing a Management Science project to a successful conclusion in terms of implementation is the issue of management involvement. This means keeping management informed and consulted during the course of the project so that they come to identify with the project and want it to succeed. Achieving this is a matter of experience.

2.5.3 Gordon, Pressman and Cohen (1990:6)

The outline of the decision-making process by Gordon, Pressman and Cohen (1990:6) is divided into more steps, but depicts the same flow (See Figure 2.4):

1. Define the objective – be clear in the definition of the objective of the decision you want to solve;

2. Determine the controllable activities – determine those activities you can control.

3. Define the uncontrollable activities – determine whether they are state-of-nature or competitive-strategy type;

4. Define the partially controllable variables, and their relationship to the controllable variables;

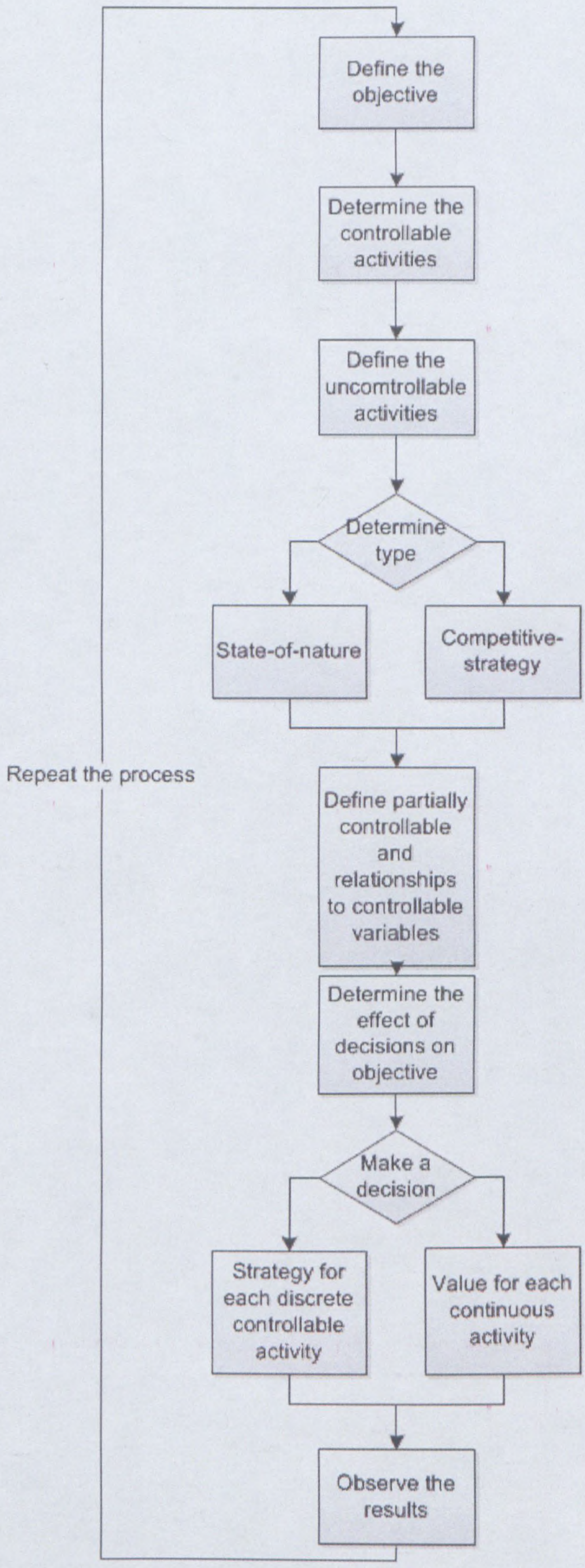

Figure 2.4 Outline of the decision process (Gordon et al 1990:7)

5. Determine the effect of each possible strategy or value for each controllable activity with respect to the objective – find the best decision;

6. Make a decision that is, select:
    - A strategy for each discrete controllable activity;
    - A value for each continuous controllable activity;

7. Observe the results;

8. Repeat the decision process over time.

Gordon *et al.* hold that a major tool of Management Science is the analytical model. It is important to note the differences between the Gordon *et al.* model and that of the other authors. Their entire model is strongly biased towards algorithmic solutions regarding Management Science problems. Their process details analysis of variables at an early stage and does not include an implementation phase as part of the process. The present author did not find their publication to be similar to any of the others.

2.5.4 Render and Stair (1994:3-9)

The Render and Stair approach follows a seven-step procedure with implementation mentioned as a vital part in the Management Science process (See Figure 2.5):

1. Defining the problem (specific and measurable objectives);

2. Developing a model (physical model, scale model, schematic model or mathematical model. Determine controllable and uncontrollable variables and also parameters);

3. Acquiring input data (accurate data is essential);

4. Developing a solution (trial and error, complete enumeration and/or algorithms);

5. Testing the solution (verification and validation);

6. Analysing the results (sensitivity analysis and post optimality analysis); and

7. Implementing the results.

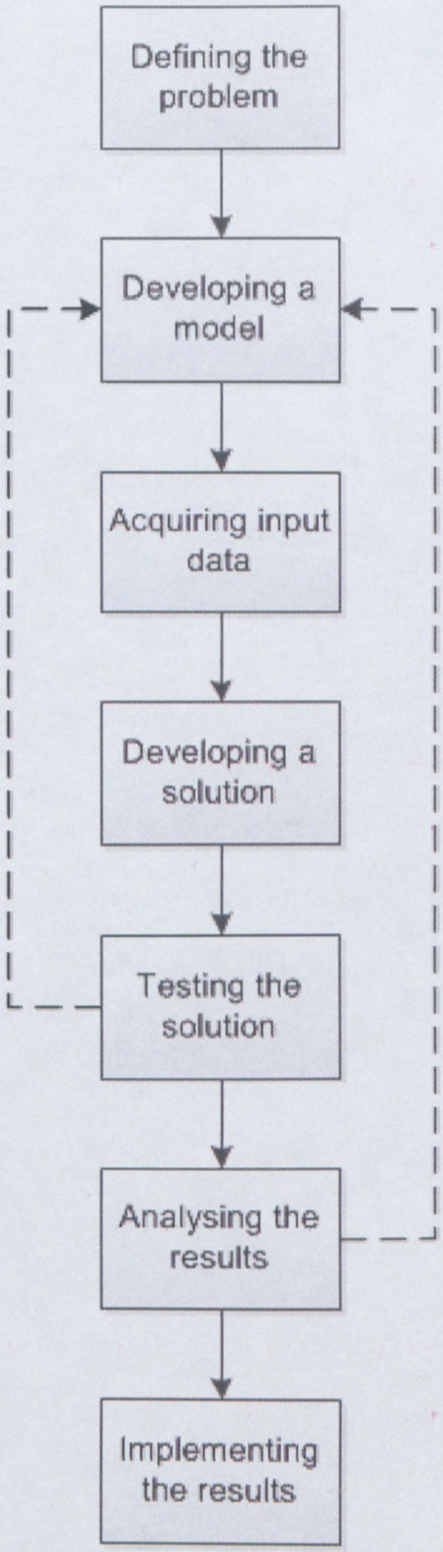

Figure 2.5 The Quantitative Analysis Approach (Render & Stair, 2006:3, fig. 1.1)

2.5.5 *Turban (1996:44)*

Turban classifies decision-making models into three groups according to their degree of abstraction. Turban does suggest the importance of a systematic process approach to decision-making with the application of management science techniques namely:

- Iconic (Scale) Models – a replica of the system ;
- Analog Models – the shape of the model differs from the actual system ; and
- Mathematical Models - due to the complexity and time constraints, a more abstract model is used by applied mathematics.

Turban's approach supports the Render and Stair model.

2.5.6 *Winston (1994:1-5)*

Winston's model is simple and supports the notion that the standard procedure includes implementation (See Figure 2.6):

1. Formulate the problem;
2. Observe the system;
3. Formulate a mathematical model of the problem;
4. Verify the model and use the model for prediction;
5. Select a suitable alternative;
6. Present the results and conclusions of the study to the organisation; and
7. Implement and evaluate recommendations.

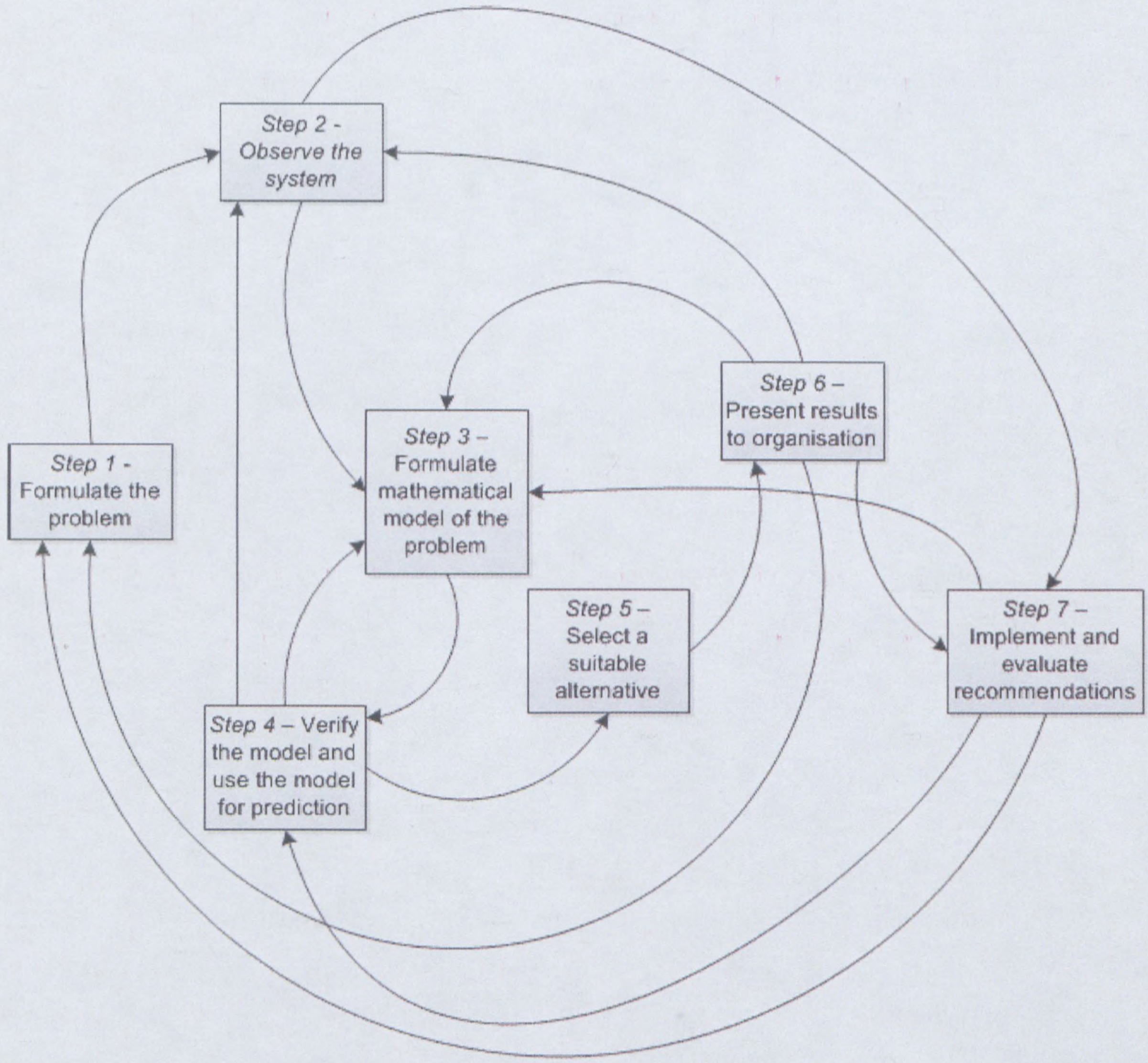

Figure 2.6 The Operations Research methodology (Winston, 1994:2, Fig 1)

2.5.7 *Arsham (2006)*

Arsham supports other authors regarding the process of Management Science methodology. Arsham lists the following main steps in the process of decision-making by means of Management Science techniques, which are illustrated in Figure 2.7.

