

**On the effects of structuring idea generation tasks and supporting
consensus building in a Multi-Criteria Group Decision Making
Environment**

by

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ABSTRACT

Decision making is a process that is characterized by several activities. For a typical semi-structured to unstructured multi-criteria task, decision-makers must go through problem exploration, the so-called intelligence phase, to understand what the task is about. Subsequent, critical activities are design of alternatives, choice generation and building consensus around the generated choices. The best idea will be implemented usually by a group of several stakeholders. Unless care has been taken to build consensus during the decision process, the implementation is unlikely to succeed. That is, the decision is unlikely to become a purposeful action. At the same time, the multiple objective nature of the considered tasks also adds to the group decision-making process.

This research explores both creativity or idea generation and supporting consensus building on the basis of the above justification. An investigation of the current status of multi-criteria group decision making is done through literature surveys of the fields of Multi-criteria Decision Making and Group Decision Support Systems. Particular emphasis of the theoretical and practical sides of this research is placed on supporting creativity and supporting consensus building. In the former, the issue of task structuring is considered as a way to better enhance the creativity process, within a laboratory experiment on a problem related to information systems and systems analysis and design. In the support of consensus building, a theoretical framework is examined within a real life study using the multiple criteria group decision-making environment, Team Expert Choice.

PREFACE

The experimental work described in this dissertation was carried out in the School of Mathematics, Statistics and Information Technology, at the University of Natal, Pietermaritzburg, from October, 1997 to November 1999 under the supervision of Prof. Don Petkov of that School.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any university. Where use has been made of the work of others, it has been duly acknowledged in the text.

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CHAPTER 1. INTRODUCTION

The Chief Executive Officer (CEO) of today's business organization no longer makes momentous decisions on his or her own. The nature of organizational decision making has changed. There are two, inter-related reasons for this. The first is the increasing complexity of organizations and the environment in which they must operate; the second relates to the increasing levels of specialization by individuals. The multi-dimensional nature or complexity of organizational problems requires these specialists to periodically interact to solve business problems effectively. Groups are inherently gifted with the ability to out-perform individuals. Many a study has been devoted to ascertain this (Nunamaker et al., 1999; Pervan, 1998). Organizational and environmental complexity not only requires group interaction, it requires those groups (and individuals that make them up) to be creative in the problem solving process. This can be seen in today's business organizations increasingly employing creativity experts to give them an edge over their competitors.

Effective problem solving groups also require the ability to readily reach agreement on the solutions or ideas they generate. At the same time, the ability to successfully implement an idea or solution depends directly on the group's ability to build and reach consensus around the required solution. In some scenarios, this consensus is the ultimate goal of the decision making process, because of the existence of numerous stakeholders. For example, joint ventures, formed for strategic business reasons, require consensual decision making on the part of the parties involved in order to function effectively.

1.1. Overview of the structure of the dissertation

This dissertation is structured in the following manner. The first chapter is an introductory chapter articulating the goals of the research, its importance and justification and broadly its foundations on the theory of decision making. The second chapter explores research issues surrounding MCDM. The third chapter is a literature survey of GSS research and its current status. The fourth chapter explores the specific theoretical foundations of the practical work

undertaken in this thesis. Chapter Five looks at the design, formulation and discussion of the experimental work of this thesis. Finally, Chapter Six concludes the research and looks at future research issues.

1.2. The background to the research problem

Before the tasks and scope of this research are outlined, it is necessary to consider the issues regarding group interaction within the broader field of decision making.

Decision making is a well-researched field with robust theoretical foundations upon which any study of group decision making systems or multiple criteria decision making must draw. In this section the foundations of decision making and the possible classifications of decisions and decision makers are briefly explored.

On the Foundations of Decision Making

“Decision making is a process of choosing among alternatives courses of action for the purpose of attaining a goal or goals” (Turban and Aronson, 1998:7). Research and surveys of managerial tasks have consistently reported that the large bulk of managerial activities consist of decision making. “The manager is first and foremost a decision maker” and “all managerial activities revolve around decision making” (Turban and Aronson, 1998; Laudon and Laudon, 1996). It has been noted that managers have considered decision making a pure art, something acquired through experience learning by trial and error. This is because of individual styles being used to approach and successfully solve the same type of managerial problems (Turban and Aronson, 1998). These styles are based mainly on creativity, intuition, judgment and experience, in contrast to being founded on systematic quantitative methods that are grounded on a scientific approach (Turban and Aronson, 1998).

However, in recent times, society has witnessed organizations evolving in a way that regularly and periodically requires groups of individuals and not just individuals to be collectively called upon to address semi-structured tasks for the benefit of the organization (DeSanctis and Gallupe,

1987; Pumsook and Jenney, 1997). Organizational problems have either become increasingly more complex and or organizations have to be more accountable for the decisions they make. There is an extended pool of stakeholders in the decisions facing organizations. This pool has grown to include what previously would have been considered outsiders to the process and the outcome.

Turban and Meredith (1994) identify the environmental changes (see Table 1.1 below) that have increased the general level of complexity of the environment in which managers must operate. For example, the state of competition has so increased that neither physical border nor legislation can protect organizations; this has had the most impact on recently democratising societies. Turban and Meredith (1994) conclude that because of these changes decision making has become more complicated than in the past.

Table 1.1 Factors Affecting Decision Making. (Adapted from Turban and Meredith (1994))

Factor	Trend		Results
Technology	Increasing	→	More alternatives to choose from
Information/computers	Increasing	→	
Structural Complexity	Increasing	→	Larger Cost of Making Errors
Competition	Increasing	→	
International Markets	Increasing	→	More uncertainty regarding the future
Political stability	Increasing	→	
Consumerism	Increasing	→	
Government intervention	Increasing	→	

The above table shows that the increase in the number of alternatives facing decision makers as a result of the changes in the major factors affecting decision making contributes to the increase in complexity of the latter. There are four reasons advanced for this. (1) There are unabated, rapid

improvements being made in technology and communication systems. (2) The cost of committing an error can be very large, precisely because of the “ complexity and magnitude of operations, and the chain reaction that an error can cause in many parts of the organization” (Turban and Aronson, 1998:9). (3) The information necessary to make decisions can be difficult to access. (4) Decisions have to be made quickly (Turban and Aronson, 1998).

As a result of these changes and trends, the trial and error approach to managerial decision making has become unreliable. Managers have to be more sophisticated and use new tools and techniques that have been and continue to be developed (Turban and Aronson, 1998). Computer applications have moved from transaction processing and activity monitoring to information systems that support problem analysis and solution applications.

Levels of Decision Making in Organizations

It is important to make the distinction between problem solving and decision making: “the three activities – fixing agendas, setting goals and designing actions – are usually called *problem solving*”; while “evaluating and choosing is usually called *decision making*” (Simon et al., 1987:11).

Anthony (1965) usefully grouped decision making in organizations into three levels:

- The Strategic level - which concerns itself classically with determining long-term objectives, resources, and policies in an organization.
- The Management Control level – which is related to the monitoring of how efficiently and effectively resources are utilized and how well operational units are performing.
- The Operational Control level – which concerns itself with deciding how to carry out tasks specified by upper and middle management and establishing criteria for completion and resource allocation.

More recently, Laudon and Laudon (1996) have suggested that another level between management control and operational control can be included,

- The Knowledge-level - which typically deals with evaluating new ideas for products and services; ways to communicate new knowledge and ways to distribute information throughout the organization.

Laudon and Laudon's (1996) definition is appealing in light of the prevalence of knowledge workers in today's organization.

Possible Classifications of Decisions

For each level of decision making in an organization there are various types of decisions that must be 'made' at various points in time. Simon's (1960) classification of these decisions types as being either programmed or non-programmed has been largely embraced in the literature. Often, this same distinction is referred to as structured and unstructured decisions (Turban and Aronson, 1998; Forman, 1997, Turban and Turban, 1996 and others). Unstructured decisions have been described as novel, important, non-routine decisions in which the decision maker must provide judgment, evaluation, and insights into the problem-definition: there is no agreed-upon procedure for making such decisions (Gorry and Scott-Morton, 1971; Stevens and Finlay, 1996). Structured decisions on the other hand are decisions that are repetitive, routine and have a definite procedure for handling them (Gorry and Scott-Morton, 1971; Laudon and Laudon 1996). In between lie decisions that are semi-structured, that is, decisions where only a portion of the decision has clear answers that can be generated by a known or accepted procedure (Laudon and Laudon, 1996).

Stages in Decision Making

While there are different types of decisions for each of the organizational decision making levels, it is important to note that decision making per se is not a single unified activity or event (Laudon & Laudon, 1996; Simon 1960; 1977, Turban and Aronson, 1998; Forman, 1997). Decision making is a process characterized by several activities, which typically take place at different times. A process can be defined as 'a series of actions, changes, or functions that bring about an end or result' (Forman, 1997:20). A process has connotations of the passage of time by definition (The American Heritage Dictionary and Roget's Electronic Thesaurus, 1987). The decision making process entails four stages (Simon, 1960):

- Intelligence – where the decision maker has to perceive and understand the problem.
- Design - once the problem has been perceived by the decision maker, possible solutions must be designed.
- Choice - once several alternative solutions have been designed, a choice solution must be identified or selected.
- Implementation – where the chosen solution is carried out.

Simon's model has been described as being mainly suitable for structured decisions. For unstructured decisions the model of Mintzberg et al. (1976) is considered more suitable. The latter contains three main decision making phases: identification, development and selection. There are a number of additional stages within these. Mintzberg et al. (1976) found, on the basis of a study of 25 strategic decision making processes that the greatest amount of activity concentrated in the development phase of the decision process. This phase involves searching, designing and screening. Other features that are significant about the work of Mintzberg et al. (1976) are the exploration of the role of time in the decision process, and the investigation of interruptions within a dynamic decision environment, in which power and organizational politics play an important role.

The distinction between the decision making phases is important for the purposes of this dissertation because the focus in Chapter Four will be on enhancing the intelligence phase of decision making by using structuring techniques and group decision making support tools and technology.

Types of decision makers

The complexity of the decision making process is compounded by the dissimilar cognitive styles of the decision makers. For example, there are **systematic** and **intuitive** decision makers (Jennings and Wattam, 1994). Systematic decision makers are people who approach a problem by structuring it in terms of some formal method. Intuitive decision makers on the other hand, approach a problem using a multiplicity of methods in an unstructured fashion. These differences are important to designers of information systems that purport to support the decision making process.

From Individual Decision Making to Group Decision Making

Research in Group Decision Support Systems (GDSS) has grown in the last 15 years as a result of progress in the understanding of group processes and dynamics, and the improved capabilities of information technologies that support them. These issues are dealt with at length in chapter three of this dissertation. At this stage it suffices to point out that a central issue in this type of research is investigating creativity support. Although much research has been conducted widely elsewhere in this area (Dennis et al, 1996, Dennis, 1999), to the best knowledge of the author there have been no studies of this kind performed in South Africa.

Among the many facets of group decision support research, the focus on the role of task structuring for brainstorming groups is a relatively new issue. It takes electronic brainstorming software environments research and practice to what DeSanctis and Gallupe (1987) defined as more machine-induced group communication patterns that can include expert advice. While much research has been conducted in the GDSS field, it has been restricted to modelling techniques of the kind found in traditional DSS. In the area of idea generation, many researchers have demonstrated the benefits of electronic support versus no support. Little attention has been paid to enhancing these environments however. For this reason, task structuring was considered seriously in formulating the scope of this research. In a multi-criteria group environment one typically observes a divergent process, first, which is associated with the generation of ideas; and subsequently a convergent process, which is directed at reaching consensus on a particular issue. Supporting consensus building logically follows the idea generation process. This is the justification for the inclusion of both topics in this study.

This research concentrates on both the divergent and convergent processes. It can be asserted that both processes play an important role in the quality of decision making within small groups; and this was another justification for the selection of the goals of this research.

While commercial group decision support environments have been on the market for about nine years, the first multi-criteria group decision support environment, Team Expert Choice was

introduced in 1997. The novelty of this type of GDSS is a further justification for the scope of work reported in this research.

1.3. Goals of the Research

The main goal of this research is to investigate the role of task structuring on creativity and ways of supporting consensus in a multi-criteria group decision support environment. Both issues are important aspects of the theory and application of multi-criteria group support systems. The sub-goals of the research are:

- (1) To investigate the foundations and current research issues in Multi Criteria Decision Making (MCDM);
- (2) To investigate the main issues in Group Decision Support Systems (GDSS);
- (3) To investigate the role of task-structuring in group electronic brainstorming sessions;
- (4) To research the issue of supporting consensus building in a multi-criteria group decision environment.

1.4. Scope and limitations of the research

The research on creativity in Group Support Systems is a very broad (see Connolly et al, 1994; Gallupe et al, 1991; Dennis and Valacich, 1993; Dennis, 1996). This research concentrates only on the role of task structuring in a brainstorming session, because relatively little research has been done on the issue. There are other general group support environments like GroupSystems V which have been used in previous research (Nunamaker et al, 1989, Grohowski, et al 1990), but this research uses a multiple criteria group support systems because it is a relatively new technology in the field of GSS.

The theory of MCDM includes several approaches as discussed in chapter two of this dissertation. However, the most widely used, commercially available multi-criteria group support environment is for the Analytic Hierarchy Process (AHP). In addition, previous work on supporting consensus building in an MDCM group setting also uses the AHP, although not in a computerized group support environment. Hence, the selection of Team Expert Choice allowed for the generation of results which could be compared with important previous work on

consensus building in a group MCDM problem (Bryson, 1997; Bryson, 1996; Ngwenyama et al, 1996). These researchers used proprietary, in-house developed software which is neither commercially available nor in the public domain.

1.5. Research methodology

A useful triad for the justification of research (Robey, 1996) includes research aims, theoretical foundations and research methods. Research aims determine both the theoretical foundations and the research methods, whereas theoretical foundations also determine the research methods (See Figure 1.1).

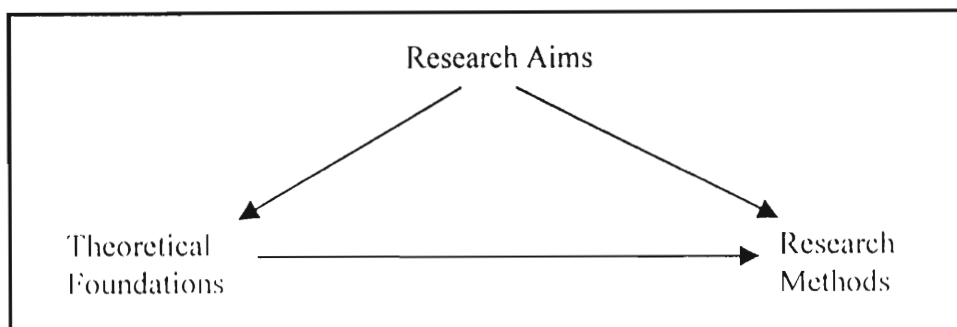


Figure 1.1 A triad for the Justification of Research (adapted from Robey (1996))

It has been suggested that the theoretical foundation of research is what distinguishes it from the realm of theoretical unfounded management consultancy (Jackson, 1995). The starting point in determining the appropriate research approaches are the aims of the research as outlined in a preceding section. The two important aspects of group processes that are considered here provide a deeper insight into the process of group decision making.

One of the sub-goals of this research is thus to conduct a detailed analysis of the literature sources in the areas Decision Making and of Multi-Criteria Group Support Systems. The surveys examine (1) the current state of GDSS after 30 years of existence; (2) the foundations and current research issues in MCDM in general and more specifically in the Analytic Hierarchy Process. The theoretical foundations of this research are formulated on the basis of the literature analysis. The issue of task structuring in idea generation is addressed through a laboratory experiment as that is the most appropriate environment for controlling some of the parameters of the research. The

theoretical dimension of that part of the research relates to the partial replication of the work by Dennis et al. (1996) and Dennis et al. (1999). Their work is new within the field of GDSS. This research embarks on verifying the conditions laid out in their studies using the Team Expert Choice environment, which is not investigated in previously published research on task structuring to the best knowledge of the author.

On the other hand, one of the outcomes from the literature survey is the indication of a need to expand the research methods used beyond the traditional laboratory experiment where appropriate. For this reason the process of supporting consensus building in a Multi-criteria Group Decision environment is investigated through a qualitative field study as it provides more insights into the issue if compared to laboratory experiments. The above considerations outline the research methodology adopted in this dissertation in line with the general guidelines expressed by Robey (1996) in Figure 1.1.

1.6. Significance of the research

The University of Natal Pietermaritzburg recently acquired a Group Decision Support System environment in the form of Team Expert Choice. The university is thus positioned as one of two tertiary institutions in South Africa to possess a group decision support system enabling it to conduct contemporary GSS research. This has presented the researcher with an opportunity to explore experimental GSS work within a reputable software environment. In addition, using Team Expert Choice is also significant because a majority of published GSS research is conducted within the confines of laboratory experimentation using Ventana Corp's GroupSystems (Nunamaker, et al. 1999). The contribution of the current research is that it applies GDSS theory using a different, yet reputable software platform for both laboratory and field studies.

Research into task structuring is one of first steps in the direction of enhancing the performance derived from group support environments through simple interventionist strategies. To the best of this author's knowledge, the work of Dennis et al., (1996) and Dennis et al., (1999), is the only other research on the matter. There is therefore both scope and need for further research in this particular area of Group Support Systems and Electronic Brainstorming in particular. The benefit

of exploring task structuring for the purposes of enhancing the productivity, effectiveness and efficiency of electronic brainstorming groups is a relevant and timely contribution to the field.

An added justification of this research is that it uses a Systems Analysis and Design task for the context of the research. To the best of this author's knowledge there are no recorded cases of similar research using Systems Analysis and Design as its context.

The practical dimension relates to the knowledge that, no such research on electronic brainstorming has been conducted within South Africa. Secondly, in exploring group multiple criteria decision making within a live environment with real stakeholders, a significant effort is made to improve the decision making by student leaders engaged in an important social activity. Thirdly, the qualitative field study with real stakeholders is justified in light of the reported dearth of other methods of research (other than laboratory experimentation) in the field of GSS (Pervan, 1998; Nunamaker, 1999).

CHAPTER 2. ON MULTI-CRITERIA DECISION MAKING (MCDM): GENERAL RESEARCH ISSUES

2.1. Introduction

Schoemaker and Russo (1991) observe that in practice when managers or decision makers have to make a decision, there is occasional reflection and "lots of shooting from the hip." Yet, decision theory and many decision approaches have been around for a long time (Schoemaker and Russo, 1991). Decision Psychology has documented the shortcomings that people, left to their own devices, typically display when making a decision: for example, over-confidence, myopic framing and looking mainly for confirming evidence (Schoemaker and Russo, 1991). The availability of many decision approaches means, where decision makers opt to follow a systematic approach to decision making, not only must they eventually make a decision or select the best alternative, they must also decide on which decision approach to use in the decision making process. They have to "decide how to decide", for there are costs and benefits associated with the various approaches (Schoemaker and Russo, 1991: 4).

In general, there is a hierarchy of decision making approaches as discussed by Schoemaker and Russo (1991). (See Figure 2-1 below). The hierarchy assumes that at the lowest level a decision maker has the option of utilizing **intuitive judgments**, which are generally "unsystematic, unreliable and suffer from consistency problems." Schoemaker and Russo (1991) report of experimental evidence where the same group of decision makers were given the same problem at different times, they ended up selecting different choices "in some instances decisions changed from week to week." Other shortcomings of intuitive judgement are the random unreliability of decision making, for example the most recent information may be over-weighted (called recency bias), this may give way to (primacy bias) that early impression formation frames subsequent questioning or freezes judgments into stereotypes. Finally, decision makers can have a framing bias (their reference points), which influences the manner in which they draw boundaries around problems and the implicit yardsticks they use to evaluate the consequences of their options (Schoemaker and Russo, 1991).

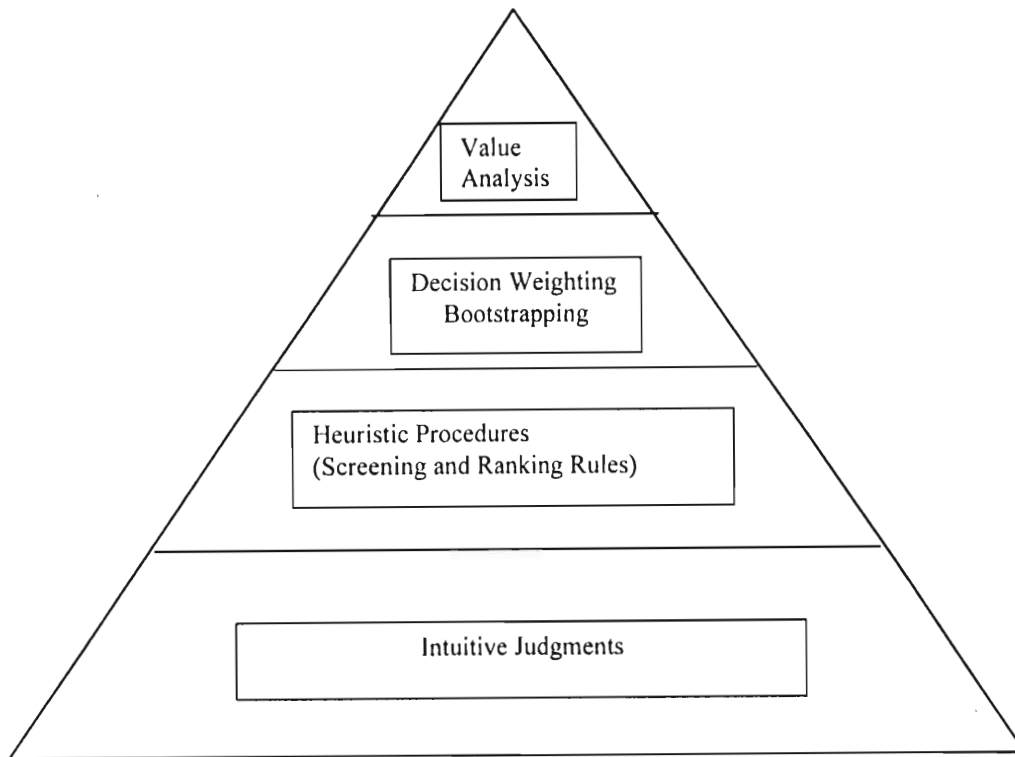


Figure 2-1 a Pyramid of Decision Approaches (adapted from Schoemaker and Russo, 1991)

Jennings and Wattam (1994) suggest that intuitive judgment is deficient enough to require "decision aids." Decision aids are based on common and simplistic strategies and fall into three categories: (1) **Cognitive Decision Rules**: these include satisficing, the use of analogs and adages, nutshell briefings, and incremental change. This implies the decision maker sticks as closely as possible to the last decision bearing on the issue and agreement. Satisficing, a cognitive decision rule, can be traced back to Simon's (1977) concept of bounded rationality. The concept states that people do not optimise, they satisfice. That is they do not choose the best alternative there is, but rather seek a "satisfactory" alternative. This is likely because "a cognitive decision rule that selects the first alternative that satisfies all aspiration levels is much easier to implement although often with less desirable results " (Dyer and Forman, 1992:101). The second category (2) **Affiliative Decision Rules** are based on 'avoiding punishment', 'following the party line' and 'preserving group harmony.' The third category is concerned with (3) **Self Serving and Emotive Rules**. That is, serving self or personal interests, 'relying on gut feel' (which is influenced by one's present mood); 'retaliating'; 'the feeling that we can do it;' feelings of elation' (Jennings and Wattam, 1994). The above decision aids may work in certain, routine choices, but may be problematic when dealing with important complex decisions (Dyer and Forman, 1992).

On the second level of the hierarchy are **heuristics**. The third and slightly more sophisticated level is **bootstrapping**, which is the modelling of expert knowledge. It can account for random noise and some amount of complexity. Finally, there are **value analysis** approaches, like the Multi-Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process, which is the focus of this research.

In general, it is reasonable that the importance, complexity and context of the decision should be the guiding factors when choosing a decision making approach. Examining decision contexts means looking at whether there are common objectives, non-common- objectives and/or conflict (Dyer and Forman, 1992). The selection of a decision approach is not a simple matter. Certain decision making approaches may be suitable for certain kinds of decision contexts and complexity. This will become evident in this dissertation as expected utility theory and the Analytic Hierarchy Process are more closely examined. Whether or not a comprehensive, multi-purpose approach is ideal or even feasible is still subject to debate.

The field of Operations Research/Management Science (OR/MS) provided a basis for dealing with formalized decision efficiency and effectiveness. Decisions must be efficient, - a preoccupation of (MIS and OR/MS); they must be effective - a preoccupation of DSS and MCDM; however they must also be explicable - a preoccupation of Human Management Systems (HMS) (Zeleny, 1982). "These three requirements correspond to the interdependence of expertise, know-what, and know-why" (Zeleny, 1982: 474). Briefly efficiency is performing a given task as well as possible with respect to a given performance criterion, usually economic. Effectiveness involves identifying what should be done and the desired effect or purpose upon which the selection of tasks is based (Zeleny, 1982). This is classically presented as "doing things right" and "doing the right things" in MIS introductory texts.

"Explicability is related to the fact that proposed goals and purposes, even if effective, must be capable of explanation. Whose purpose is to prevail and why?" (Zeleny, 1982: 475). Explicability is especially relevant today, precisely because more and more decisions involve the interests of a group of individuals. The ability to convince others about the desirability of a given purpose is a necessary condition for a successful decision implementation (Zeleny, 1982). In this dissertation, a field study is performed in an environment where explicability is very important. These requirements are related to the traditional field of Operations Research/Management Science that

provided a basis for dealing with formalized decision efficiency and effectiveness. These requirements are related to the traditional classification of management problems into the categories of operational, tactical and strategic.

2.2. An Overview of Multiple Criteria Decision Making

This chapter will present an exploration of issues surrounding MCDM as a "decision analysis" tool. It will explore some of the nomenclature used in the discipline; briefly outline the premises of two well known MCDM approaches with the view of examining where MCDM stands today, especially with regard to supporting decision making within group contexts. The final section of this chapter will then examine the Analytic Hierarchy Process, a MCDM method, with respect to its application in more detail. At the end of the chapter, further potential areas of research will be reflected upon.

In this dissertation, it is noted that in introducing the foundations of multi-objective or multi-criteria decision making, their concepts are largely based on the perspectives of the first multi-criteria methods articulated in multiattribute utility theory (May, 1954) and multiobjective programming also known as the "multicriterion simplex method." The latter was first explored in 1963 by Peter Bod (Zeleny, 1982; Goicoechea et al. 1982).