1. **Understanding the problem:**

   In order to clearly understand the problem, the objectives and constraints that are involved are critical for the decision-maker.

2. **Constructing an analytical model:**

   Model construction involves the "translation" of the problem into precise mathematical language in order to make calculations and comparisons of the outcomes under different possible scenarios.

3. **Finding a good solution:**

   The proper solving technique depends on specific characteristics of the model. Once the model is solved, validation of the obtained results should be done in order to avoid unrealistic solutions.

4. **Communicating the results:**

   The results should be properly communicated to management. This is the "sale" part. If the decision-maker does not buy the recommendations, he/she will not implement any of them.

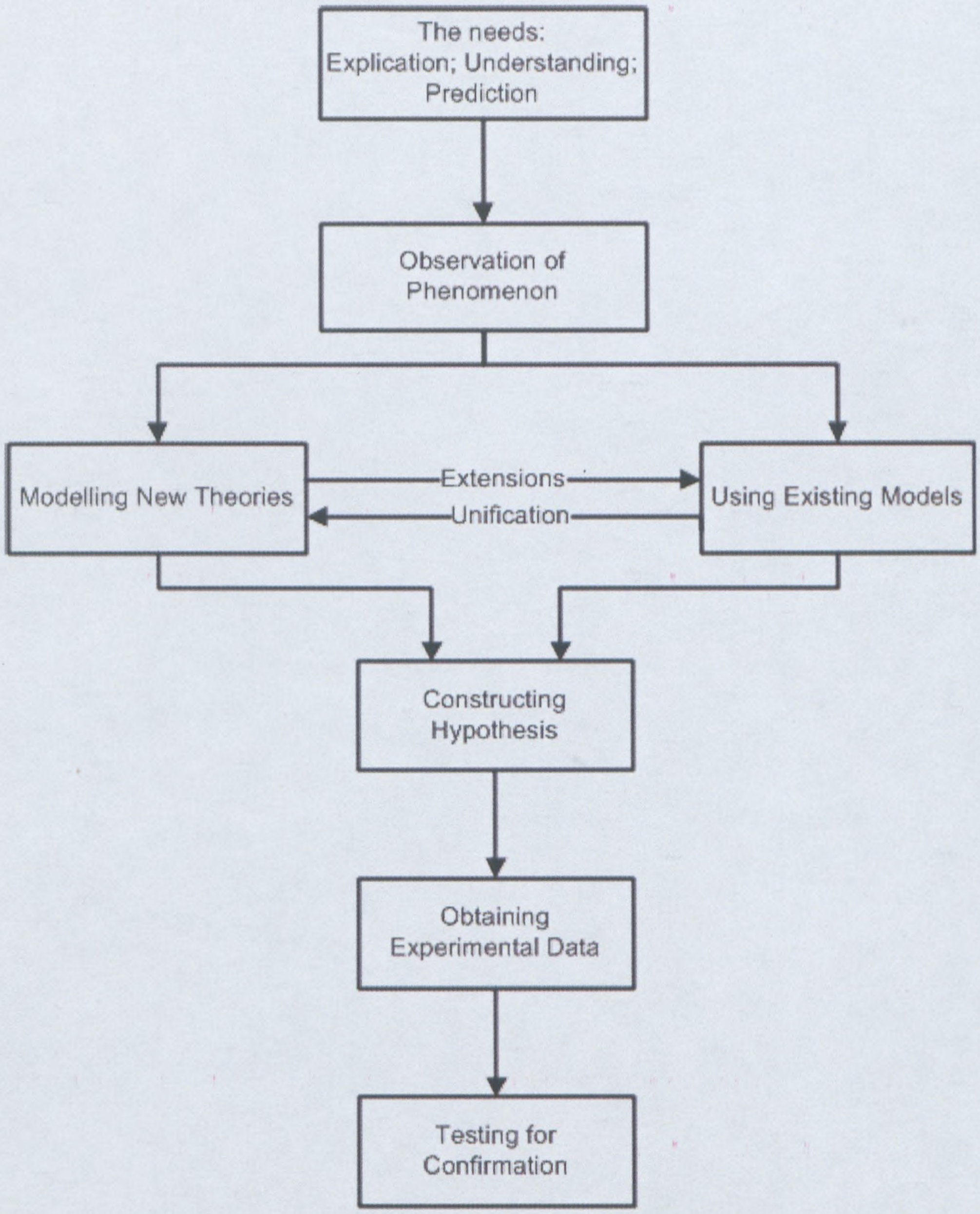

Figure 2.7 The Scientific Model (Arsham, 2009:online)

Like Gordon *et al*, Arsham does not mention the implementation process as part of his scientific model.

The authors all support the theory that understanding a problem encompasses a problem structure and a diagnostic process, which assist in problem formulation and representation. The problem formulation stage is the most important aspect of the decision-making process. Problem understanding is an interactive process between the decision-maker and the management of the organisation. The management may be unfamiliar with the analytic details of the problem formulation, for example, what elements to include in the model, and how to include them as variables, constraints and indices. Hence, it is of paramount importance to clearly communicate with management and staff to ensure that the correct assumptions are made and documented.

The Management Science approach to decision-making includes diagnosis of current decision-making and the specification of changes in the decision process. The diagnosis process involves determining how decisions are currently made, specifying how decisions should be made and understanding why decisions are not being made as they should be. Specification of changes in the decision-making process involves choosing what specific improvements in decision-making behaviour should be achieved and this defines the objectives.

Although the phases of the decision process are normally initiated in the order listed, they usually do not terminate in this order. In fact, each stage usually continues until the process is complete and continuously interacts with the others. There could be an infinite number of feedback loops involved in making a single decision.

2.6 Research model

The following model in Figure 2.8 was constructed for application in the research of Management Science application, after consulting research of the various authors regarding a scientific model.

The process is based on a combined input from the seven authors and the experience of this author.

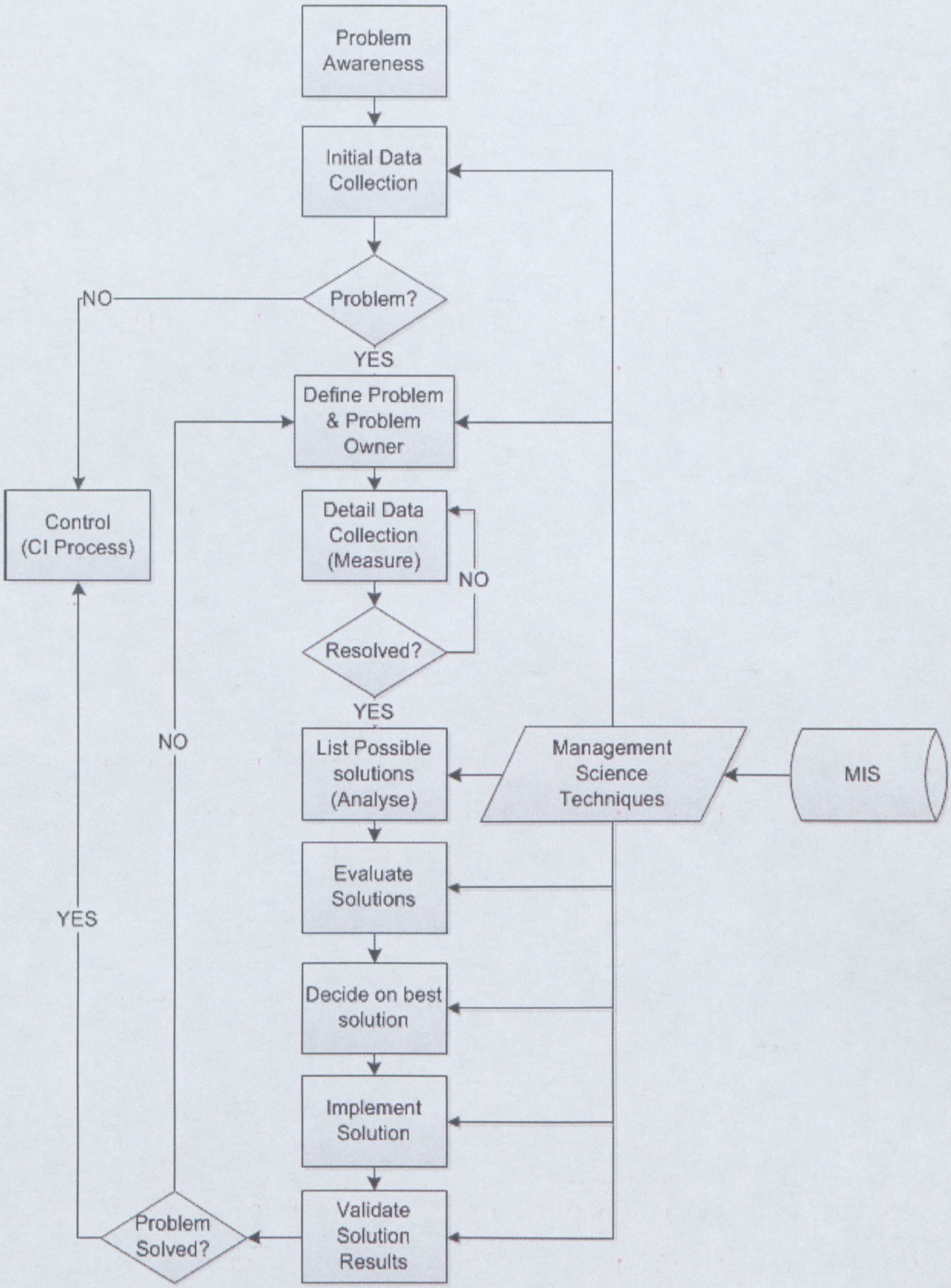

Figure 2.8 Problem Solving Model, Erasmus (2009)

2.7 Management Science Modelling

Management Science, in its simplest form, is the science of model building. Arsham (current: online) states that a progressive approach to modeling for decision-making involves two distinct parties: one is the decision-maker and the other is the model-builder, known as the management scientist. The scientist assists the decision-maker in the decision-making process. The scientist should be equipped with more than one set of analytical methods. In the context of South African small businesses, the scientist and decision-maker is usually one and the same person, as management is required to take their own decisions.

The literature review shows that specialists in model building are often tempted to study a problem, and then go off in isolation to develop an elaborate mathematical model for use by managers, namely the decision-maker. However, the manager may not understand this model and may either use it blindly or reject it entirely. The specialist may feel that the manager is too ignorant and unsophisticated to appreciate the model, while the manager may feel that the specialist lives in a dream world of unrealistic assumptions and irrelevant mathematical language. In fact, many decisions do not require complex mathematical equations in order for them to be made, but mere common sense, hence "soft OR".

The Management Science modeling process is more than a set of analytical methods. Management Science models are aimed at assisting the decision-maker in the decision-making process. A fundamental part of Management Science modeling is the "systems approach" to problem solving. This approach indicates that the context of organisational problems is as important as the stated problem. Defining a problem, collecting data, consulting with people who are involved in the solution and implementing change, are all aspects of Management Science education and training. As it is easier to make plans than to carry them out, models that are not implemented are ones that were not drawn up correctly, nor taken seriously from the outset.

The Management Science modeling process helps to improve operations in business and government through the use of scientific methods and the development of specialized techniques. Operations Research is not "research"; it is the process cycle of re-searching for an optimal (or desirable) strategic solution to the existing decision problem/situation.

2.8 Management Science competencies

Steen (2001: online) states that mathematics in the workplace makes sophisticated use of elementary mathematics rather than elementary use of sophisticated mathematics.
Work related mathematics is rich in data, which is interspersed with conjecture that is dependent on technology and tied to applications. Work contexts often require multi step solutions to open-ended problems, a high degree of accuracy and proper regard for tolerances. This supports the view that Management Science is about more than mere complex mathematics, but also involves the application of a scientific model and recognition of the correctly modelled solution.

Synonyms that are given for the word competency include: proficiency, skill, and ability. To illustrate the application of competency for this research, the following example is used: If two people's competency levels are compared, the following may be found:

Table 2.1 Mathematical Competency (Erasmus, 2009)

Skill	Person1	Person 2
Mathematical application	Basic understanding of applied mathematics, only in problem solving.	In-depth understanding and application of mathematics in everyday life.
Mathematical Modelling	Can apply the models once they are set up, but cannot set them up.	Can set up mathematical models from problems experienced by the organisation. Follows a set procedure.
Interpretation of models	Can interpret other scientists' models and provide comment.	Can interpret other models and suggest changes or improvements.
Knowledge of OR techniques	Knowledge of the seven main OR techniques, but can only apply one or two.	Knows about and has experience in the application of most of the OR techniques. Bases most of the modelling on fresh models before deciding on available techniques

It is important to realise that Person 2 has few limitations in his competency as a Management Scientist, while Person 1 has a limited competency when it comes to Operations Research. Competency has little to do with qualification (although important), but experience and a passion for research drives the successful and highly competent Management Scientist to stay at the spearhead of this specialist field. It is indeed possible for the Management Scientist to become limited in his competency if he does not stay abreast of new developments and trends in the Operations Research field.

It should be noted that the mere fact that some managers had Operations Research as part of their electives at the institution where they studied, does not make them competent at Management Science. The under-utilisation of management information to make important decisions has become more problematic with the rapid growth of information overload.

2.9 Management Science techniques

In order to determine the levels of Management Science competencies, the available techniques should be identified. For the purpose of this research, a study of the techniques found in popular published handbooks, was utilised (see Table 2.2).

Techniques that were applied for this research include the following:

- **Linear Programming**
  In mathematics, Linear Programming (LP) is a technique to optimize linear objective function, subject to linear equality and linear inequality constraints. Linear Programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model with a given list of requirements, which are represented by linear equations.

- **LP Simplex Method**
  In mathematical optimisation theory, the simplex algorithm, which was created by American mathematician George Dantzig in 1947, is a popular algorithm which numerically solves linear programming problems.

- **Simulation**

  Simulation can be defined as a technique that imitates the operation of a real-world system as it evolves over time. Operations simulation is done by the development of a simulation model that usually takes the form of a set of assumptions about the operational system under scrutiny (Winston 1994:1183).

- **Markov Analysis**

  A Markov chain is a random process where all information about the future is contained in the present state. To be more exact, if the process has the Markov property, this means that future states depend only on the present state and are independent of past states. In other words, the description of the present state fully captures all information that can influence the future evolution of the process. Being a stochastic process means that all state transitions are probabilistic.

- **Transportation Problems**

  In mathematics and economics, transportation theory is a name which is given to the study of optimal transportation and allocation of resources.

- **Assignment problems**

  The assignment problem is a fundamental combinatorial optimisation problem within the branch of optimisation or operations research in mathematics. It consists of finding a maximum weight matching in a weighted bipartite graph.

- **Mathematical Modeling**

  A mathematical model uses mathematical language to describe a system. Mathematical models are not only used in the natural sciences and engineering disciplines (such as physics, biology, earth science, meteorology, and engineering), but also in social sciences (such as economics, psychology, sociology and political science); physicists, engineers, computer scientists, and economists use mathematical models most extensively.

- **Network Models (Diagrams)**

  A network diagram is a special kind of cluster diagram, which even more generally represents any cluster, small group or bunch of something, whether structured or not. Both the flow diagram and the tree diagram can be regarded as specific types of network diagram.

- **Project Management CPM/PERT**

  The Program (or Project) Evaluation and Review Technique, which is commonly abbreviated as PERT, is a model for Project Management, designed to analyse and represent tasks that are involved in completing a given project. The Critical Path Method (CPM) or critical path analysis is a mathematically based algorithm, which schedules a set of project or operational activities.

- **Inventory Models**

  Inventory theory (or, more formally, the mathematical theory of inventory and production) is the sub-specialty within operations research that is concerned with the design of production/inventory systems to minimize costs. It studies decisions that firms and the military face in connection with manufacturing, warehousing, supply chains, spare part allocation and so on; it provides a mathematical foundation for logistics.

- **Dynamic Programming**

  In mathematics and computer science, dynamic programming is a method which solves complex problems by breaking them down into simpler steps. It is applicable to problems that exhibit properties of overlapping sub problems and optimal substructure (described below). When applicable, the method takes much less time than naive methods.

- **Decision Theory**

  Decision theory in mathematics and statistics is concerned with identifying values, uncertainties and other issues that are relevant in a given decision and the resulting optimal decision.

- **Games Theory**

  Games theory attempts to mathematically capture behavior in strategic situations, in which an individual's success in making choices depends on the choices of others.

- **Queuing Theory**

  Queuing theory is a mathematical study of waiting lines. The theory enables mathematical analysis of several related processes, including arriving at the back of the queue, waiting in the queue - essentially a storage process, and being served by the server(s) at the front of the queue.

- **Goal Programming**

  Goal programming is a branch of multi objective optimisation which, in turn, is a branch of Multi-Criteria Decision Analysis (MCDA), which is also known as Multiple-Criteria Decision-making (MCDM). This is an optimisation programme. It can be thought of as an extension or generalisation of linear programming to handle multiple, normally conflicting objective measures. Each of these measures is given a goal or target value that should be achieved.

- **Integer Programming**

  Integer programming studies linear programs in which some or all variables are constrained to take on integer values. This is complex and, in general, much more difficult than regular linear programming.

- **Non Linear Programming**

  In mathematics, Nonlinear Programming (NLP) is a process, which solves a system of equalities and inequalities, collectively termed constraints, over a set of unknown real variables, along with an objective function, which is either maximized or minimized, where some of the constraints or the objective function is nonlinear.

- **Extreme value theorem (Extrema)**

  In calculus, the extreme value theorem states that if a real-valued function is continuous in the closed and bounded interval, then the function must attain its maximum and/or minimum value, each at least once.

- **Forecasting Models**

  Forecasting Models look at the future events. They determine and recommend to management suitable actions and processes that should be implemented to avoid negative effects.

- **Statistical Process Control**

  Statistical Process Control (SPC) is an effective method which monitors a process through the use of control charts. Control charts enable the use of objective criteria to distinguish background variation from events of significance based on statistical techniques.

- **Decision Trees**

  A decision tree (or tree diagram) is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility.

- **Multi-criteria Decision-making**

  Multi-criteria Decision Analysis (MCDA), sometimes called Multi-criteria decision-making (MCDM), is a discipline, which is aimed at supporting decision-makers who are faced with making numerous and conflicting evaluations. MCDA aims at highlighting these conflicts and deriving a way to come to a compromise in a transparent process.

Competencies that are listed by five authors in Management Science are detailed in Table 2.2 below.

Table 2.2 Management Science Techniques (Erasmus, 2007)

Technique	Gordon, Pressman & Cohen	Render and Stair	Winston	Walker	Lee, Moore & Taylor
Linear Programming	X	X	X	X	X
Simplex Method	X	X	X	X	X
Simulation	X	X	X		X
Markov Analysis	X	X	X		X
Transportation problems	X	X	X	X	X

Technique	Gordon, Pressman & Cohen	Render and Stair	Winston	Walker	Lee, Moore & Taylor
Assignment problems		X	X		X
Mathematical Modeling	X	X	X	X	
Network models	X	X	X	X	X
Project Management CPM/PERT	X	X	X	X	X
Inventory models	X	X	X		X
Dynamic programming	X	X	X	X	X
Decision theory	X	X	X		X
Games theory	X	X	X		X
Queuing theory	X	X	X		X
Goal programming	X	X	X		X
Integer Programming	X	X	X	X	X

Technique	Gordon, Pressman & Cohen	Render and Stair	Winston	Walker	Lee, Moore & Taylor
Non Linear Programming		X	X		X
Unconstrained Extrema				X	
Constrained Extrema				X	
Forecasting models		X	X		
Statistical Process Control		X			
Decision Trees	X	X			
Multi-criteria Decision-making		X	X		
Decision-making under uncertainty	X	X	X		

2.10 Chapter Summary

It is evident from the literature study that the management science processes and competencies can be summarised as outlined below:

Problem Solving can be regarded as the field, which is labelled as Management Science, as defined by several of the authors studied.