2.2.1. On Single Criterion Optimisation

For many years after the birth of Operations Research (OR), it was generally considered acceptable that the only way to formulate a problem correctly consisted of defining a single criterion. This criterion would represent the effectiveness of the system under study (Roy and Vanderpooten, 1995). The strategy of suboptimisation in OR as described by one of the founding fathers of Operational Research, Harvey Wagner is to select one sub-objective, for example profit maximization, and push it to its limits. This is done although doing so might have some negative consequence elsewhere. Should the negative effects of such suboptimisation start showing up, then the next pressing sub-objective is selected and that pushed to its own limits. This notion is evident in the writing of Wagner (1969:132) "optimise on the first function, then go on to each other function, one by one, employing the previous optimal basis as an intuitive solution." This notion of suboptimisation is also evident throughout the articulations of economic theory, welfare

theory, game theory and decision analysis theory (Roy and Vanderpooten, 1996; Zeleny 1982). In these fields, one usually considers things from a rational point of view which involves maximizing the expected utility of a decision that is usually represented by a single criterion. This is usually expressed as a search for the optimum i.e. maximum or minimum of a function of variables that are constrained by equations or inequalities. For example one could seek to maximize the objective function $\mathbf{z}(\mathbf{x})$ i.e.

$$\max \mathbf{z}(\mathbf{x})$$

subject to

$$\begin{aligned} g_i(\mathbf{x}) &\leq 0, & i &= 1, 2, 3 \dots m \\ x_j &\geq 0, & j &= 1, 2, 3 \dots n \end{aligned}$$

The objective function $\mathbf{z}(\mathbf{x})$ and $g_i(\mathbf{x})$ are defined on an n -dimensional Euclidean vector space of decision variables,

$$\mathbf{x} = (x_1, x_2, x_3 \dots x_n) \in \mathbf{R}^n$$

with values in \mathbf{R} , the set of real numbers.

In this problem the feasible region is defined by

$$\mathbf{X} = \{ \mathbf{x} : \mathbf{x} \in \mathbf{R}^n, g_i(\mathbf{x}) \leq 0, x_j \geq 0 \quad \text{for all } i \text{ and } j \}$$

Note that the functions $\mathbf{z}(\mathbf{x})$ and $g_i(\mathbf{x})$ can be linear or non linear functions of the decision variables, x_j . This optimisation problem seeks to find \mathbf{x}^* , an element of the feasible region \mathbf{X} , such that $\mathbf{x}^* \in \mathbf{X}$ will result in a maximum value for $\mathbf{z}(\mathbf{x})$ (Goicoechea et al., 1982).

Optimising a single function is arguably a task that most people can perform. The problem is typically well defined and unambiguous. Moreover, an impressive battery of analytical tools have been developed allowing for quick and mostly error-free calculations to be performed (Zeleny, 1982). "The quantitative models of econometrics, operations research and management science assist in untangling complicated cause-effect structures and interdependencies" (Zeleny, 1982: 485). For example, maximizing sales as a single function is relatively simple if sales were the only variable or objective that mattered. If all else fails, one can drop the price to zero; and if that did not optimise results either, one could pay for the items to be taken (Schoemaker and Russo, 1991). However, in this example, simultaneously maximizing the profit function could be another legitimate criterion. Roy (1977) observes that the reality of executive decision making is that, real

decisions are based on a progressive comparison of the preference systems of multiple actors, in a generally fuzzy environment, evolving through interactions within the sphere of different political, value, and power frameworks. Attempting to reduce such a variety of factors into a single criterion of choice would constitute a gross misrepresentation of reality. Historically, Multiple Criteria Decision Making (MCDM) has indicated a concern with this class of problems that involves multiple attributes, objectives, or goals; objectives that are often competing for the same, finite resources. By emphasizing the multiplicity of criteria it presents an attempt to avoid using a common measure of value when the choice involves heterogeneous items (Iz and Gardiner, 1993; Stewart 1992).

The multiplicity of criteria in every arena of business, public policy and even personal decision making is today almost self-evident. In this research, however focus will be on business or organizational decision making.

2.2.2. The Formulation Of The Multi-Objective Problem

A multi-objective problem is characterized by a p -dimensional vector of objective functions

$$\mathbf{z}(\mathbf{x}) = [z_1(\mathbf{x}), z_2(\mathbf{x}), \dots, z_p(\mathbf{x})]$$

and a feasible region \mathbf{X} as defined above. Contrary to the single-objective case, in lieu of seeking a single optimal solution, a set of non-dominated solutions is sought (Goicoechea et al. 1982). This set of non-dominated solutions is a subset of the feasible region, \mathbf{X} . The main characteristic of the non-dominated set of solutions is "for each solution outside the set but still within the feasible region, there is a non-dominated solution for which all objective functions are unchanged or improved and at least one which is strictly improved" (Goicoechea et al., 1982:19). Thus the concept of "optimisation" within a multi-objective programming problem cannot be said to exist since one cannot in general optimise *a priori* a vector of objective functions (Goicoechea et al., 1982). Keen (1977) similarly notes that optimisation in the traditional mathematical sense is impossible if multiple criteria are involved.

Goicoechea et al. (1982) propose that the set of non-dominated solutions be formulated as follows:

$$\text{max-dominate } z(\mathbf{x}) = [z_1(\mathbf{x}), z_2(\mathbf{x}), \dots, z_p(\mathbf{x})]$$

subject to

$$\mathbf{x} \in \mathbf{X}$$

The term “max-dominate” is used to convey the intent to search and identify the set of non-dominated solutions that is, the set of solutions that dominate the other solutions in \mathbf{X} (Goicoechea et al., 1982).

Assuming more of each objective function is desirable then given a set of feasible solutions \mathbf{X} , the set of non-dominated solutions, denoted by S is defined as follows:

$$S = \{ \mathbf{x}: \mathbf{x} \in \mathbf{X} \quad \text{there exists no other } \mathbf{x}' \in \mathbf{X} \text{ such that} \\ z_q(\mathbf{x}') > z_q(\mathbf{x}) \quad \text{for some } q \in (1, 2, \dots, p) \\ \text{and } z_k(\mathbf{x}') \geq z_k(\mathbf{x}) \quad \text{for all } k \neq q \}$$

Based on the definition of S as one moves from one non-dominated solution to another non-dominated solution and one objective function improves then one or more of the other objective functions must decrease (Goicoechea et al., 1982). Finally, there is a set of non-dominated objectives, Z , given a p -dimensional vector of objective functions, $z(\mathbf{x})$, a set of feasible solutions and a set of non-dominated solutions S . Z is represented as follows

$$Z = \{ z(\mathbf{x}): z(\mathbf{x}) \in R^p, \text{ and } \mathbf{x} \in S \}$$

so that for every $\mathbf{x} \in S$, there corresponds an element $[z_1(\mathbf{x}), z_2(\mathbf{x}), \dots, z_p(\mathbf{x})]$ in the set of non-dominated objectives, Z (Goicoechea et al., 1982; Zeleny 1982). The ordering of the set of non-dominated objectives can be accomplished by using additional criteria. "The additional criteria can be determined by considering the preferences of the decision maker as they relate to the various objective functions, their tradeoffs, and the probability of achievement associated with the value of an objective function" (Goicoechea et al., 1982:23).

The concept of non-dominated solution was similarly considered as the Pareto optimum, or theory of "Pareto optimality" applied to operations research and productive efficiency.

Simon's (1960) concept of satisficing indicates that certain cognitive limits lead decision makers to think in terms of bounded rationality. This concept has often been thought of as a suitable extension and modification of the concept of optimisation. However, Zeleny (1982) argues that the notion of satisficing is only superficially compelling.

2.2.3. Inherent Conflict in a Multiple Criteria Problem

Often in complex decision situations such as policy planning issues characterized by multiple criteria, decision makers are frequently more concerned with resolving conflict, reducing risk and managing cognitive strain than with optimising solutions (Zeleny, 1982, Saaty, 1990). Conflict is an inherent property of any multi-criteria problem; this is largely due to limited resources and or varying individual vested interests (Goicoechea et al., 1982). Von Neumann and Morgenstern (1953: 10) articulate it as follows

“...this multiple objective situation is certainly no maximum problem, but a peculiar and disconcerting mixture of several conflicting problems. This kind of problem is nowhere dealt with in classical mathematics. It arises in full clarity even in the most "elementary" situations, e.g. when all variables can assume only a finite number of values”

Under these circumstances, "the MCDM model becomes a methodology supporting the problem-solving process of the decision maker" (Zeleny, 1982: 63).

Conflict can only be resolved through innovation or adaptation, i.e. developing alternatives previously unknown, or changing the current value structure of the decision maker so that the decision maker becomes satisfied with one of the available alternatives (Goicoechea et al. 1982). The very source of pre-decision conflict is the non-availability of suitable alternatives and especially the infeasibility of the ideal alternative (Zeleny, 1982). Thus the decision maker starts searching for new alternatives, preferably those closely approximating the ideal. In this search for an alternative the ideal alternative becomes a reference point. If the ideal alternative became feasible the decision would stop and the conflict would be resolved. Initially, the search is systematic with more and more information being gathered and perhaps even more decision makers being brought into the process. However, as the decision maker realizes that additional information is unlikely to reverse or significantly influence the existing order of preferences, the process becomes more biased and subjective (Zeleny, 1982). Conflicting criteria are derived from the various, basic needs and values of human beings.

For instance, a potential employee when considering a new job will consider not just salary, but future expected rates of increase, fringe benefits, working conditions, vicinity to the home, responsibility and the levels of challenge entailed in the job. The choice can be complex and even 'agonizing' (Zeleny,1982). Being faced with multiple and conflicting objectives implies that a trade-off necessarily takes place for the choice to be made. In other words, in a partial to complete ordering of the set of non-dominated solutions, improving achievement with respect to one objective can only be accomplished at the expense of another. Pareto optimality (efficiency) is exactly that point at which one cannot improve one measure without decreasing another.

2.2.4. The Role of the Decision Maker

The set of non-dominated solutions was defined as a subset of the initial set of feasible solutions. In the tradition of multiple-objective decision making, this was done without considering the preferences of the decision maker. The related set of non-dominated objectives generally represents a collection of incomparable solutions, since the objective functions may be incomparable in the first place. Such incomplete orderings imply the need for introducing value judgments into the solution process, the 'value structure' of the decision maker. In this regard, the decision maker can be asked to articulate his or her preferences to order the alternative solutions in the non-dominated set (Goicoechea et al. 1982). There are two methods that have been used in accounting for the value structure of the decision maker:-

1. Methods which rely on the prior articulation of preferences and
2. Methods which rely on progressive articulation of preferences.

Methods of prior articulation of preferences require, as inputs, value judgments from the decision maker independently for each point of view (in order to construct a partial preference model for each point of view) and some inter-criteria preference information. methods of progressive articulation of preferences on the other hand permit the systematic exploration of the decision space without requiring the prior specification of any preferences (Bana e Costa et al., 1995). In addition, much of decision theory is pre-occupied with whether decision methods should recommend the best way to make optimal decisions regardless of what the disposition of the decision maker is; or whether to attempt to understand the manner in which humans make decisions, seeing as they have been doing so for as long as they have existed. In the next section,

decision theories are defined, as this becomes important in evaluating the current MCDM schools of thought later in the chapter.

2.2.5. A Discussion on Descriptive, Normative and Prescriptive Decision Theories

A descriptive theory is one which purports to describe the world as it is, explaining how people make decisions and predicting the decisions that they may make (Howard, 1992, Keeney, 1992). Its quality or performance is measured by the extent to which it accurately characterizes and predicts the behaviour of actual systems or the behaviour of peoples (Keeney, 1992; Howard, 1992). A normative theory on the other hand, establishes norms for how things should be. Consequently, "normative models have no place in the physical sciences because they deal with fact rather than human behaviour" (Howard, 1992:32). Still, proponents of normative theory believe that in a decision making environment, where human will is very much the issue, not only is it possible, but often it is desirable, to propose the norms for decision making, norms so cogent that once accepted any departure from them would be considered a mistake (Howard, 1992: 29). The term "decision analysis" is defined as *applied decision theory* (Howard, 1992). "Decision analysis is the engineering use of the norms of decision theory in the practical world" (Howard, 1992:52).

Howard (1992) uses the word normative in the sense of "rules that should govern decision making" (Howard, 1992:51). Keeney, (1992) defines normative approaches to decision making as focusing on the rational procedures for decision making and how decisions should be made in order to be logically consistent with these rational procedures. Other authors have used the word normative to mean "ideal descriptions of individual decision making that should not necessarily be followed in actual practice" (Howard, 1992:51).

Prescriptive decision making is according to Howard (1992) merely reference to the decision process that is to be recommended to the decision maker even if the normative rules are violated in the process. These prescriptive rules are merely approximations of the norms that are necessary when applying the norms in practice. "They are not mistakes in the sense of violations of the norms of decision making, ... but are rather interpretations required to apply the norms sensibly in the world" (Howard, 1992:52). In many cases these are founded on higher decision rules such as

"one should not spend more resources on a decision process than the results of the process are worth to one" (Howard, 1992:52). For Howard (1992), the only time it would be worth risking violating the norms would be when the cost of ensuring that they were satisfied was more than the cost of the potential violation. "In a prescriptive approach the analyst begins with a description and draws up prescriptions based on normative hypotheses validated by the reality thus described" (Roy and Vanderpooten, 1996). Accordingly there is no reason therefore for violating the norms in any decision, or any reason to think decision analysis or decision engineering is any different from any other engineering discipline (Howard, 1992).

Keeney (1992) proposes a useful framework, depicted on Table 2.1 below. In the table there are three rows representing the three theories normative, descriptive and prescriptive. The first three columns are part of a matrix representing all decision problems; classes of decision problems and specific decision problems. The next two columns represent the criterion for evaluating axioms and the judges who apply the criteria.