Decision-making is a process whereby management makes use of the results of the problem solving activity and chooses the best solution from alternatives that are presented.

A Management Scientist is a person who studies the defined problem, gathers data and selects techniques, which are then used to present decision-makers with the necessary alternative solutions. Decision-makers make decisions based on information and alternatives that are supplied by the problem solver.

Problem solving, and thus decision-making, requires information, while management should manage the structure of their information. The road map regarding application of knowledge can be summarised as follows:

- Data + meaning = information;
- Information + structure = applicable information;
- Information + application = knowledge; and
- Applying knowledge to problems = decision-making.

In most South African Small, Medium and Micro Enterprises, the decision-maker and problem solver is one and the same person. Hence, the manager requires an understanding of the scientific model for decision-making, as well as competencies to analyse problems, formulate solutions and suggest alternatives. The manager, who engages with problem solving and subsequent decision-making, requires competencies in the techniques that are available and become available in Management Science. Above all, managers should demonstrate a visionary, as well as a holistic approach in this regard.

The next chapter gives an overview of the research objectives, and the case study design.

3 RESEARCH OBJECTIVES AND DESIGN

3.1 Introduction

This chapter focuses on the research methodology, which was applied in this study. This includes an explanation of how the research sample was decided upon and also how the research was executed. Furthermore, it focuses on the research design, the process that was used for the collection of data and the validity and reliability of such data. The first section discusses the research problem and the purpose of the research.

3.2 Research problem

The main objective of this research is to discover whether South African Textile companies have competencies that are required to apply Management Science tools and techniques; if not, why not? If yes, what procedure do they follow and what positive results, if any, do they obtain? The research assumption is this: The gap between the required mathematical literacy of managers in South Africa and what they are actually capable of, leads to poor decision-making in companies. An increasing amount of information is available to management in present Information driven business environments. Business has become increasingly complex owing to information overload, and proof of this is the amount of information which is available on the Internet. Managers are expected to make sound decisions using all available information. Management Science competencies in business, which analyse information for decision-making purposes, seem to be lacking, if one considers the number of large corporate companies that battle to maintain high profits. The competencies needed in business include, among others, Mathematical Modelling, Operations Research, and Mathematical Science.

3.3 Research objectives

The main objective of this research is to determine the Management Science competencies of the personnel in a textile manufacturing organisation.

The key objectives of the research were to:

- Identify if personnel in the textile manufacturing organisation utilises Management Science techniques to assist in the decision-making process;

- Determine if Management Science techniques are utilised within the textile manufacturing organisation;

- Identify which techniques are utilised by management and why; and

- Determine the procedures, which are utilised by the textile manufacturing organisation to facilitate the decision-making process.

3.4 Research sample and structure

The entire management team of the textile manufacturing organisation was selected as a study group. The structure of the management team is represented in the organisational diagram shown in figure 3.1. The team was divided between the main management business units of the organisation. The management team is comprised of 13 managers of which four are female and nine male. This selection of all the managers was done to ensure a sample across the entire organisation. Of the 13 managers who were interviewed, 10 had a relevant qualification in the textile industry. The two senior directors (the CEO and the Financial Director) had exposure to Scientific Management during their post graduate studies. Each of the managers completed the organisational diagram which was used in the interview to obtain information to test the research assumption. This was done to obtain an adequate representative sample across all departments within the organisation. Access to information concerning the complexity of the decision that was required, was outside the scope of this study, but is listed as a limitation of this study. Questions that were fielded during the interviews are discussed in detail in section 3.5 of this chapter.

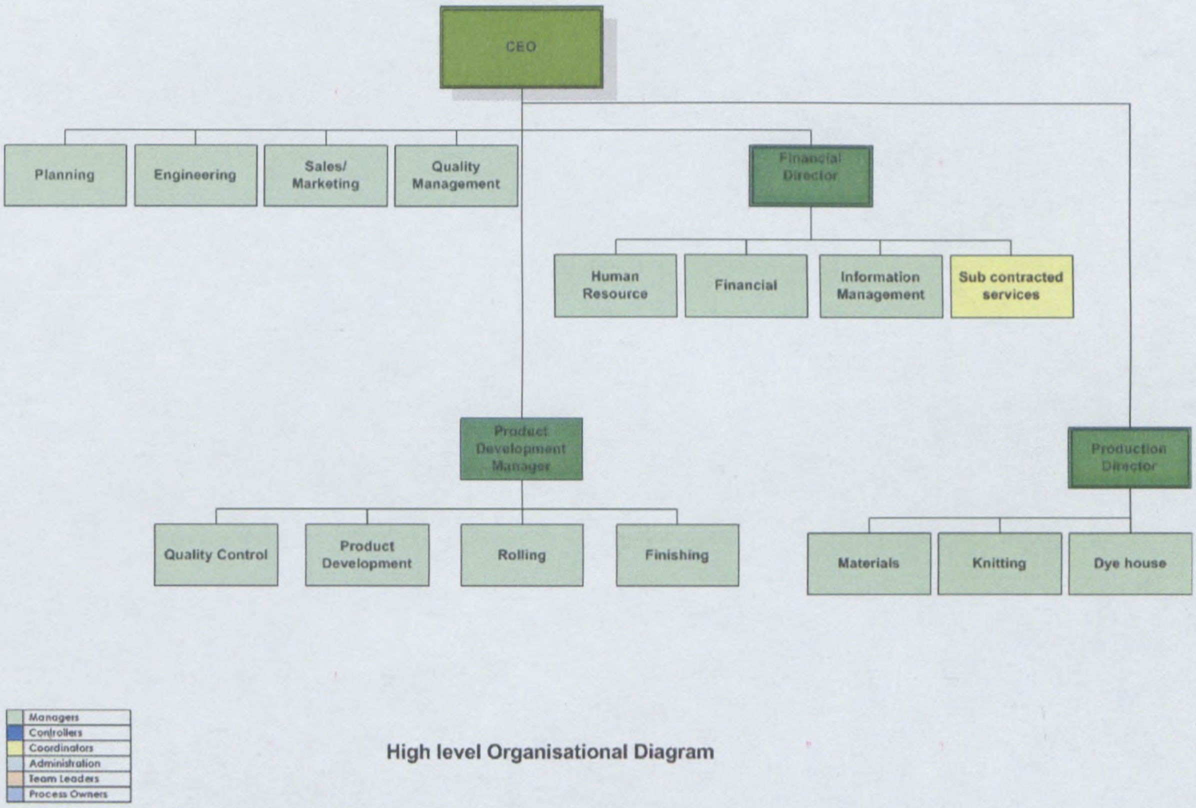

Figure 3.1 Study Company Organisational Diagram (2008)

Interviews were used as the basic data collection method to avoid misinterpretation of questions that could have happened had the questions been in the form of a questionnaire. Management Science is a misunderstood field and managers are easily confused by terms that are used in the field of Management Science and Operations Research. The interview was developed especially to cover the objectives of this study, and to serve as input to future study. Each manager was interviewed over a period of four months. The interview questions are discussed in section 3.5 of this chapter. These interviews were analysed and the results are described in Chapter 4.

3.5 Interviews, Surveys and Questionnaires as research techniques

3.5.1 Introduction

Questionnaires come in many shapes and sizes depending on the information that is required, the targeted group and the survey method that is being used. According to Nel, Rader and Loubser (1988:232) all questionnaires are designed to achieve three related, very important and relevant goals. They are to "maximize the relevance and accuracy of the data that were collected, to maximize participation and cooperation from the targeted respondents and to facilitate the collection and analysis of the data"

With this in mind, the researcher placed much emphasis on the following:

- Making the questionnaire as concise as possible without compromising the accuracy of the collected data.
- Ensuring definitive answers by making sure that the questions were definitive.
- Keeping the content of the questionnaire as simple as possible. Where seemingly complicated issues needed to be answered e.g. "total cost of ownership," an explanation of the concept was given to assist with the understanding thereof.
- Avoiding leading questions.
- Providing sufficient information so that the respondents could participate without having to refer to others.
- Avoiding questions that might embarrass or belittle the respondent.
- Providing a question flow that was logical and well sequenced.
- Using scaled questions and other formats such as multiple choice questions and open-ended questions where applicable.
- Using bridging in the questionnaire to save time and increase respondent participation. In other words creating a bridge between one question and another if a question is not appropriate in a particular circumstance.

Much effort was placed upon relating all the questions to the objectives of the research study. In other words, the questions that were posed in the questionnaire were relevant to the research study and its objectives.

In-depth individual interviews were conducted. According to Aaker, Kumar and Day's (2003:191) such methodology provides the opportunity to explore the subject matter comprehensively as face-to-face interviews allow the researcher to "read" the respondents' feedback and to obtain clarity if there are any areas of uncertainty during the interview.

3.5.2 What is a Survey?

The survey method is usually associated with the deductive approach, and the results are based on a questionnaire. This allows the data to be standardised and therefore makes for easy comparisons. Structured observation, like the one associated with organisation and methods research, and structured interviews, where standardised questions are posed to all interviewees, both fall within the survey research method category (Saunders, Lewis and Thornhill, 2000).

3.5.3 How to use Surveys and Questionnaires

The first stage of a survey is to select the sample. The sample selected must not be biased and should represent the population from which it is drawn. If the population is large then it could be too time consuming and expensive to collect data. That is why, by using a sample rather than a population, statistical techniques may be used to generalise the findings of the survey in an inexpensive manner. The second stage of the survey is to decide on how to ask the survey questions (Hussey and Hussey, 2000).

3.5.4 Face-To-Face

An example of a face-to-face scenario would be that of a personal interview. Personal interviews provide an excellent way to get in-depth and comprehensive information and the process simply involves one person interviewing another. Some drawbacks are that they tend to be very expensive because of the one-on-one nature of the interview. Typically, an interviewer asks questions from a written questionnaire and then records the answers verbatim. Personal interviews are only generally used when subjects are not likely to respond to other survey methods (StatPac Inc, 1997-2005).

Thorough steps should be taken in designing a survey and those steps are:

- The first step is planning the survey content. This involves reviewing the literature and observing the interviewing members. It also entails formulating hypotheses about the problem or issue that the survey addresses.

- The second step is the sample plan.

- The third step requires the construction of the questionnaire, the administration of the instructions and a pilot test.

- The fourth step concerns the arrangement for data collection (e.g. telephone or mail surveys) and following up non-respondents.

- The fifth step is to code the questions, input the data and edit the data.

- The sixth step is to analyse the data and report on it in writing so that the original questions may be answered.

- The last step is to provide feedback to those who commissioned the survey.