(The depicted X on Table 2.1 shows the focus of attention of the theory)

Table 2.1 Features that distinguish normative, descriptive, and prescriptive decision making

Theories	Problem		Focus		
	All Decisions	Classes of Decisions	Specific Decisions	Criterion	Judges of Theories
Normative	X			Correctness	Theoretical Sages
Descriptive		X		Empirical Validity	Experimental Researchers
Prescriptive			X	Usefulness	Applied Analysis

[Adapted from Keeney (1992:58)]

As can be seen from Table 2.1 with normative theory the focus is on *all decision problems*. The criterion for evaluating a set of axioms is whether they are logically correct, meaning that they are rational and lead to logically consistent decisions. The appraisal on logical correctness requires a conclusion reached by "wise sages" meaning those individuals concerned with the theoretical foundations of decision making (Keeney 1992:58). With descriptive theory on the other hand, the choice of axioms is not one of preference or professional belief. Rather the issue is whether the axioms describe the manner in which people actually make decisions. According to Keeney (1992), since the question needs to be empirically tested by researchers, the focus

typically is on classes of decision problems that are conveniently aggregated, e.g. investment decisions.

Finally, prescriptively the point of interest is in addressing specific decisions. Here a decision analyst would focus on one decision problem at a time and is not particularly concerned with whether the axioms utilized to support the analysis for that given problem are appropriate for other classes of problems or all other problems. The main criterion is whether the axioms are a selection of axioms for a specific decision problem (Keeney, 1992). In addition, Keeney (1992) identifies an overall set of assumptions that axiomatic systems must fit into for the purposes of prescriptive decision analysis. There are five aspects that theoretical assumptions (axioms) need to address (Keeney, 1992:60; Saaty 1990, Keen and Raiffa, 1993).

- structuring the problem,
- quantifying the objectives,
- describing the possible impacts,
- integrating information to provide guidance for decision making and
- communicating the insights of the analysis

The first aspect, structuring the decision problem forms the foundation of any specification analysis (Keeney, 1992; Saaty 1990; Keen and Raiffa, 1993). It means identifying the alternatives and qualitatively specifying the objectives in a manner useful for quantitative analysis (Keeney, 1992; Keen and Raiffa, 1993). For prescriptive analysis a combination of theoretical and operational assumptions is necessary. The choice of appropriate theoretical axioms depends, among other things, on the implementation of these axioms in given situations (Keeney, 1992; Keen and Raiffa, 1993).

Table 2.2 A Categorization of Assumptions Required for Prescriptive Decision Analysis

	Focus of Assumptions				
	Identifying Problem	Quantifying Objectives	Describing Impacts	Integrating Information	Communicating Insights
Theoretical Assumptions	FOCUS OF FORMAL AXIOM SYSTEMS				
Operational Assumptions					

[Adapted from Keeney (1992)]

From the above it is clear that normative, descriptive and prescriptive theories to decision making address different questions. It is important to bear in mind that different theories are often developed with different objectives in mind, and that many tricky issues are involved (Winkler, 1990).

2.2.6. On the Use of Decision Methods for Individual and Group Decision Making

In its earlier times, MCDM focused on supporting individual decision makers; it has since seen a growing interest in adapting multiple criteria decision methodology to the needs of multiple decision makers and collaborative technologies (Iz and Gardiner, 1993). The existence of several participants in the decision making process further compounds the issue of multiple criteria decision making. Intuitively, one imagines that it is hard enough balancing several conflicting criteria emanating from the same individual. Yet doing the same action for criteria and values derived from a group of decision makers is considerably more complex.

There is some debate on whether the decision methods traditionally applied to individual decision making could be equally applied to group decision making. The question is relevant to proponents of normative, descriptive or prescriptive theories alike. By his own admission, Howard (1992:53), "would be reticent to offer any warranty on the quality of the decision making ...in a group decision process" using expected utility's normative tools. Howard's observations are aligned to the ideas articulated by Arrow (1957) that no group decision process, except dictatorship, would satisfy the simple requirements that would need to be placed on any sensible decision process. Certain members of the group may utilize (all the problems of) gaming, misrepresentations of agenda and manipulation. Some may be motivated to be deceptive about their representations of the basis elements (i.e. of the alternatives, information preferences (Howard, 1992:53). Therefore, Howard asserts, he cannot vouch for the success of normative theory for successful implementation in a group environment in the private sector. Within government sector environs, he is even more sceptical.

On the contrary, according to Keeney (1992), it is a common misconception that expected utility axioms are not suitable for the decision problems involving more than one decision maker. He attests that this is simply not true. He observes that the axioms themselves never mention the

need for a decision maker or the role of the decision maker. The axioms simply state that one can obtain preference judgments necessary to construct the probabilities and utilities for the decision problem. So, if there were a group and the group was willing to somehow specify the necessary preference judgments to utilize in the analysis, then the analysis might be useful (Keeney, 1992). In fact, with expected utility theory " there is no need to have an identifiable decision maker or decision makers" (Keeney, 1992:69). The analyst could identify a knowledgeable interested party to construct the appropriate utility functions or even complete the analysis with various utility functions provided by the analyst himself or herself based on his or her understanding of the problem. If the resulting analysis provides insights that reach the decision makers and influences decisions, this could be very important and certainly qualifies as decision analysis. Indeed, for some problems one cannot forecast who all the decision makers will be in the future (Banville, et al., 1998; Keeney, 1992).

Group decision making contexts are just one example illustrating the limitations of objectivity for decision making theories and approaches. In many real-world problems, the "decision maker" as a person, truly able to make a decision, does not always exist. Usually several people (actors or stakeholders) take part in the decision process and it is important not to confuse who ratifies the decision with the so-called decision maker in the decision process. The decision maker is in fact the person (or set of persons) for whom or in the name of whom the decision aid is provided (Banville, et al., 1998; Roy and Vanderpooten, 1996).

There are other fundamental limitations of objectivity; and these are well researched in the field of MCDM. Roy and Vanderpooten (1996) show three other major aspects that have to be taken into account when considering the limitations of strict objectivity in the use of decision aids, methods or approaches. These limitations confront any decision aid or method be it prescriptive, descriptive, or normative. The first limitation relates to the fuzziness of the borderline (or frontier) between what is and what is not feasible. Moreover, this borderline is frequently modified in the light of what is found through the decision analysis study itself. The second limitation refers to the preferences of the decision maker. That is, even when the decision maker is not a mythical person, his or her preferences seldom seem well shaped. In and among areas of firm convictions lie hazy zones of uncertainty, half-held beliefs or indeed conflicts and contradictions (Roy and Vanderpooten, 1996). Roy and Vanderpooten (1996) add that it must be

conceded therefore, that the decision analysis study itself contributes to eliminating questioning, solving conflicts, transforming contradictions and to destabilizing certain convictions. If, within this context, a decision is made to resort to a multi-criteria approach, the elaboration of the set of decision criteria cannot be founded on purely objective considerations (Roy and Vanderpooten, 1996; Saaty, 1990, Saaty and Vargas, 1994). The third limitation of objectivity relates to data imprecision and uncertainty in that, "data such as the numerical values of evaluations or performances, the characteristics and the analytic forms of the probabilistic distributions, the weights of criteria, ... are often imprecise, uncertain, or ill determined" (Roy and Vanderpooten, 1996). Finally, in general, it is believed to be impossible to say that a decision is a good or bad one by referring only to a mathematical model. There are organizational, pedagogical and cultural (socio-political) aspects of the entire decision process. These also contribute to the making of a given decision, its quality and success (Roy and Vanderpooten, 1996, Banville, et al. 1998, Ngwenyama and Lee, 1997).

The above underline the extent to which factors of an objective nature for example, the characteristics of alternatives interact in decision aids with factors of an entirely subjective nature arising from both the actors' system of values and the way in which ill-determined consequences are evaluated (Roy and Vanderpooten, 1996). It is impossible to deny the importance of the subjective factors and to put them aside in an attempt to use a "totally objective" approach (Roy and Vanderpooten, 1996; Saaty, 1990; Zeleny, 1982, Saaty and Vargas, 1994, Saaty, 1991a).

2.2.7. The Issue of Measurement and Measurement Scales

The introduction of the decision maker's (subjective) preferences into the analysis necessitates a concomitant measurement tool. The issue of measurement for multiple criteria decision making tools, techniques and methods is one that stirs strong debate. Each method or technique uses some form of measurement scale as a fundamental assumption. This ordinarily would not pose any questions were it not for the fact that, the use of the different scales frequently yields different results (Pervan and Klass, 1993; Saaty, 1991c). A decision theory must ultimately justify the way it elicits preferences and judgments, converts them to numbers, manipulates them and produces an overall answer that belongs to one of these scales (Saaty, 1991c). In this section the basic characteristics of mathematical measurement in general are visited. The performance of each method or technique is then examined.

Pure mathematical measurement has the following characteristics: unequivocal order, equal intervals and an unambiguous zero (Mladenova and Millwood, 1998). These features allow for the performance of mathematical operations with the elements characterized on the scale. The assumptions about ordering and the equality of intervals allow for the addition and subtraction operations with such scales, while the unambiguous zero allows for division and multiplication in terms of the scale (Zeleny, 1982; Pervan and Klass, 1993; Saaty, 1980; Saaty, 1991, Vargas, 1994; Mladenova and Millwood, 1998).

There are three major measurement scales: the nominal, ordinal and cardinal scales, which are discussed next.

The **Nominal Scale** is the simplest kind of scale. In a nominal scale there is naming but no ordering. Properties are broken down into equivalent classes, but the classes are not ranked with respect to one another. The only rule for the formation of such scales is that the classes be mutually exclusive (Pervan and Klass, 1993). Nominal Scales are invariant under the identity transformation (Saaty, 1991).

Ordinal Scales, on the other hand, are topological scales, which merely order the elements or properties of elements with respect to one another. Things are ranked in some order without the pretence of maintaining equal intervals between the elements. These scales do not permit any arithmetic operations (Mladenova and Millwood, 1998). Ordinal scales are purely relational: objects are rank-ordered and no meaningful numerical properties can be assigned to them. It can only be said: object A is preferred to object B, that A is equal to B, or that B is preferred to A. However, it cannot be said by how much. The intensity or degree of preference is not apparent from ordinal scales. Ordinal scales can be expressed through numerical or verbal rankings such as [1, 2, 3...etc. or good, average bad, etc.] The Boolean variable [1 or 0] assigned to a preference is a special case of ordinal scales. For ordinal numbers, the intervals or the differences between them are meaningless for example [7 minus 5 and 4 minus 2], so that any algebraic manipulations of these numbers are also meaningless (Zeleny, 1982: 131; Pervan and Klass, 1993; Saaty, 1980; Saaty and Vargas, 1991). Ordinal scales are invariant under strictly monotone transformations (Saaty, 1991).

Cardinal Scales on the other hand assign meaningful numerical values (numbers, intervals, ratios etc.) to the objects in question. So that addition, subtraction and multiplication of these by a constant is meaningful [$7-5 = 4-2$]. Cardinal scales can be further divided into interval and ratio scales (Pervan and Klass, 1993; Saaty, 1980; Zeleny, 1982).

- **Interval Scales** are characterized by the allowance of an arbitrary zero point. ($^{\circ}\text{F}$ and $^{\circ}\text{C}$ are typical examples). Interval scales are constructed to rank features in a manner, which relies upon the assumption of the equality of intervals between classes, thus permitting simple addition and subtraction operations. However, because a zero is not recognized or is arbitrary, multiplication and division are not permitted (Pervan and Klass, 1993; Saaty, 1980; Zeleny, 1982). Interval scales have the form $ax+b$, where $a>0$, $b\neq 0$ (Saaty, 1991c). Interval scales are invariant under positive linear transformations (Saaty, 1991).
- **Ratio Scales**, on the contrary, are characterized by a non-arbitrary zero point or an unambiguous zero as well as unequivocal ordering and equal intervals. Here the multiplication by interval-scaled variables is allowed (Pervan and Klass, 1993; Saaty, 1980; Zeleny, 1982). Ratio scales are a special case of interval scales, with the form $ax+0$, $a\neq 0$. While one can add or subtract interval scales numbers one cannot multiply or divide them. With ratio scales, all four arithmetic operations can be performed on them. Ratio scales are invariant under positive similarity transformations (Saaty, 1991).

Related to measurement scales is the definition of **anchors** (Zeleny, 1982). Anchors are points of reference. Points of reference must be defined for the reason that in practice it is not sufficient to ask, "Do you prefer more to less?" One needs to know with respect to what. That is, what is the framework of inquiry, misery or money? The framework or point of reference makes a difference to the response given. Later in this chapter when comparing the two methods, the AHP and the MAUT, it will be seen that this area is one where MAUT and AHP proponents do not agree (Harker and Vargas, 1990, Winkler, 1990). Nevertheless, in practice, it has been reported that decision makers especially those in group environments instinctively resort to simple additive scoring when confronted with multiple criteria choices, although this evidence is anecdotal (Zeleny, 1982; Stewart, 1992).

2.2.8. On The Terminology of MCDM

There is still some controversy regarding standard terminology in the field of MCDM. This is indicative of its still evolving state: there is an “absence of a consistent and unified terminology, even as to what is meant by criteria” (Bana e Costa, et al. 1995: 263). In this section some of the terms as will be used in this dissertation are explained.