(Welman and Kruger,1999)

3.5.5 When it is appropriate to use the Questionnaire

This technique can be used at any stage of development, depending on the questions that are asked in the questionnaire (Hom, 2001). In situations where large amounts of data are likely to be collected, it is important to make sure that the researcher asks everyone the correct and the same questions. To avoid a large range of answers, questions with a fixed set of possible answers can be asked and the people being asked can be encouraged to select one of the possible answers on the questionnaire sheet (Geography Exchange, 1999).

There is no set rule for when to use a questionnaire. The choice of whether or not to use a questionnaire will be made based on a variety of factors, including the type of information being gathered and the available resources for the data collection. A questionnaire should be considered in the following circumstances:

- When the resources and money available are limited.
- When it is necessary to protect the privacy of the participants.
- When corroborating other existing findings.

(Georgia Tech, 2005)

3.5.6 Advantages of Questionnaires

The researcher can contact large numbers of people quickly, easily and efficiently using a questionnaire (Sociology Central, 2003). They are very cost effective when compared to face-to-face surveys and other data collection methods, especially when involving large sample sizes and large geographic areas. Written questionnaires become even more cost effective as the number of research questions increases (Walonick, 2000).

Questionnaires are relatively quick and easy to create (Walonick, 2000). Interpretation and analysis is easy, as data entry and tabulation for nearly all surveys can be easily done with many computer software packages (Sociology Central, 2003).

Questionnaires are familiar to many people, nearly everyone has had some experience completing one and they do not make people apprehensive (Walonick, 2000).

A questionnaire is easy to standardise therefore reducing the amount of bias in the results as there is uniform question presentation. The researcher's opinions will not influence the respondent to answer questions in a certain manner, as there are no verbal or visual clues to influence the respondent (Walonick, 2000).

Questionnaires are generally less intrusive than telephone or face-to-face surveys, because when a respondent receives a questionnaire in the mail, they are free to complete the questionnaire in their own time or not complete it at all. Unlike other research methods, the respondent is not interrupted by the research instrument (Walonick, 2000).

Questionnaires can be used to ask potentially embarrassing questions (such as sexual and criminal matters) more easily than other methods, because they can be anonymous and completed in privacy. This increases the chances of people answering questions honestly (Sociology Central, 2003).

3.5.7 Disadvantages and Limitations of Questionnaires

A major disadvantage of a questionnaire is the possibility of a low response rate. Low response is the 'curse of statistical analysis' and can dramatically lower confidence in the results as the sample becomes unrepresentative of the target population. Response rates vary widely from one questionnaire to another, but well-designed studies will constantly produce a high response rate (Walonick, 2000). The problem of self-selecting the sample is large when it comes to questionnaires. When the response rate is very low, the responses received may only be the opinions of the very highly motivated section of the sample; people with strong opinions that take the time and trouble to complete and return the questionnaire (Sociology Central, 2003).

The questionnaire format makes it difficult for the researcher to examine complex issues and opinions (Sociology Central, 2003). Questionnaires are unable to probe respondents' responses, as they are structured instruments that allow little flexibility to the respondent with respect to their responses. Respondents often want to qualify their answers, so by allowing frequent space for comments, the researcher can to some extent overcome this disadvantage. Comments are sometimes the most helpful of all the information on the questionnaire and usually provide insightful information that would otherwise have been lost (Walonick, 2000) and even when open-ended questions are asked, the depth of answers that the respondent tends to provide are more limited than with other methods of research, making it difficult for researchers to gather information that is rich in depth and detail (Sociology Central, 2003).

With questionnaires, gestures and other visual cues are not available, therefore they lack personal contact and this will have an effect on the information being requested. For example: a questionnaire requesting factual information will probably not be affected by the lack of personal contact, while a questionnaire probing sensitive issues or attitudes may be severely affected (Walonick, 2000).

With a postal questionnaire, the researcher can never be certain the person to whom the questionnaire is sent actually fills it in, or it may not be suited to some people e.g. people that are poorly educated (Walonick, 2000).

Where the researcher is not present when the questionnaire is being answered, it is difficult to know whether or not a respondent has understood a question properly and the researcher has to hope the questions asked mean the same to all the respondents as they do to the researcher (Sociology Central, 2003).

3.6 Research interview questions

Face –to- face interviews were utilised for data collection of the study organisation. The following research questions for research data collection were fielded during the interviews:

3.6.1 Question 1

Does the organisation have formal management systems in place to supply data which facilitates management decisions?

Question 1 Objective: Determine whether available information is structured to assist the decision-making process.

Qualitative Measure: This information was recorded via face-to-face interviews to determine whether information, which facilitates decision-making, is available to management.

The figure below was employed to support the interview questions:

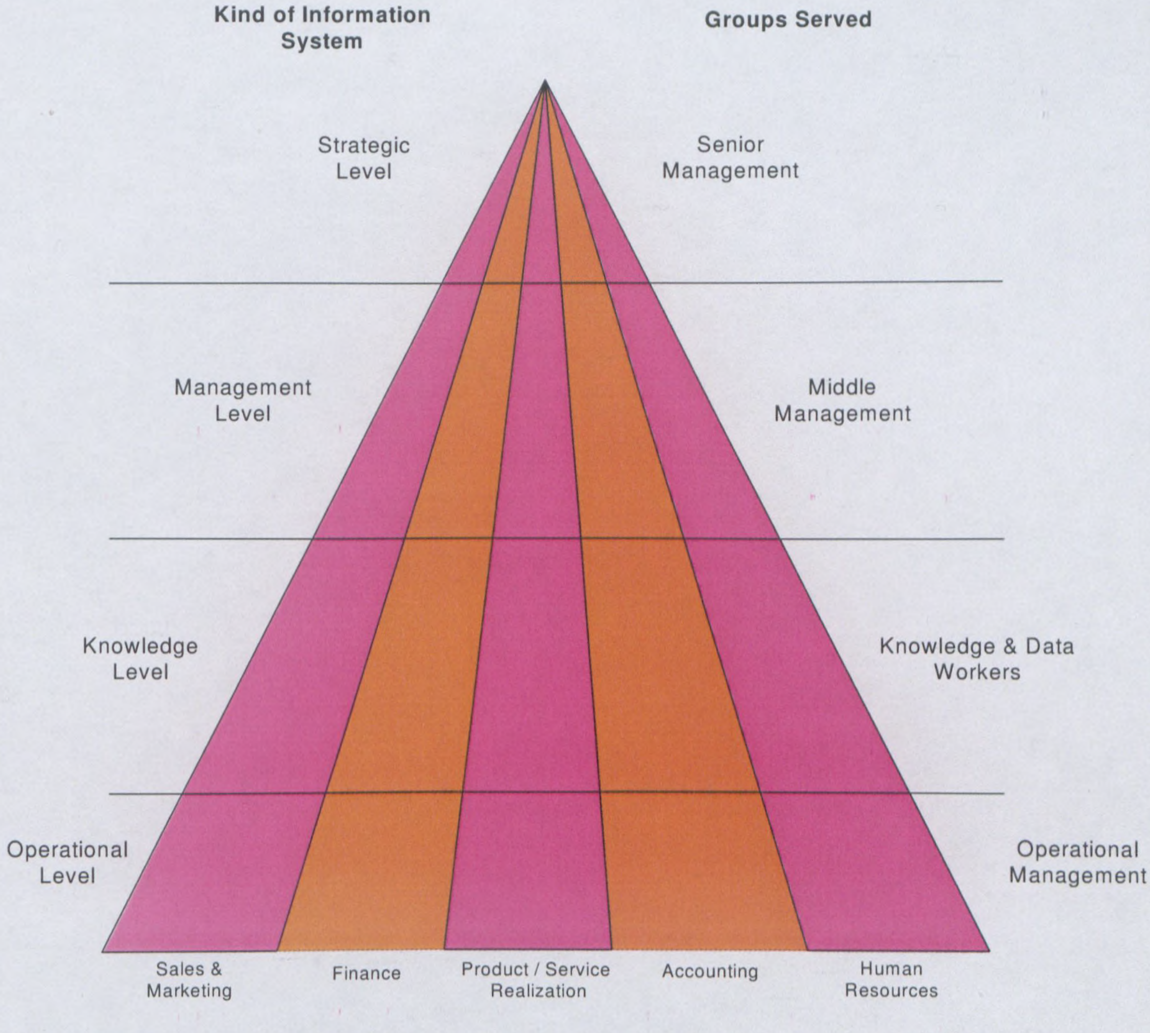

Figure 3.1, Types of information systems (Laudon and Laudon, figure 1.6, 1996:17)

3.6.2 Question 2

What level of Information Systems (IS) does the organisation make available?

Question 2 Objective: Determine the structure types of information required to facilitate decision-making.

Qualitative Measure: The information systems structure matrix, which was developed by Laudon and Laudon (figure 3.2), was applied to determine if:

- the information systems that are available are structured, retrievable

If the information was not easily retrievable, managers would not be able to make objective decisions.

- **Strategic Level Information Systems**

The support systems at this level are known as Executive Support Systems (ESS). Executive Support Systems include all systems that are employed by top management within an organisation and are used for forecasting and planning.

- **Management Level IS**

Known as Management Information Systems (MIS) and Decision Support Systems (DSS), these are utilised for management activities, scheduling, analysis, control, budgeting and costing.

- **Knowledge Level IS**

Knowledge Work Systems (KWS) are used by knowledge workers to influence operational strategies, as well as Office Automation Systems (OAS) such as workstations and data processing software.

- **Operational Level IS**

Transaction Processing Systems (TPS) are mainly applied for execution of administration, accounting and record keeping.