- **Attributes**: are descriptors of objective reality (Stewart, 1992). They may be actual objective traits or may be subjectively assigned traits. They are perceived characteristics of objects. They cannot be separated from the decision maker's values and model of reality.
- **Objectives**: once the attributes have been specified, the decision maker must decide which attributes to maximize or minimize. Is the potential employee going to maximize job challenge and minimize fringe benefits? In answering these questions, the decision maker specifies an objective. Objectives thus represent directions of preference for the decision maker; that is, his needs and desires. There are only two directions of preference: more or less, implying maximize or minimize (Zeleny, 1982). Objectives are not attributes but are derived from one or more attributes. There is an implied hierarchy in the relationship between objectives and alternatives.
- **Goals**: are fully identifiable with the decision maker's needs and desires. They are *a priori* determined specific values or levels defined in terms of attributes and or objectives (Zeleny, 1982). They can be precise desired levels of attainment or more fuzzily delineated. For example maximizing profit is an objective but achieving a return of 15% on investment is a goal. Goals are "that which will satisfy or reduce the striving" (Goicoechea et al., 1982: 25).
- **Criteria**: are measures, rules and standards that guide decision making. Attributes, objectives and goals can be referred to as criteria. Criteria are all attributes, objectives and goals that have been judged as relevant to a particular decision situation by a specific decision maker (Zeleny, 1982). Bouyssou (1995) proposes a general definition of a criterion, "a tool allowing for the comparison of alternatives according to a particular point of view". (See also Stewart, 1992). This definition incorporates the common language sense of the use of the term criterion as in measures, rules and standards (that guide decision making). The Oxford

Dictionary (1984:172) defines criterion as a "principle or standard that a thing is judged". The definition also caters for the technical notion of a criterion as a model of preferences between elements of a set of X real or fictitious actions (Stewart, 1992).

Some of these definitions are subject to debate (refer to Henig and Buchanan (1996) for additional comments).

2.2.9. On the Types and Characteristics of Decision Criteria

In the literature, decisions have been classified with respect to different criteria. One classification reflects the inherent existence of uncertainty in a decision. Where there is certainty about the decision situation, the decisions have been defined as decisions under certainty. While decisions under risk are when the probabilities of occurrence of an event are unknown. There are decisions under uncertainty, where even the probabilities of occurrence of a particular event are unknown. This classification is aligned to the decision classification continuum of well-structured, semi-structured and unstructured decisions (Radford, 1981).

Substantial research (Saaty, 1980; Keeney and Raiffa, 1976) has been done on the identification of criteria: exploring the desirable properties which should be satisfied by a set of decision criteria. For instance, Stewart (1992) proposes that decision criteria should be independent and should avoid the double counting of issues. Zeleny (1982:21) describes "a useful taxonomy of different patterns or modes of deciding itself." He observes that "criteria can either be well defined and quantitatively measurable or they may be mostly qualitative, poorly measurable and laden with uncertainty" Zeleny (1982:21). In the former instance the alternatives of choice are well described, their consequences are measurable and their impacts understood. In the latter case the alternatives are only imprecisely characterized by the criteria, their outcomes are uncertain and the cause-effect relationships are unclear. A decision maker can be quite clear, in some cases, of what his or her preferences are and be able to articulate them as a single dominant criterion. Alternatively the decision maker's preference may have many sides and be describable only through the multiple criteria of choice. The decision maker's task of deciding can in this way be classified into four basic groups or modes (Zeleny, 1982):

1. Clearly defined, certain alternatives, which are evaluated in terms of single criteria, named **Computation** (analysis).

2. Poorly defined, uncertain alternatives, which are evaluated in terms of single criteria named **Judgment** (MAUT is of this type).
3. Clearly defined, certain alternatives, which are evaluated in terms of multiple criteria, named **Compromise**.
4. Poorly defined, uncertain alternatives, which are evaluated in terms of multiple criteria, named **Inspiration or Intuition**.

This taxonomy is useful in that it provides a distinction between problems of computation, judgment, compromise and inspiration, with the concomitant implication that possibly different strategies ought to be used in dealing with the different types of decision problems. In more recent times, Lai and Hwang (1994) define another taxonomy of decision tasks (that have multiple and usually conflicting criteria). Their classification suggests that there are two decision task categories, namely:

- (1) Multiple Attribute Decision Making (MADM) and
- (2) Multiple Objective Decision Making (MODM).

- MADM is defined as being associated with problems whose number of alternatives has already been predefined i.e. certain (Lai and Hwang, 1994). Here the decision maker is required to select, prioritise and rank a finite number of courses of action in the face of multiple (conflicting) attributes. This classification should then include the **compromise** mode defined by Zeleny (1982).
- MODM is defined as being associated with problems whose alternatives have not been pre-determined i.e. uncertain (Lai and Hwang, 1994). Here, the decision maker is primarily concerned with designing a "most" promising alternative with respect to limited resources. This would include Zeleny's **inspiration** mode.

This research concerns itself predominantly with the area of Multiple Attribute Decision Making (MADM) also referred to as Multiple Criteria Decision Analysis (MCDA), possibly to indicate an attempt to show its linkages to classical decision analysis (DA) (See Lootsma, 1996).

The above two classifications show uncertainty or imprecision as an intrinsic factor in real decision tasks. Imprecision will always exist (Lai and Hwang, 1994). Traditionally, the modelling

of imprecision in decision analysis has been done through probability theory and or fuzzy set theory. Even though probability theory presents a stochastic or a random nature of decision analysis it does not measure the imprecision that results from human behaviour. Probability theory is rather a way of modelling incomplete knowledge about the (external) environment surrounding human beings (Lai and Hwang, 1994). Even so, probability theory has formed a significant part of MCDM theory and research. It is a tool that is used for example in Expected Utility Theory and the Multi-Attribute Utility Theory (MAUT).

The criticism of the use of probability theory is largely founded precisely on the basis that probability theory does not capture the subjective nature of human decision making (Lai and Hwang, 1994), the very uncertainty that appears to be prevalent in most decision tasks that warrant the use of a formal method of analysis in the first place. On the contrary, fuzzy set theory captures the subjectivity of human behaviour. It is better equipped to handle the imprecision that arises from mental phenomena, phenomena which are neither random nor stochastic (Lai and Hwang, 1994; Keen and Raiffa, 1993). However, fuzzy set theory will not be examined in this thesis as it is considered to be beyond the scope of this research.

That a rational approach to decision making should take human subjectivity into account rather than relying only on objective probability measures is echoed by many researchers (Lai and Hwang, 1994; Saaty, 1980, Saaty and Vargas, 1994; Forman, 1993; Zeleny, 1982; Keen and Raiffa, 1993). The next section will explore several approaches that do take subjectivity into account.

2.3. An Overview of Outranking Methods and Utility Theory

This section examines three different schools of Multiple Criteria Decision Analysis (MCDA) that have emerged, with respect to their philosophical orientation and some of the axiomatic assumptions upon which they are based. That there are still several 'schools' of MCDA methods is a revelation of the state of MCDA theory and development (Lootsma, 1996).

2.3.1. Outranking Methods (ORM)

The Outranking Methods approach states that for two alternatives A_i and A_j , A_i outranks A_j ($A_i S A_j$) if given all that there is to know about the two alternatives A_i and A_j , there are enough arguments to decide that A_i is at least as good as A_j . The goal of ORM is to find all alternatives that dominate other alternatives while they cannot be dominated by any other alternative from the decision maker's viewpoint. ORM derives ordinal or absolute scales and assumes nothing about rank preservation: it is built on the principle of dominating alternatives (Vargas, 1994).

In ELECTRE I, an ORM tool, the major issue is the threshold of concordance used to define the outranking relation. The threshold values are selected by the decision maker. The concordance threshold (c^{\wedge}) defines the minimum amount by which an alternative must dominate another, and the discordance threshold (d^{\wedge}) is the maximum amount by which an alternative can be dominated by another, when it does not dominate it on all criteria. An alternative will score the full value of the criterion if it dominates another alternative. The assumption being made is that all the criteria are equally weighted. There does not appear to be guidelines on how to set these thresholds, and their values belong to the same scale as that of the criteria weights (Vargas, 1994).

The major reported difficulties experienced with ELECTRE I and II were due to the fact that the performances of the alternatives on the different criteria were often imprecise and even ill-determined. Moreover, this inaccurate knowledge was not explicitly taken into consideration (Roy and Vanderpooten, 1996). ELECTRE III presented two new features: (1) the possibility of working with indifference and preference thresholds i.e. with the concept of "pseudo criteria" (2) the introduction of a fuzzy outranking relation instead of a preference model containing only two crisp outranking relations (Roy and Vanderpooten, 1996). ELECTRE IV has been developed with a real-world problem, which provides the ranking of alternatives for cases in which it is especially difficult to indicate the relative importance of each criterion. Significantly, this does not amount to assigning an equal importance to each criterion (Roy and Vanderpooten, 1996).

The ORM is perceived by its proponents as being the French or European school of MCDA. The outranking school however, purports to be neither a normative, descriptive or prescriptive theory.

Its proponents claim it should be viewed as a constructivist approach (Roy and Vanderpooten, 1996). This however has been criticized in that: "as soon as we acknowledge that our aim is no longer or is only secondarily to describe or discover but rather to construct or create we necessarily distance ourselves significantly from the question for norms or prescribing... We do not believe that some axiomatic results will lead us to believe ... we possess the means of gaining access to truth" (Roy and Vanderpooten, 1996:27).

2.3.2. The Foundations of Expected Utility Theory and Some Violations of its Properties

Utility Theory is said to be possibly the most widely accepted normative theory for decision making under risk (Keller, 1992). The theory has several required properties. The term property refers to either an axiom or a characteristic resulting from a combination of axioms. Keller suggests that since the properties are seen as appropriate components of a normative theory, they could be called the principles or *desiderata* to emphasize their normative status. Although, there are many strains of utility theory, like more generalized utility theories, Subjective Expected Utility (SEU), the Multi-Attribute Utility Theory (MAUT) and Expected Utility Theory (EUT), expected utility theory is discussed because some of its fundamental assumptions inform the foundations of MAUT.

The Expected Utility Theory (EUT). some of its properties and their violations

As a normative theory, the norms it proposes are the most important thing about expected utility theory. The norms it proposes are frequently the standards by which the theory is judged. If the norms or properties it proposes are sound then the method is sound. It is however debatable on what basis the soundness of these norms is to be judged. Are they to be judged from an implementation point of view or are they to be judged from a theoretical soundness point of view, the case of "wise sages". If for example the implementation is so cumbersome so as to hinder actual use by real world decision makers, for whom is the method sound?

In this section, some of the normatively appealing properties upon which expected utility theory is founded and some of their violations in practice are introduced.

The axiomatization of Expected Utility Theory by Von Neuman and Morgenstern (1947) shows that if a set of some apparently normatively appealing axioms holds, alternative actions can be ranked by their expected utilities (Keller, 1992). The Expected Utility Theory shows that the expected utility of an alternative action is equal to the weighted average of the utilities of the possible outcomes where the weights are the objective probabilities of each outcome (Savage, 1954). Subjective utilities can be computed by allowing the decision maker to derive his own subjective probabilities of events, which are then used to compute the subjective expected utility of each alternative (Savage, 1954).

There are some fundamental axioms of EUT, such as the substitution, ambiguity indifference, separability, the reduction of compound lotteries, the fixed reference level and transitivity properties (Keller, 1992, Howard, 1992, Keeney, 1992, Keen and Raiffa, 1993). These cannot, within the scope of this research, be discussed in detail. Only transitivity is discussed for the purposes of illustrating the differences of EUT with the Analytic Hierarchy Process.

The Property of Transitivity

The relation of preference is assumed to be transitive: If A is more preferable than B , and B is more preferable than C then it follows that A is also more preferable than C [$A \succ B$ and $B \succ C$ then $A \succ C$]. A must have a higher utility than C . This is the utility maximization assumption. The two, utility-maximization and transitivity requirements are inseparable (Keller, 1992). Intuitively, the transitivity of preferences for simple, single- criteria choices appears acceptable. For multiple criteria however, the transitivity of preferences seems not always to be true, as will be discussed below.

Violations of the Transitivity of Preferences

There have been numerous studies of the violations of the property of transitivity. This includes the preference reversal phenomenon (Grether and Plott, 1979; Lichtenstein and Slovic, 1971). However, these studies have assumed equivalence between judged and choice indifferences, which is now being questioned (Bostic, Herrnstein and Luce, 1991; Tversky, Sattath and Slovic, 1988). In a study conducted by MacCrimmon (1965) it was found that business executives sometimes violated transitivity. However when these were verbally pointed out, many of the

business executives chose to re-adjust their orderings to become transitive. The property of transitivity has, with the advent of the Analytic Hierarchy Process, become even more contentious. As will be seen later in this chapter the AHP does not absolutely demand the transitivity of preferences.

Utility-maximization theory requires that at least preference relations are transitive; otherwise, it would not work. Even though utility-maximization and transitivity requirements are inseparable normatively, in real world situations the intransitivities of preferences occur sufficiently often to be a curse upon modern decision theory (Saaty, 1992). Notwithstanding the fact that transitive relations are far more mathematically tractable than intransitive ones, one must recognize that they exist and provide a theory, which accounts for them. (Zeleny, 1982; Saaty, 1992). Fishburn (1983) does not assume indifference relations are necessarily transitive. That is, $B > A$ and $A > D$ are not assumed to imply $B > D$ in all cases. It was also found that intransitive choices can be expected to occur whenever more than one dimension exists in the attributes along which people order their choices (May, 1954). For uni-dimensional choices, he concludes that there can be no intransitivity of choices.

At the same time, subjects often wish to persist in the violations of other expected utility properties, especially substitution, sure-thing and ambiguity indifference (Keller, 1992). There is substantial evidence regarding the descriptive violations of the axioms upon which expected utility theory is based. The first reported paradox was initiated by Allais in 1953 (Keller, 1992) and it shows that subjects systematically make choices that violate principles of expected utility demonstrating that that expected utility is not a fully descriptive model of choice under risk. These violations have encouraged debate and developments of strains of utility theory that account for these violations. Some authors have responded to the charges of descriptive violations in an attempt to clarify the issue. In the main, there have been three broad categories of responses to the descriptive violations of expected utility. Firstly, some authors have argued that expected utility theory's purpose is normative. Thus, there is a need to re-clarify the conditions under which EUT is an appropriate model for prescriptive use and when it is not, as is the case when distributional equity is involved (Howard, 1992; Keeney, 1992; Keen and Raiffa, 1993). Secondly, there is a need to develop prescriptive techniques, for example, visual problem representations to aid decision makers to conform to expected utility theory (Howard, 1992;

Keller, 1992). Thirdly, new models have been proposed or developed, including the generalized utility models, that may be descriptively valid and that might be used prescriptively in special settings (Miyakoto, 1992, Keller 1992, Winkler, 1990).

The Multiattribute Utility Theory (MAUT)

Parts of MAUT are built on Expected Utility (EU) and Subjective Expected Utility (SEU) (Keeney and Raiffa, 1976; von Winterfeld and Edwards, 1986). MAUT is founded on a value function based on an additive score representing goal achievement according to each criterion, so that the total score or value of the alternative described by an attribute vector \mathbf{x} would be as follows

$$v(\mathbf{x}) = \sum_{i=1}^p v_i(x_i) \quad (1)$$

At a basic level \mathbf{x} has only the property of preference ordering so that if x^a is preferred to x^b then $v(x^a) > v(x^b)$. Traditional MAUT assumes that the utility function (u) is additive, which requires the independence (or substitutability) of attributes. If attributes are not fully independent then one might find that function (u) is not decomposable into its component parts and must be considered holistically as an irreducible entity (Zeleny, 1982: 413). Significantly, in order to ensure that this assumption holds it is necessary for the criteria to be preferentially independent. This means a decision maker should be able to explicitly state whether a given trade-off between two attributes representing two criteria is acceptable or not, *ceteris paribus*. There are only two binary relations for comparing two alternatives: strict preference, P and indifference, I . Both must be transitive. This excludes all cases of incomparability, which can come from conflicting criteria.

The Multiattribute Utility Theory (MAUT) evaluates utility functions intended to accurately express the decision maker's outcome preferences in terms of multiple attributes. If an appropriate utility is assigned to each possible outcome and the expected utility of each alternative is calculated, then the best course of action for any decision maker is the alternative with the highest expected utility (Keen and Raiffa, 1993). According to Fishburn (1970) indifference is defined as the absence of strict preference. Under such hypotheses, the alternatives

of any set can be ranked without ambiguity from the best to the worst (Roy and Vanderpooten, 1996).

This concept of trade-off is central to MAUT; and so is the additive value function: an increase of one unit of $v_i(x_i)$ will always be exactly compensated by a loss of one unit $v_j(x_j)$. This occurs regardless of the value of x_i (Vargas, 1994). $v_i(x_i)$ represents an interval scale of preference, where unit increments in $v_i(x_i)$ have the same marginal value to the decision maker. The scores are not, however arbitrary ordinal preference measures. In this way rank preservation or preference transitivity is critical to the premises of MAUT (Vargas, 1994).

MAUT is described as tending to reduce the complex problem of assessing multiattribute utility function into one of assessing a series of uni-dimensional utility functions. These individually estimated component functions are then glued together again in the form of "value tradeoffs". The tradeoffs are determined subjectively through the judgment of the decision maker, as in: "How much improvement am I willing to give-up in terms of objective *A* in return for specific improvement from objective *B*?" The main objective of MAUT is to establish a super-objective, to maximize the overall utility (Zeleny, 1982). As a result one of the most important tasks for MAUT is to establish the independence of attributes. In addition, the scaling factors used do not measure the relative importance of each attribute. These only reflect the relative importance of each attribute as it changes from its worst to its best available value (Zeleny, 1982).

A related criticism of utility theory is expressed by Zeleny (1982): that most utility theory assumes that all alternatives are comparable in the sense that given any two alternatives one or the other is either strictly preferred or the two are seen to be preferentially equivalent (choice indifferent). Yet, there is a presumption that one cannot express the intensity of one's preferences. If one is presumed not to be able to express the intensity of one's preference (as assumed in ordinal utility models) then the notion of indifference (which is a precise expression of preference intensity) becomes difficult or even impossible to estimate. If the decision maker does not strictly prefer one alternative to another, the absence of strict preference should not imply indifference. Certain pairs of alternatives are non-comparable because the decision maker either (1) does not know how to; or (2) does not want to or (3) is not able to compare them (Roy, 1977). To confound such non-comparability with indifference is to considerably over-simplify the decision

making process (Roy, 1977). In reality, it is well noted that there is a need to monitor the strengths of preferences as expressed by decision makers between the different gains and losses in one or more attributes. This requires the value function to do more than just preserve order (Vargas, 1994).

2.4. The Fundamentals of the Analytic Hierarchy Process and Major Research Areas in it

2.4.1. Introduction

In the preceding section, the general foundations of MCDM and of the expected utility theory were examined. Expected Utility's offspring MAUT (Multi-Attribute Utility Theory) was also briefly considered. In this section, the Analytic Hierarchy Process (AHP) is examined, starting with its foundations and extending to its areas and contexts of application.

Thomas L. Saaty developed the Analytic Hierarchy Process, a multi-criteria decision support approach, in the 1970's. The Analytic Hierarchy Process is a descriptive theory that includes procedures leading to outcomes, as they would be ranked by a normative theory (Saaty, 1991). In order to adequately examine and illustrate how the Analytic Hierarchy Process works, this section will conceptually introduce and define the AHP. Then it will briefly explore its mathematical aspects to illustrate adequately how it works.

2.4.2. A Conceptual Description of the Analytic Hierarchy Process

The AHP is a process-technique that focuses on the choice phase of decision making. " It helps decision makers structure complex decisions, develop measures of utility and synthesize measures of both tangibles and intangibles with respect to competing objectives. (Dyer and Forman, 1992). The Analytic Hierarchy Process is based on three principles:

- decomposition, of the overall problem into an hierarchy
- comparative judgments and
- synthesis of priorities.

In Saaty's words

"The Analytic Hierarchy Process is a method of breaking down a complex situation into its component parts, arranging these parts or variables into a hierarchic order, assigning numerical values to subjective judgments on the relative importance of each variable, and synthesizing the judgments to determine overall priorities of the variables" (Saaty, 1990:3).

With the Analytic Hierarchy Process, the problem is structured as a hierarchy and assessments are made in the form of paired comparisons. The AHP combines two other well-known approaches: (1) causal processes and (2) purposive action processes (Saaty and Vargas, 1991). In causal processes, an action is described as an event with specific outcomes with the sequence being cause → event (outcome), where the cause may be internal or external to the system. In purposive action processes, the sequence is action → event (outcome) → consequence (for the actors involved). In the latter case, the actions are no longer identical to the events. The actions of the actor in the system control the outcome of events and are selected through the conscious choice of the actor, who chooses the alternatives he believes are beneficial to him. Moreover, the outcome does not depend on the outcome of previous events through a causal process or on the attribute of the individual. The actor makes his choice of actions through his perception of the consequences that the outcomes will have for him or her. According to Saaty and Vargas (1991) the AHP synthesizes the two approaches by identifying the outcomes that are beneficial to the actors, while simultaneously providing a way of assessing the causes or factors which may have more to do with certain types of outcomes.

The mathematical foundations of the AHP are relatively conceptually simple to understand. The purpose of the approach is to use weights, called **priorities** to allocate a resource among activities or to implement the most important activity according to the rank of the activities. The task is to find the relative strength (i.e. priority or weight) of each activity with respect to each objective. The result obtained is then synthesized for each activity in order to derive a single overall priority for all activities.

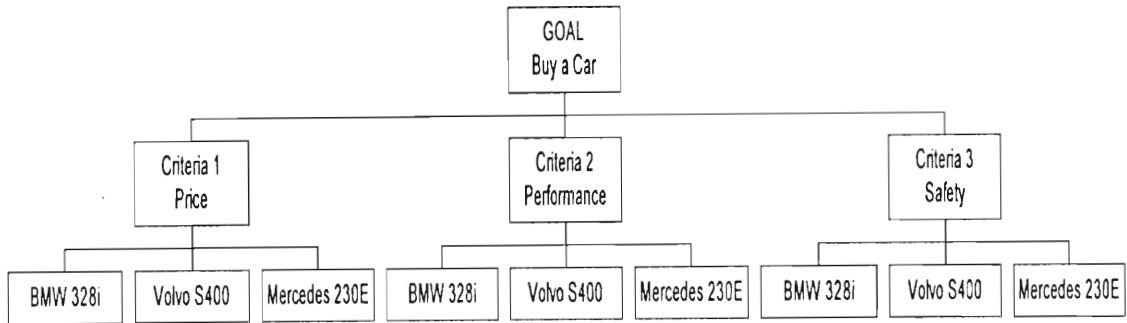


Figure 2.2 A Model for Car Selection

In Figure 2.2, for instance a decision maker wants to purchase a motor vehicle (the overall goal). She has reduced her alternatives to three models, i.e. a BMW, a Volvo and a Mercedes. There are three criteria (or objectives) that the decision maker has identified as relevant to the decision: price, performance and safety for all alternatives. In some instances, the objectives themselves may need to be prioritised with respect to another set of (higher level) objectives. The priorities of the (higher level) objectives are then used as weighting factors for the priorities derived for the activities. The process of comparing the higher level objectives with still higher ones may be continued up to a single overall objective (goal). This arrangement of the activities, objectives, to criteria to alternatives - makes up the hierarchical structure.

The decision making process is about establishing mappings between alternatives and attributes and between attributes and criteria. Before selecting an alternative, the final act, the structure should be fully assessed; although there is no objective measure to show that the construction of the structure is complete (Henig and Buchanan, 1996). It is the effort of construction that counts, and of necessity this is an iterative process. The reward is a better understanding of the decision maker's preferences and a possible extension of the set of alternatives.

Once the hierarchy has been defined, the AHP provides a method for scaling the weights of the elements in each level of the hierarchy with respect to the elements on the next higher level. The essential requirement for analysis by hierarchies is to be able to decompose a problem into levels, each level consisting of similar elements and having an impact on the levels above and below it (Saaty, 1984). Within each level a pairwise comparison of the elements is performed. Pairwise comparisons indicate the strength with which one element dominates another with respect to the criterion they are being compared (Saaty and Vargas, 1991). So that, in the example illustrated above a pairwise comparison in the first instance would reflect the relative strength of

performance to price with respect to buying a motor vehicle, or performance to safety and so on. Out of n factors there would be $n(n-1)/2$ judgments required to generate the pairwise comparison matrix entries because the reciprocals and the diagonal elements can be entered automatically.

There are two kinds of comparisons the AHP can use: **absolute** and **relative** comparisons (Saaty, 1990; Saaty, 1994a, Saaty and Vargas, 1991). From a cognitive psychology point of view with absolute comparisons, an alternative is compared with standards on various attributes that are stored through experience in memory. For relative comparisons, the alternatives are compared in pairs according to a common attribute (for example the BMW vs. the Volvo with respect to safety). Both types of comparison result in ratio scales of measurement in the AHP (Saaty, 1991c, Peniwati, 1996, Vargas, 1994, Saaty, 1996a). Relative measurement is usually needed in all problems, tangible and intangible (Saaty and Vargas, 1991). Absolute measurement is the normative mode, while relative measurement is the descriptive mode (Saaty and Vargas, 1991).

Absolute measurement is applied to rank alternatives in terms of the criteria; using the **ratings** or **intensities** of the criteria, such as excellent, very good, good, average, poor, and very poor. In the above example, the three criteria: safety, performance and price could be given intensities of excellent, very good, good and so on to very poor upon which each alternative car would be rated. After setting the priorities on the criteria (or sub-criteria), pairwise comparisons are also performed on the ratings of these. The ratings may be different for each criterion. An alternative is then evaluated or scored by identifying for each criterion, the relevant rating which describes that alternative best (Saaty, 1980; Saaty, 1990; Saaty and Vargas, 1991; Saaty and Kearns (1991). The final act is, the weighted (global) priorities of the ratings are added to produce a ratio scale score for that alternative. In general, the absolute measurement method is suitable for choice decisions that involve criteria that are set independently of the alternatives and when dealing with a large number of alternatives.

However, with absolute measurement there can be no rank reversal of the alternatives, when one alternative is added or another removed (Saaty, 1994b; Saaty and Vargas, 1991). This is particularly relevant where the importance of the criteria does not depend on the number of alternatives or on their priorities, even though it may be independent from the alternatives according to some function, meaning or context. This is in contrast to relative measurement (Saaty and Vargas, 1991). With relative measurement, the addition of a new alternative or

removal of an old one can result in the reversal of ranks of the original alternatives. This is clear to see because the priorities of the old alternatives change when an addition or removal of an alternative occurs. This property of the AHP has caused much consternation among proponents of utility theories and other MCDA practitioners and academics. One way of avoiding the possibility of rank reversal within the AHP is the use of the ideal mode of synthesis (Saaty, 1994c) in lieu of the original distributive mode.

In order to quantify the judgments, and or where the weights are unknown, the Analytic Hierarchy Process uses a fundamental scale with values that range from 1 to 9 as shown in Table 2.3 below. The reasons for choosing such a scale are summarized below (Saaty, 1994a; Saaty, 1990).