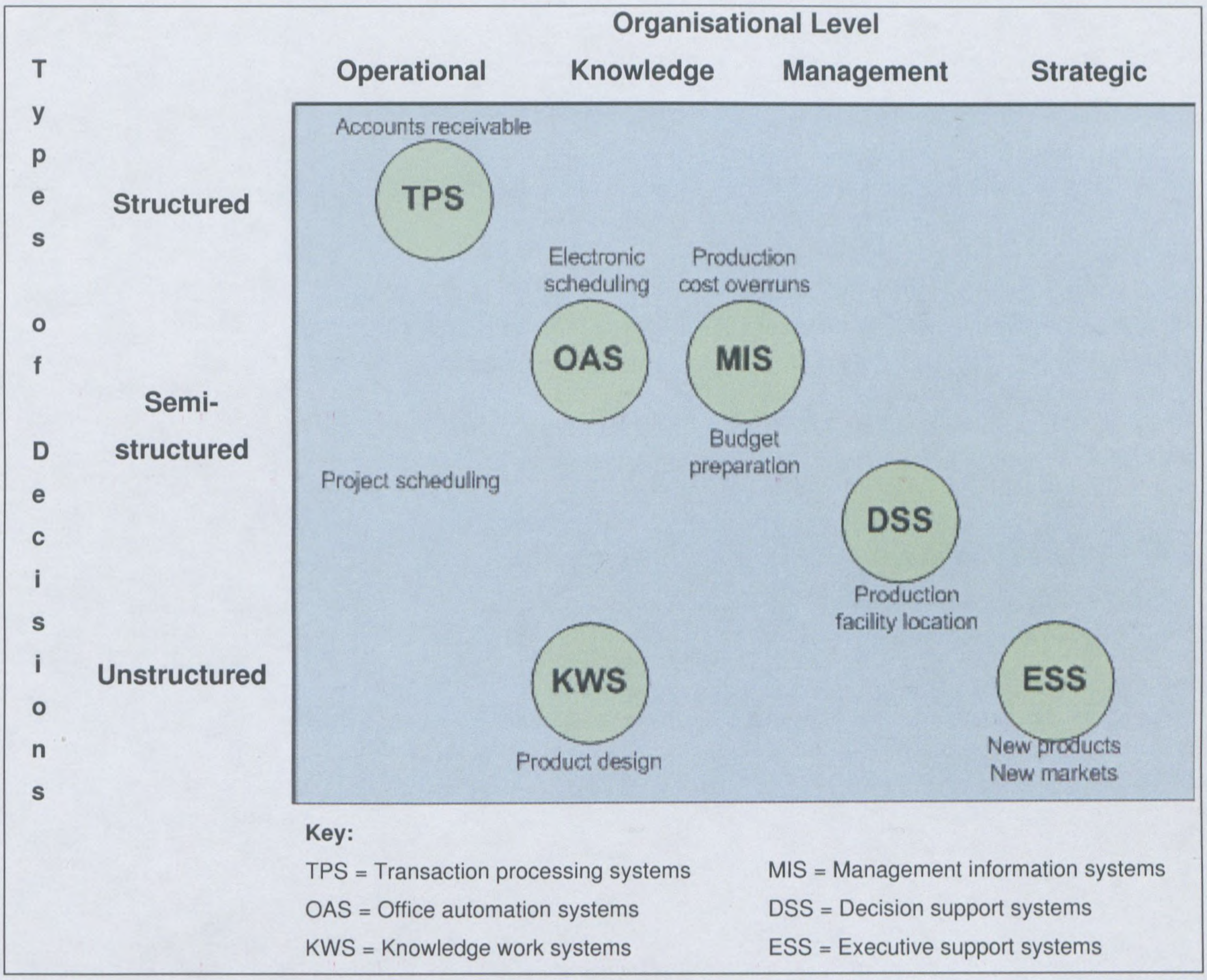

Figure 3.2 Decision Types (Laudon and Laudon, figure 4.2, 1996:121)

3.6.3 Question 3

Do they have Management Science competencies?

Question 3 Objective: Evaluate the skills and formal education of management to determine exposure to the Management Science and Decision-making Theory.

Qualitative Measure: Managers' formal exposure to decision-making theory was investigated by reviewing techniques that were listed and by testing the decision-making model, which was developed by the present author, and is attached to this thesis.

3.6.4 Question 4

If the manager does have Management Science competencies, which techniques does he/she apply?

Question 4 Objective: To determine, which Management Science techniques they apply.

Qualitative Measure: The list of techniques obtained from the literature study was utilised to determine the techniques applied by the manager of the various business units.
The list of techniques is an annexure of this study.

3.6.5 Question 5

What procedure do they follow to facilitate decision-making?

Question 5 Objective: To determine decision-making steps that is employed by management to facilitate decision-making.

Qualitative Measure: To determine the process steps that each manager follows to systematically break down a problem or challenge in order to reach a formal decision.

3.7 Data Analysis

Data that was collected during the interviews and from the questionnaires was interpreted and analysed by the present author. Results of the data analysis were captured and processed by the utilisation of a spreadsheet based model, which was designed by the present author.

3.8 *Chapter summary and limitations*

The chosen sample for this study was limited to one organisation in an industry that is under pressure to become more profitable and to work more smartly. Access to information and the complexity of decision-making was outside the scope of this study, and is therefore a limitation of the study. The management team of the organisation is not representative of the total population of managers across all South African textile companies. More research is required to lift the sample size and validate the research findings. It is, however, safe to assume that the management team that was sampled is representative of managers in the greater Western Cape business community.

The next chapter presents the results and the discussion.

4 CHAPTER 4 – RESULTS OF RESEARCH

4.1 Results from decision-makers

This section discusses the interviews with decision-makers. Insights were gained regarding the decision-making processes that were employed using the information that was available.

4.1.1 Information collection

Informal interviews were held with 13 managers of the textile manufacturing organisation. These include people at director level, and at both senior and lower management levels. As indicated by Figure 4.1 the gender split of the 13 who were interviewed, nine are male and four are female. All but one had formal NQF level 6 and higher qualifications and only 4 of the 13 had post graduate qualifications.

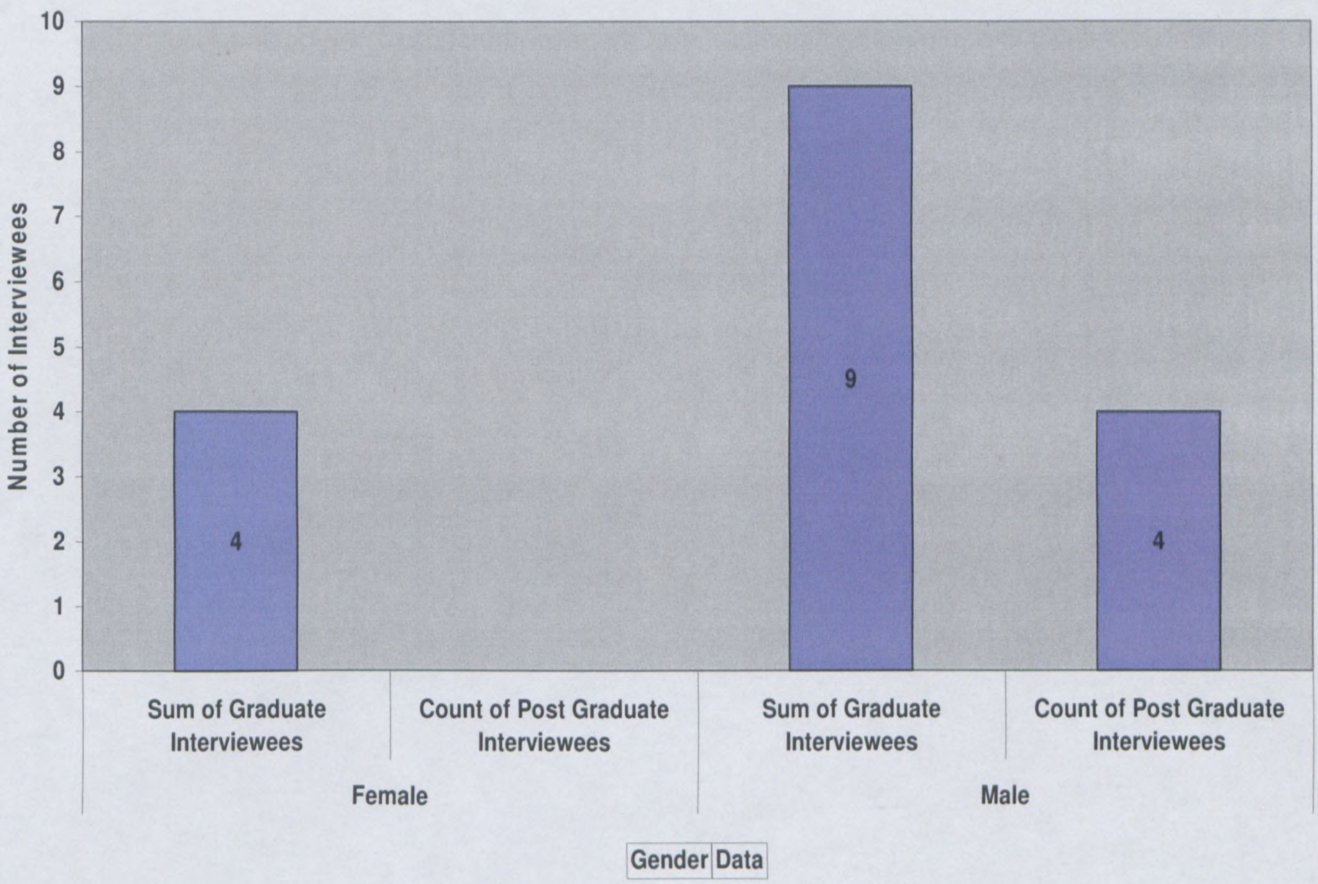

Figure 4.1 Gender Split

Each decision-maker discussed examples of decision-making that they were involved in during their day-to-day functioning within the organisation. Subjectivity and potential incompleteness of records were partially managed by asking all interviewees the same questions. All interviews were conducted by the same interviewer.

Questions 1 and 2 were fielded to all decision-makers, but only to the Information Technology Manager, Financial Manager and Chief Executive Officer had a influence on the structuring of information that was supplied to them for decision-making. Questions 3 – 5 were posed to all decision-makers and recorded on record sheets which are attached to this study. With regards to the management science techniques, it was possible for the interviewees to be untruthful about their understanding and application of the techniques, as this paper's scope was merely to determine stated use and not actual practical application.

4.1.2 Discussion of Question 1

Does the organisation have formed management systems in place, which supply data to facilitate management decisions?

All 13 respondents confirmed that there are reports available on the SAP ERP information system, which facilitate decision-making. The level of understanding regarding how to extrapolate reports and analyse these to assist in the decision-making process, is low. Although most knew how and where to obtain the reports, only six of the 13 knew how to analyse the reports to extract useful data, which would serve as an input to the decision-making process. Reports and MIS are structured in accordance with the Laudon and Laudon model (Figure 3.1).

4.1.3 Discussion of Question 2

What level of Information Systems (IS) does the organisation make available?

The organisation has implemented a fully functional SAP R3 ERP information system. Maintenance of the SAP system and training of staff on the use of the SAP system has not taken place over the last few years. This has created a situation where staff and specifically management have been unable to stay abreast of information that is available to them. This has led to reports that the level of understanding of management is low. Information has been available, but not everyone has had the appropriate skills to interpret it.

Internal spreadsheets and data capturing has been employed by seven of the 13 managers that were interviewed, to facilitate data analysis for constructing reports for senior management meetings. This practice specifically took place at an operational and knowledge level of the Laudon and Laudon decision type matrix (Figure 3.2).