Table 2.3 The Analytic Hierarchy Process Scale and its verbal interpretation

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Weak Importance (of one over the other)	Experience and judgment slightly favour one activity over another.
5	Strong Importance	Experience and judgment strongly favour one activity over another.
7	Demonstrated Importance	An activity is strongly favoured and its dominance is demonstrated in practice.
9	Absolute Importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	Used when compromise is needed
Reciprocals of the above numbers	If activity i has one of the above numbers assigned to it when compared to activity j , then j has the reciprocal value when compared to with i .	
Rationals	Ratios arising from the scale	If consistency were to be scale forced by obtaining n numerical values to span

(1) The qualitative distinctions are meaningful in practice and have an element of precision when the items being compared are of the same order of magnitude or close together with respect to the property used to make the comparison.

- (2) The ability to make qualitative distinctions is well represented by the five attributes: equal, moderate, strong, very strong and extreme and interpolations between them when desired.
- (3) The limit of seven (plus or minus two) items in simultaneous comparisons suggests that if seven (plus or minus two) elements are compared and if they are all slightly different from one another, a nine point scale would be needed to distinguish among these differences.
- (4) There are both local and global priorities. Local priorities are defined with respect to the root of a cluster in a hierarchy, whereas global priorities represent the priority with respect to the overall goal.

2.4.3. A Brief Axiomatic Description of the Principles of the Analytic Hierarchy Process

The AHP is mainly based on four axioms (Saaty, 1994a) namely,

- (1) reciprocal;
- (2) homogenous
- (3) hierarchic or feedback independence; and
- (4) expectations about the validity of the model and about derived rank order.

1) The Reciprocity of Comparisons

The reciprocal comparisons are based on the simple abstract principle that, "magnitude comparison between two objects, on a common property is established by using the smaller object as a unit of measurement and estimating the larger one as a multiple of that unit" (Saaty, 1994a: 44). In addition, "it is essential that the smaller object be the first one used to estimate the magnitude of the larger object in order to determine the reciprocal value for the smaller one. If the larger object is to serve as the unit, it must be decomposed by using the smaller object as the unit" (Saaty, 1994:44). The reciprocal relation between the two objects, x and y , has the form: $y=1/x$ from which the symmetric relation $xy=1$ is known as inversion. Inversion assumes that the magnitudes of x and y can be established with respect to a third magnitude, which has an arbitrary unit value.

Graphically, when x is allowed to vary continuously over real numbers, this specifies a hyperbola in the xy -plane. More generally "it specifies a ratio in a potential field between two points A and B so that A has a potential of $1/x$ from B and B a potential of $1/y$ from A" (Saaty, 1994a: 44). Finally, reciprocal comparisons are of two kinds continuous and discrete, but both types of

comparisons give rise to numbers that belong to a ratio scale. Comparisons require a particular kind of information, although when actual numbers are available they can be used to estimate relative measurement. Where there are no scales, judgment must be used to make the estimate. Cognitive psychologists contend that judgment relies on the brain to respond accurately to a stimulus of varying intensity. However, judgment must precede the existence of scales (Saaty, 1994a).

2) The Homogeneity of elements

The axiom of homogeneity implies that for accuracy, judgment must be confined to a narrow range of discrimination among intensities. For wider ranges one needs to cluster homogenous elements together and include a common element to act as a pivot from one cluster to the next (Vargas, 1994).

3) Hierarchic or feedback dependence

According to this axiom, to deal with multiple attributes there are two concepts of independence that the Analytic Hierarchy Process needs: outer dependence and inner independence. A set of alternatives, A is said to be *outer dependent (independent)* on a *criterion C* if there does not exist a $w_c \in W$, where w_c is an element in the set of alternatives and W is the set of criteria on a level above the alternatives in the hierarchy. A set of alternatives A is said to be *inner independent with respect to the criterion C* if, and only if the elements in A are outer dependent on themselves according to the criterion (Vargas, 1994). Further, in a hierarchy:

- a) A level is outer dependent on the level above it.
- b) A level is inner independent with respect to all the elements in the level above it
- c) A level is outer dependent on the level below it (Vargas, 1994).

More details on dependencies in the AHP can be found in Saaty (1996), where he deals with the Analytic Network Process, which is beyond the scope of this dissertation.

4) Expectations about the validity of the model and about derived rank order

When making a decision the hierarchy is assumed to be complete (Vargas, 1994, Henig and Buchanan, 1996).

The implications of the above axioms can be illustrated in the following manner. Suppose one is given n elements to compare $[A_1 \dots A_n]$, and assume that the weights of the elements are known

respectively as $[w_1 \dots w_n]$. Further, suppose that a matrix of pairwise comparison ratios is formed whose rows give the ratios of the weights of each element with respect to the others. This gives the following equation:

$$\begin{matrix}
 & A_1 & \dots & A_n \\
 A_1 & \left(\begin{matrix} w_1/w_1 & \dots & w_1/w_n \\ \dots & & \\ A_n & w_n/w_1 & \dots & w_n/w_n \end{matrix} \right) & & \\
 \dots & & & \\
 A_n & & &
 \end{matrix}
 \begin{matrix}
 \left(\begin{matrix} w_1 \\ \dots \\ w_n \end{matrix} \right) \\
 \mathbf{w}
 \end{matrix}
 =
 \begin{matrix}
 \mathbf{n} \\
 \\ \\
 \left(\begin{matrix} w_1 \\ \dots \\ w_n \end{matrix} \right) \\
 \mathbf{nw}
 \end{matrix}$$

If for example the elements were A_1 to A_n were gold bars whose respective weights w_1 to w_n were being compared to form the matrix \mathbf{A} , then the reciprocal nature of the matrix \mathbf{A} is easily illustrated in that the element $w_{ij} = 1/w_{ji}$. That is if one gold bar is estimated to be 10 times larger than another then the other which serves as the unit of comparison must be 1/10 times as heavy as the first. Also, any gold bar compared to itself should produce a weight ratio of 1; hence the diagonal elements are all unity in a reciprocal matrix.

The above matrix \mathbf{A} has been multiplied on the right by the vector weights \mathbf{w} , the result of this multiplication is \mathbf{nw} . To recover the scale from the matrix of ratios, the equation $\mathbf{A}\mathbf{w}=\mathbf{nw}$ or $(\mathbf{A}-\mathbf{nI})\mathbf{w}=0$ must be solved. This gives rise to a system of homogenous linear equations that has a non-trivial solution, if and only if the determinant $(\mathbf{A} - \mathbf{nI})$ vanishes, i.e. that n is an eigenvalue of \mathbf{A} (Saaty, 1994a, 1990).

Since every row is a constant multiple of any other row, the matrix \mathbf{A} has unit rank and therefore all its eigenvalues, except one, are zero. The sum of the eigenvalues is equal to the trace of the matrix (i.e. the sum of its diagonal elements). In this case the trace of \mathbf{A} equals n . Therefore n is the eigenvalue of \mathbf{A} , it is the largest principle eigenvalue and associated with it is a non-trivial positive solution \mathbf{w} . To make \mathbf{w} unique its entries are normalized by dividing by their sum. Thus, given a comparison matrix the scale can be recovered. In this case, the solution is any column of matrix \mathbf{A} normalized (Saaty and Vargas, 1991). Significantly, matrix \mathbf{A} has the reciprocal property of $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$ (Saaty, 1994a, 1990; Saaty and Vargas, 1991). Another property of matrix \mathbf{A} is that ideally it is **consistent**. Its entries satisfy the condition $a_{ij}a_{jk}=a_{ik}$.

A positive n by n matrix is said to be **consistent** if:

$$a_{ij}a_{jk}=a_{ik} \text{ and } i, j, k = (1, \dots, n)$$

The relations $a_{ji} = 1/a_{ij}$ and $a_{ii} = 1$ must be preserved in the matrices in order to maintain consistency. The reason as illustrated above being, if for example element $x_1(w_1)$ is estimated to be k times heavier than element $x_2(w_2)$, then common sense requires that element $x_2(w_2)$ be estimated to be $1/k$ times the weight of the first (Saaty, 1994a).

The AHP provides the decision maker with a way of examining the consistency of the entries in a pairwise comparison matrix and the hierarchy as a whole, through a consistency ratio measure (Golden and Wang, 1989). The consistency index (C.I.) is defined as

$$\text{C.I.} = (\lambda_{\max} - n)/(n-1)$$

where λ_{\max} is the largest eigenvalue of the $n \times n$ pairwise comparison matrix. If the decision maker is perfectly consistent in specifying the entries then, then $\lambda_{\max} = n$ and C.I. = 0. Where the decision maker is inconsistent then $\lambda_{\max} > n$. Saaty (1990) has proposed the consistency ratio (C.R. to measure the degree of inconsistency) where

$$\text{C.R.} = \text{C.I./R.I.}$$

The R.I. (random index) value is computed from 500 $n \times n$ positive reciprocal pairwise comparison matrices whose entries were randomly generated using the 1 to 9 scale (Saaty, 1990). If the consistency ratio were significantly small, then the estimates would be accepted. Otherwise, an attempt would be made to improve the consistency by getting additional information. Finally, a value of C.R. under 0.10 it taken to mean that the decision maker has been sufficiently consistent (Saaty, 1990).

An inquiry into what contributes to the consistency of a judgment, yields the answer that the following elements contribute to consistency (Saaty, 1994a; Saaty, 1994b):

- (1) The homogeneity of the elements in a group that is "not comparing a grain of sand with a mountain".
- (2) The number of elements in a group - to improve consistency, it is accepted that an individual cannot compare more than seven objects (plus or minus two) simultaneously without

becoming more inconsistent. This is based on psychological experiments, which can be justified mathematically (Saaty, 1990).

- (3) "The knowledge of the analyst about the problem under study" which will contribute to the ability to understand and facilitate more or less consistency.

2.4.4. On Some Applications of the Analytic Hierarchy Process

The Analytic Hierarchy Process has been used in a multiplicity of settings globally. It is the most widely used decision analysis methodology in the United States of America (Golden and Wang 1989; Zahedi, 1986) and also around the world (Xiang and Ming: 1991 and Vachnadze and Markozashvili, 1987; Vargas, 1994). Moreover, the majority of Analytic Hierarchy Process applications have been in group settings. This is because it structures any complex, multi-person, multi-criterion and multi-period problem hierarchically. The need for sharing ideas, consensus building, and justification purposes in group decision making is catered for. This is the primary reason why the members of the group decision environment studied in this research the Students' Representative Council (SRC) were motivated to use the approach.

There are more than 2000 title papers on the theory and application of the Analytic Hierarchy Process contained in just Saaty (1994b). Some examples are in conflict resolution (the 'miracle' South African negotiated settlement is an outcome of a process that included Analytic Hierarchy Process specialists); generating alternatives; setting priorities; faculty member selection; site location, predicting outcomes; planning and forecasts. Attempting to illustrate all the areas of application of the AHP is not feasible within the confines of this research. Although the AHP has a relatively short history (Winkler, 1990) compared to the tradition of Utility Theories, it appears to have gained significant worldwide acceptance. This is in spite of some of the animated theoretical arguments and debates that have been characteristic of the interaction between the proponents of the Analytic Hierarchy Process and those of Utility Theories.

2.4.5. On Issues and Characteristics that differentiate the Analytic Hierarchy Process from Utility Theories

The existence and foundations of the different streams of thought in the field of MCDA were discussed in Section 2.2.5. The ORM and Expected Utility Theory have already been explored. In this section the features that distinguish the Analytic Hierarchy Process and the Multiattribute

Utility Theory (MAUT) and to a lesser extent the Outranking Methods (ORM) are explored. Evidently, proponents of these streams of thought are engaged in debates that often attempt to prove the superiority of one method over the other. For the purposes of this discussion, the major axiomatic differences of both are summarized in the Table below.

Table 2.4 A Summary of the axiomatic differences between MAUT and the AHP

MAUT	AHP
Normative	Descriptive
Absolute Measurement	Relative Measurement
Interval Scales	Ratio Scales
Preference Elicitation: Lottery Comparisons	Preference Elicitation: Pairwise Comparisons
Intransitivity of Preferences and no Rank Reversal	Transitive Preferences and rank reversal possible
Rationality assumption	Accounts for Judgmental Biases
Group Support?	Group Support?
Handles uncertainty	Handles uncertainty through interval judgments

2.4.5.1. The Measurement Scale of the Analytic Hierarchy Process Compared to Expected Utility Theory

Both the AHP and utility theories are preoccupied with the scales they use: the Analytic Hierarchy Process uses ratio scales for both criteria and alternatives, while the MAUT uses interval scales for the alternatives only. Conceptually, it has been shown that MAUT is a normative approach and the AHP a descriptive and prescriptive approach (Saaty, 1997). While Howard (1992) argues for preserving the scientific way in which decisions must be made, Saaty, in defence of the prescriptive approach observes that

"People have been making decisions for a very long time. Contrary to what most of us who are interested in decision making may like to believe, most people do not take seriously the existence of theories which purport to set their thinking and feeling right. They claim to know their own value system and what they want. They may wonder how anyone else can know well enough to tell them how best to organize their thinking in order to make better choices. Yet, research has shown that complex decisions are beyond the capacity of the human brain to synthesize intuitively and efficiently. Since decision-making is a natural characteristic of people, how do we describe what they do so that an ordinary mortal can understand what we are saying? We do not wish to legislate the

method with which people should make decisions but only to describe it...In the process we may learn things that can help people make better decisions"(Saaty, 1990d: 259).