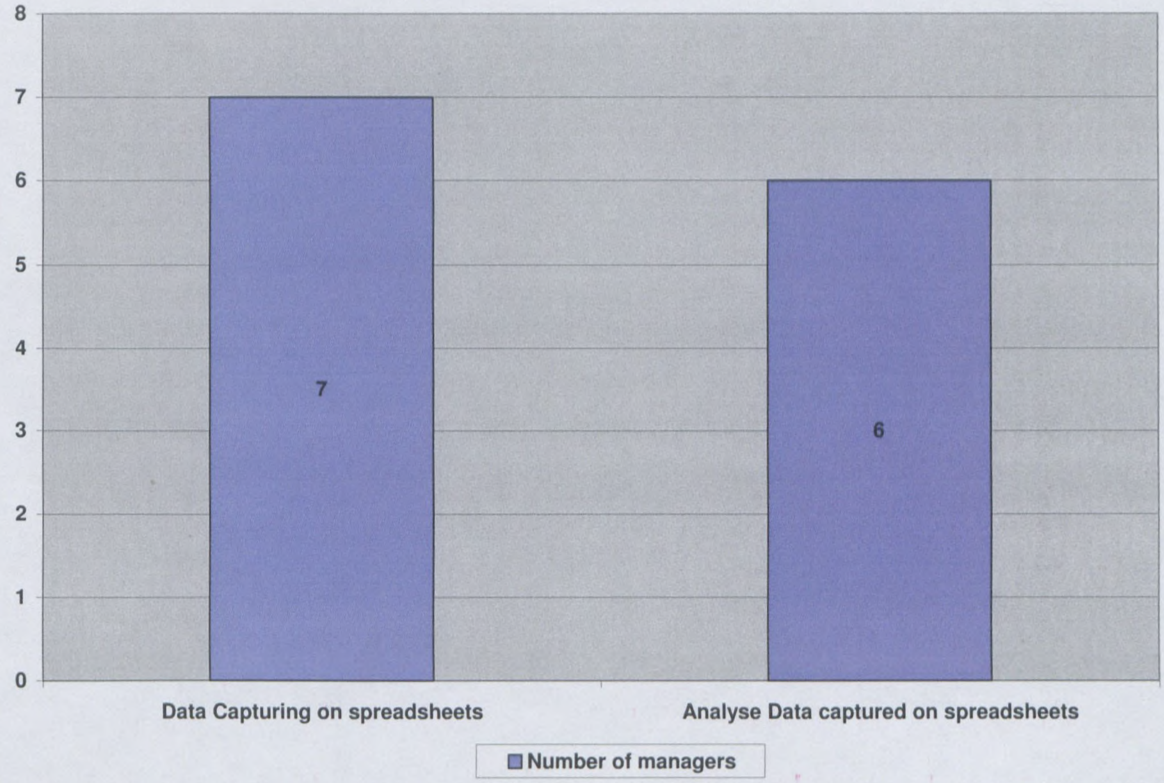

Figure 4.2 Total capturing data for analysis on spreadsheets

As can be seen in Figure 4.2 only 6 of the 13 managers interviewed captured data on a spreadsheet and analysed the data they captured for decision making.

The SAP ERP system does have an ability to supply information on all six types of decisions as per the Laudon and Laudon decision type matrix. This case study found that information that was available from the SAP system is not fully utilised to assist in decision-making. This has led to fragmented and low quality decisions being made in isolation.

Due to the fact that information and data capturing on spreadsheets is not part of an integrated management system, like the SAP ERP system implemented at this organisation, decisions are often made in isolation with little regard for overall alignment with organisational vision. The spreadsheets generated to facilitate decision-making were not integrated into a company wide database. Duplication of reports and information analysis was evident.

4.1.4 Discussion of Question 3

Determine the understanding of decision-making by reviewing the decision process with each manager.

A total of five of the 13 managers had formal exposure to Decision-making Theory. All of the 13 who were interviewed make use of Decision-making Theory in their day-to-day conduct. All agreed that the problem solving model was helpful and simple to understand, while only five of them made use of a similar structured approach to decision-making. The other eight were required to make decisions on a regular basis, but followed no formal structured process.

4.1.5 Discussion of Question 4

If the manager does have Management Science competencies, which techniques do he/ she apply?

The list of competencies was reviewed with interviewees and the following matrix was populated:

Table 4.1 Management Science awareness matrix

Management Science Technique	Number out of 13 indicating awareness	Percentage (out of total complement
Linear Programming	3	23%
Simplex Method	1	8%
Simulation	7	54%
Markov Analysis	4	31%

Management Science Technique	Number out of 13 indicating awareness	Percentage (out of total complement
Transportation problems	2	15%
Assignment problems	5	38%
Mathematical Modeling	10	77%
Network Models	11	85%
Project Management CPM/PERT	11	85%
Inventory Models	11	85%
Dynamic Programming	0	0%
Decision Theory	12	92%
Games Theory	1	8%
Queuing Theory	2	15%
Goal Programming	2	15%
Integer Programming	2	15%
Non Linear Programming	2	15%
Unconstrained Extrema	0	0%
Constrained Extrema	0	0%
Forecasting Models	11	85%

Management Science Technique	Number out of 13 indicating awareness	Percentage (out of total complement
Statistical Process Control	13	100%
Decision Trees	10	77%
Multi-criteria Decision-making	7	54%
Decision-making under uncertainty	7	54%

The Management Science awareness matrix (Table 4.1 and Figure 4.3) shows that Management Science awareness of some techniques (4 of 15) are high (> 70%). For 9 of the 15 techniques awareness are low to very low.

Although managers indicated that they were aware of these techniques, they were not asked to demonstrate them in practice. It is thus possible that a manager could indicate awareness of a technique without really being so.

The level of application, and thus competency, was observed to be low, since only two managers with knowledge of the techniques said they actually applied them. It is possible that a manager could indicate the ability to use a technique without really being able to do so.

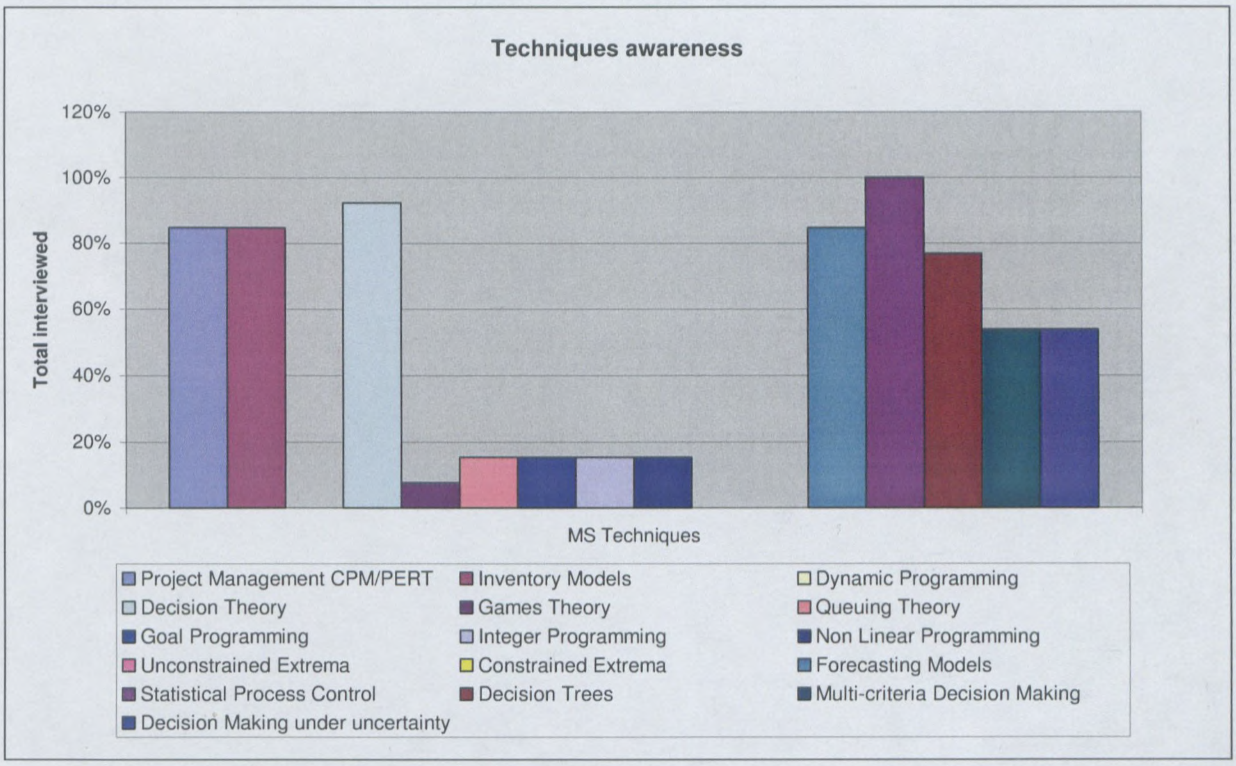

Figure 4.3 Management Science awareness graph

The top 10 techniques managers were aware of are summarised in the following table:

Table 4.2 Top 10 techniques awareness

Technique	Number	Percentage
Statistical Process Control	13	100%
Decision Theory	12	92%
Network Models	11	85%
Project Management CPM/PERT	11	85%
Inventory Models	11	85%
Forecasting Models	11	85%
Mathematical Modeling	10	77%
Decision Trees	10	77%
Simulation	7	54%

Technique	Number	Percentage
Multi-criteria Decision-making	7	54%
Decision-making under uncertainty	7	54%

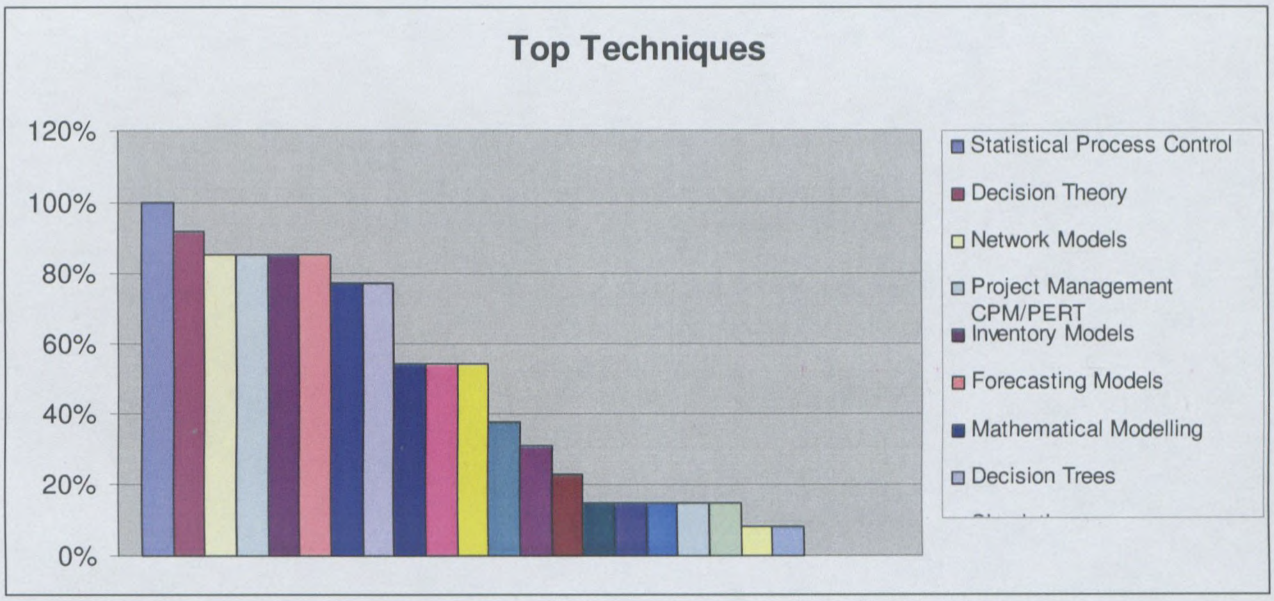

Figure 4.4 Top techniques awareness

The top 10 techniques (Table 4.2 and Figure 4.4) that management indicated they were aware of are mostly of a low mathematical complexity.

4.1.6 Discussion of Question 5

What procedure do they follow to facilitate decision-making?

A total of five of the 13 people who were interviewed made use of a structured decision-making process. Of these 5 managers only two could prove that they utilise a process in line with the Problem Solving Model developed as part of this study. Both of these could provide evidence of decisions made regularly based on a structured problem solving model.

The process they applied was in line with the sample process that was supplied by the author as part of the interview input. The time spent defining the problem or issue upon which the decision was made, was not assessed during this study, but should prove important with regards to the total decision-making process.

In chapter 5 the conclusion and results of the research are detailed.

5 CHAPTER 5 – DISCUSSION OF THE RESULTS

5.1 Objectives of research

The main objective of this research was the determination of Management Science competencies in a textile manufacturing organisation.

Key objectives of the research were to:

1. Identify whether or not the textile manufacturing organisation utilises Management Science techniques to assist in the decision-making process;

2. Determine whether or not Management Science techniques are utilised within the textile manufacturing organisation;

3. To identify which techniques are utilised by management and why; and

4. To determine the procedure that is utilised by the textile manufacturing organisation to facilitate the decision-making process.

5.1.1 Discussion of study

This study indicates that eight of the 13 of the managers in the organisation did not have the necessary competencies which are required to make decisions based on a Management Science technique.

Of the remaining five managers, two made use of Management Science techniques to assist in decision-making.

No one pointed out that there was a lack of available information with which to populate a mathematical model. It is thus safe to assume that the management information available was sufficient to assist in the decision-making process.

A total of ten managers were not aware that the decisions that they made could be assisted by the application of Management Science techniques. They knew where to get the information to make management decisions. Both the analysis of the information and the ability to identify extra sources of information were lacking.

There seems to be a direct relation between managers who had post graduate qualifications and their ability to use and present data in reports to assist in the decision-making process.

All the managers made use of reports that were supplied by the SAP ERP information management system to manage their particular areas of responsibility. No one revealed that they had the knowledge to be able to set up new or alternative reports to make data analysis easier.

No management scientist was employed by the organisation on a full time basis. The CEO did, however, appoint a management scientist specialist to assist in the definition and analysis of minimum reports that were required by management to assist in the decision-making process. Managers were thus required to act as both management scientists and decision-makers.

More than 80% of the managers made use of technology (MS Office) to assist in the analysis of information that was available to them. No awareness of more sophisticated techniques such as DSS (Decisions Support Systems) existed amongst the managers. This could be attributed to two main reasons. Firstly it seemed as if the managers of this organisation did not have the necessary experience or education to effectively make use of the information available to them to facilitate the decision-making process. This situation has resulted in the practice of generating spreadsheets of information that could have been supplied in a better format from the outset. Secondly, only four of the 13 managers had any exposure to formal Management Science techniques. What is interesting though is that only two of the four knew how to apply them.

Managers showed a preference for using self-help decision-making tools of low sophistication. Even the managers with formal Management Science education had the tendency to make use of basic decision theory and simple spreadsheet based decision-making algorithms. This can be mainly attributed to the lack of time the management team had to measure and analyse causes of problems. The lack of a full time management scientist could also have compounded this situation. During the study a management scientist was appointed by the CEO to assist in the analysis of data and generation of management reports to assist the management team. During the three month period the Management Scientist was at the plant, the level of decisions made and techniques used increased.

Double capturing of data took place owing to an inability to interpret the SAP ERP reports. A total of eleven managers made decisions based on basic SAP reports and did not analyse these to determine mathematical relevance.

Personal style and background also played a major role in the analytical approach to decision-making. A total of eight managers did not realise the impact that their decisions had on the overall organisational wellness. This could be due to the low level of managerial experience that these managers possessed. Of the 13 managers studied, only four had received formal management training at a graduate level. Although some of the other managers had attended courses in management, these did not seem to equip the managers efficiently to act as managers in the plant. Four of the managers “came through the ranks” as managers and had no previous formal exposure to management and decision-making.

Managers who were interviewed, agreed that the decision-making process that they would prefer to follow could be summarised by the flow diagram, which is attached to this thesis. They also agreed that defining a decision or problem is very important, and so it is worthwhile spending time and energy on this task.

6 CHAPTER 6 – CONCLUSIONS AND RECOMMENDATION

6.1 Conclusions

This study attempted to show the relationship between the level of Management Science awareness and competency for decision-making, based on available data.

This study shows that managers made daily decisions without basing them on any Management Science techniques. The decisions made were based on gut feelings and most decisions had no scientific basis. The reasons for this were attributed mainly to a lack of time available to facilitate the gathering, measurement and analysis of data available to them from the MIS utilised by the organisation.

Although outside the scope of this study, the quality of decisions was found to be low and risky for the organisation.

Decisions made were largely based on self generated spreadsheets and data misinterpretation could have taken place.

A total of two of the 13 managers realised the importance of analysis of data that could be achieved by means of Management Science techniques. They indicated that if they had more time available and the correct information easily at hand, they would apply Management Science techniques more often.

Of the all the managers interviewed, only one was competent enough to apply Management Science techniques on a regular basis to facilitate decision-making.

69% of managers made decisions within this organisation with little consideration for the long-term impact that these decisions might have on organisational health. Decisions were made on the spot, hence reactively, rather than proactively. The problems solved by this kind of decision-making tended to recur. Operational inefficiency was evident and the quality of decisions being made on the factory floor was very low.

Management Science competency was found to be low among managers of this textile manufacturing company. This can be due to their overall lack of exposure to the various techniques listed in this study. It was evident that even the manager who had exposure to formal tertiary training in the application of Operations Research techniques, had difficulty indicating the frequency with which he applies these techniques. It was suggested that the main reason for the lack of application of these techniques was the lack of time available to analyse information and build mathematical models.

This study also revealed that the people that had the competency in Management Science did not necessarily know where to get the information from in order to build algorithms for Operations Research. Most of the managers did not realize that the SAP ERP system could be setup to supply information that is easy to manipulate to use in the generation of a mathematically based decision model.

It did appear though that even if they had had this information, ready to use in the form of SAP reports, they would not have had the competency to utilize it.

Few Management Science techniques are utilised by this textile manufacturing organisation to assist in the decision-making process. Decisions are largely made on gut feel and seem to recur often. The use of Management Science techniques was not promoted by senior management, as even they did not fully understand and support the use of such techniques.

Certain unsophisticated Management Science techniques are utilised within the textile manufacturing organisation, mostly Statistical Controls and Decision Theory.

Techniques were utilised not to facilitate decision-making as a whole, but more to assist in the daily monitoring of production and financial key performance indicators. This was never the less accepted as usage for the purpose of this study.

Techniques that were utilised by management were driven by what could be done in as little time as possible. Management felt that they did not have the time to build time consuming Management Science models. With the introduction of a full time Management Scientist the number of decisions tripled. The quality of these decisions was not assessed due to the time constraints of this study.

No clear structured approach was utilised by the textile manufacturing organisation to facilitate the decision-making process. Management did not give clear guidance on the protocol to be used for decision-making and no procedural support existed.

No formal education and training exists in the organisation. Exposure to Management Science techniques and their importance in scientifically based decision-making was clearly supported by management. It would be safe to assume that a formal training program to teach managers the importance of scientific decision-making would have made a positive impact on the quality of decisions made.

6.2 Recommendation

The author recommends further study concerning the application of Management Science by managers who have had little or no exposure to scientific management training.

This author believes that even managers with little or no formal Mathematical education can become competent in the application of Management Science techniques.

The results and findings can act as a springboard for further study regarding harnessing management science skills in an organisation with immense exposure to global influences.

Mathematics that is taught at tertiary institutions should be investigated for its application to decision-making for personnel who only have lower levels of schooling. Many Managers attend leading business schools where than are educated in Operations Research. However, once they are qualified, not many of them ever make use of the Management Science competencies they were taught. It is recommended that a study should be made of how many MBA students actually make use of Management Science to facilitate decision-making once they are back in the main stream of the business world. The gap between mathematics taught at school level and university level has been studied outside the Republic of South Africa, but not really in this country. It could prove beneficial to the school curriculum to look at the South Africa case.

This study has shown that even if structured information is available, it does not guarantee that managers will know how to apply it within their area of responsibility. It is thus important for managers to fully understand the data available to them in the MIS they have at their disposal. Further study into the effect of data warehousing and Business Intelligence should be embarked on. Business Intelligence has become vital to the modern organisation, as the amount of information that is available to managers has out stripped the human ability to process it. Business Intelligence will become the future of information structuring and decision-making.

Further investigation is required to determine the impact that poor mathematical exposure at schooling level has on managers in business. This study has shown a relationship between the level of mathematical literacy and the application of management science techniques. The effect of having studied matric mathematics at school was outside the scope of this study.

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Annexure A - Sample record sheet

Business Unit									
Technique									
Linear Programming									
The Simplex Method									
Simulation									
Markov Analysis									
Transportation Problems									
Assignment problems									
Mathematical Modeling									
Network Models									
Project Management CPM/PERT									

Annexure A - Sample record sheet

Business Unit										
Technique										
Inventory Models										
Dynamic Programming										
Decision Theory										
Games Theory										
Queuing Theory										
Goal Programming										
Integer Programming										
Non Linear Programming										
Unconstrained Extrema										

Annexure A - Sample record sheet

Business Unit									
Technique									
Constrained Extrema									
Forecasting Models									
Statistical Process Control									
Decision Trees									
Multi-criteria Decision-making									
Decision-making under uncertainty									

Annexure B - Problem Sovling Model (Erasmus, 2009)