Zeleny (1982:478) echoes similar sentiments when he notes:

"We know next to nothing about how and why people make decisions; yet we feel entitled to advise them how and why they should make them. If atoms and molecules failed to adhere to the laws supposedly describing their behaviour, we would not call such behaviour irrational or suboptimal. Yet when people fail to follow the axioms of rationality invented by other people, their behaviour is considered suboptimal and irrational"

Relative measurement

MAUT proponents have rejected relative measurement and the hierarchic composition of the AHP. Dyer (1990) argues that the rankings produced by the AHP are arbitrary. He contends, arbitrary rankings occur when the principle of hierarchic composition is assumed. "This principle requires that the weights on the higher levels of the hierarchy be determined independently of the weights on the lower levels" (Dyer, 1990:249). In other words, the weights on the criteria do not depend on the alternatives under consideration. Finally he suggests that the key to correcting this flaw is the synthesis of the Analytic Hierarchy Process with the concepts of MAUT. However, these sentiments are disputed on the basis of the fact that they rely on the foundations of MAUT (see Saaty, 1990a).

Preference Elicitation Methods

The Analytic Hierarchy Process has been criticized for the "ambiguity of the questions that the decision maker must answer" (Dyer, 1990). In addition, the defence claim of the Analytic Hierarchy Process that ambiguity is inherent in all preference elicitation methods including those of classical utility theory (Harker and Vargas, 1987) has been described as misleading (Dyer, 1990). Dyer argues that the elicitation questions associated with the AHP have more in common with the questions used to determine a strength of preference function, which requires a subjective estimate of strength of preference on a cardinal scale (Dyer, 1990).

The AHP is regarded as being easy to use for the purposes of preference elicitation. On the contrary, Olson et al. (1996) in a comparative study of MCDM approaches found that MAUT was comparatively more difficult to understand. SMART which is a Multi-Attribute Value

Theory (MAVT) tool is a simplified version of MAUT in that it does not seek the decision makers attitude towards risk was also found to be easier to use. Belton (1993) reports that there is a general tendency for a wider acceptance within the utility theory school of MAVT, precisely because it is simpler than MAUT in not requiring the decision maker's attitude to risk.

Dealing with Uncertainty

The AHP has been criticized for being found wanting in handling uncertainty. Proponents of the AHP have refuted this. The AHP allows for the incorporation of uncertainty in the decision making process through interval judgements (Saaty, 1990), and recently through emerging fuzzy logic extensions of the Analytic Hierarchy Process. See also (Saaty and Vargas, 1987; Forman 1993; Haines, 1998).

The 'great deal' of time required to process the pairwise comparisons in a typical Analytic Hierarchy Process analysis is another criticism that has been levelled at the Analytic Hierarchy Process (Forman, 1997). For a moderately sized problem, the AHP may be too time-consuming. However, the "AHP is not designed for use on the vast majority of the thousands of decisions we make each day but rather for the 'crucial' decisions that individuals and organizations must make" (Forman, 1997:35).

Scales of Measurement, Inconsistency and the Transitivity of Preferences

The one to nine scale of the AHP has also been criticized, together with the use of the eigenvector approach to average inconsistent judgments (Dyer, 1990). Arguably, relative comparison, as Saaty points out is the tool of the human brain as demonstrated by cognitive psychologists. Luce and Raiffa, (1957:25) observed:

"No matter how intransitivities exist, we must recognize that they exist, and we can take only little comfort in the thought that they are an anathema to most of what constitutes theory in the behavioural sciences today... Or we may limit ourselves to 'normative' or 'idealized' behaviour in the hope that such studies will have metatheoretic impact on more realistic studies... Transitive relations are far more mathematically tractable than intransitive ones"

Relative comparison is used all the time and it will not disappear through lack of a fitting axiomatic framework (Saaty, 1991a). As demonstrated earlier intransitivity is likely to emerge in

pairwise comparisons, and the AHP does not demand transitivity or perfect consistency ($\lambda_{\max} = n$) but provides a measure of inconsistency in each set of judgments (Forman, 1993). Many authors have argued in defence of the intransitivity of preferences in that "if intransitivity frequently occurs as an integral part of the human decision making strategy then it cannot be wished away. It must be incorporated into our models as well. There is nothing inconsistent about the intransitivity of preferences" (Zeleny, 1982: 85; Forman 1997). The inconsistency of judgments is shown at the end of the process (Forman, 1997, Saaty, 1990). Forman (1997) suggests it is important that a low inconsistency *not* (sic) become the goal of the decision making process. A low inconsistency is a necessary but not sufficient condition for a good decision. He observes that it is more important to be accurate than consistent. "In fact it is possible to be perfectly consistent but consistently wrong". Other authors have argued that it is natural for decision makers to want to be consistent, it is a prerequisite to logical thinking, and that transitivity violations would undermine the confidence the decision makers may initially have in the tool (Lootsma, 1993). However, Dyer (1990a) argues these areas are relatively minor operational issues and do not represent flaws in the basic methodology of the Analytic Hierarchy Process.

2.4.5.2. Rank Reversal in the Analytic Hierarchy Process - The Preservation of Rank Paradox.

The objection to the Analytic Hierarchy Process allowing rank reversal is regarded as a more substantive objection by proponents of classical utility theories. Dyer (1990a) contends that rank reversal is actually a symptom of a much more profound problem with the Analytic Hierarchy Process, that is, the rankings provided by the Analytic Hierarchy Process are arbitrary. The rank reversal phenomenon is explored first. Simply stated rank reversal implies that the ranking of alternatives as determined by the AHP may be altered by the addition or subtraction of another alternative for consideration (Dyer, 1990a).

The major objection from the proponents of utility theory against relative measurement comes from the acceptance of Utility Theory's axiom on the transitivity of preferences. This axiom states that if an additional activity is introduced in the comparisons of the original set $[A_1, \dots, A_n]$, or if one of them is deleted, there should be no change in the rank order of the original set (Howard,

1992). In the Analytic Hierarchy Process, this is true when the matrix A is consistent but not when A is inconsistent.

The point is illustrated using an example quoted in the literature, (Corbin and Marley, 1974; Saaty, 1996a) that of a woman in a small town wishing to buy a hat. The lady enters the only hat store in town and is shown two hats A and B , that she likes equally well, and thus may be considered equally likely to buy. However, it is then supposed that the salesperson discovers a third hat, C , which is identical to A . The lady may well choose hat B for sure (rather than risk the possibility of encountering someone wearing a hat identical to hers). This result contradicts regularity, a condition of choice theory that has to do with rank preservation (Saaty, and Vargas, 1994).

These violations of the utility theory property of independence from irrelevant alternatives occur sufficiently regularly in the real world to pose an integrity problem for a decision aid that does not account for them. For example in politics the tactic of vote splitting is often used, where for example, there are two candidates one rightist and the other leftist with a result of 60% for the leftist candidate and 40% for the rightist candidate. If a third, less popular rightist candidate, is introduced, this would split the right vote between the two options available to the right and the leftist candidate could emerge as the winner.

Although, "axiom 4, developed by Saaty (1986), of the theory of the AHP explicitly excluded copies and near copies from consideration" (Harker and Vargas, 1987). Dyer contends that the reasoning behind the exclusion of copies and near copies is without foundation and cannot be supported on either intuitive or technical grounds. Rather when ranking a set of alternatives by some procedure, it is expected that when a copy of one of them is added to the set, the procedure should rank this copy the same as its matching alternative (which the AHP does do). In addition, it is expected that the procedure assign both alternatives the same rank as that of the original matching alternative (which the AHP does not do). The only exception should occur where the criteria include a concern about the uniqueness of an alternative and or if "the copy provides additional information that changes the perception of the decision maker regarding the alternatives" (Dyer, 1990a: 253).

To conclude, an observation relevant to one of the sub-goals of this research is made and that is about a decision making environment with “lifeworld actors” (Ngwenyama and Lee, 1997) with a vested interest in a decision. It is almost inconceivable that the addition or removal of a said alternative does not in itself present additional information that may or may not change the decision makers perception of the decision problem including both alternatives and criteria.

"The mere presence or absence of an alternative in relative measurement introduces additional information regarding the dominance of that alternative with respect to the other alternatives, irrespective of their number. This information is like adding or deleting a variable in a linear programming problem. The new optimum must be re-calculated from the start. In addition the new optimum would not usually coincide with the previous optimum on some of the variables" (Harker and Vargas, 1990)

The simple presence or absence of an additional or previously available alternative be it a copy, near-copy or different alternative alters the decision context. It is also possible that the decision maker may wish to re-define the criteria in light of the changes in the available options or criteria, however. This thinking is consistent with the concept that as decision aids (or facilitators) interact with decision makers and the decision making process itself they affect the outcome of the process in some way. More pertinently, in practice, in a structured organizational decision process, alternatives do not suddenly appear to be added onto the process or removed willy-nilly. The initial decision to include or exclude alternatives, in the first place, is a considered one. Most business organizations would not waste time or money worrying about phantom alternatives or dispensable alternatives. In sum, when an alternative is added or removed a re-ranking appears necessary. This is not to say that a reversal of rankings is necessary, but that it is possible.

There are cases, nevertheless where one would want to preserve rank, such as in admissions selection in an academic institution (Saaty, 1991). As already mentioned the AHP uses absolute measurement. In this case, this does not end the debate as absolute measurement is also based on hierarchic composition, implying if the original construction of intensities were also changed, by adding (or removing) a new rating category, such as "above average" onto ["high", "medium" and "low"]. Then using the AHP to generate scores to the now four possible ratings on this criterion, "the rankings may change even if none of them are the rating "above average" and no other ratings are changed (Dyer, 1990a: 274). The ideal mode of synthesis in the AHP is another way of preserving rank. Although Dyer (1990) contends that the real issue is not the phenomenon of

rank reversal per se, but a “much more profound problem” with the AHP: “the rankings provided are arbitrary”. Dyer suggests that a solution would be one that incorporates the property of difference independence from utility theory, although Saaty refutes this in his reply.

On the other hand, some authors have argued that the AHP and the MAUT are more alike than dissimilar. For example, see Forman (1993) and Keller (1992). More specifically, when comparing the Analytic Hierarchy Process' absolute or ratings mode - (which has been described as the normative mode (Saaty and Vargas, 1991; Harker and Vargas, 1990)) - with MAUT, the only significant difference is the way the value function is derived for the alternatives. As the Analytic Hierarchy Process uses pairwise comparisons the MAUT uses lotteries.

Other differences involve the way in which the analysis is structured when there are numerous attributes and how weights are derived for the attributes. These differences are becoming less and less apparent as MAUT practitioners have begun to use the Analytic Hierarchy Process approach for these aspects of the problem. Thus if the absolute or ratings approach of the AHP is compared to MAUT, the only difference is the questioning used to derive the shape of the value function (Forman, 1993).

2.4.5.3. On Some Issues Related to the Hierarchical Structuring of Problems

With the AHP, problems are structured either in the form of a hierarchy, or as a network (in the case of existing interdependencies between the elements of one level, or feedback from lower levels in the hierarchy). The hierarchy has long been seen as a suitable representation for handling complexity (Simon, 1962), and is widely used in general systems theory, cybernetics and hard systems thinking. According to Saaty (1994b), the basic principle to follow in creating this structure is always to see if one can answer the following question: Can I compare the elements on a lower level using some or all of the elements on the next higher level as criteria? Hierarchies are only special cases of more general network models that can capture the interdependencies between elements within a level, or feedback from a lower level to a higher one.

As a multi-criteria decision making theory, the AHP is suitable for evaluating subjective issues revealing cultural and political differences within the context of a given problem (see Saaty and Alexander, 1990).

AHP models include both qualitative and quantitative data and in this way it reflects the subjectivity of the decision maker as an important element of complex problems, where not all decision factors can be measured precisely in quantitative terms. However, the incorporation of subjective data in a decision problem is a controlled subjectivity; controlled through the Consistency Ratio (Saaty, 1990). The latter provides an effective feedback mechanism for the quality of decisions based on the pairwise comparisons of decision makers.

It can be easily observed that the higher levels in a hierarchy usually reflect policy factors that would be considered mainly by top-level management. On the other hand, lower levels of an AHP model comprise features reflecting more specific knowledge about the problem. In a decentralized decision making environment such operational level knowledge is typical for decisions that are taken by individual organizational units (Petkov, 1994).

2.4.5.4. Group Decision Making Contexts and the AHP

The suitability of each MCDA approach to group decision making in general and within specific group decision contexts is another distinguishing factor between the AHP and MAUT. However, it is distinguishing in so far as the AHP makes provision for group decision making and has been applied on many occasions to group decision environments. In contrast it is the absence of group decision support within utility theory that is evident. Group decision support, and in particular mapping multiple criteria decision analysis to organizational group decision environments is a major sub-goal of this research. Hence, this aspect is assigned a section of its own. In this section, a continuum of decision contexts is presented and the Analytic Hierarchy Process's ability to handle these is examined. There is almost nothing in the literature on the application of other MCDA approaches to group decision support environments (Lootsma, 1996).

Why is the Analytic Hierarchy Process suited to Group Decision Making? Numerous researchers (Nunamaker et. al, 1991) have pointed out the need to focus on supporting the decision process as opposed to the isolated task. Of the four decision making phases defined by (Simon, 1960), DSS and GDSS research has to date placed emphasis on the intelligence and design phases with relatively little attention paid to the choice phase (Dyer and Forman, 1992).

In group decision making situations, there is little assurance that all available and pertinent information has been considered or even that the choice made by consensus is the one that is

most likely to achieve the stated objective. Limited human capacity to process information, inherent in complex decisions, impacts on the human ability to make the kinds of tradeoffs implied by choices involving several conflicting dimensions. (Jennings and Wattam, 1994). From this, it is evident that groups and indeed group support systems need multiple criteria methods to deal with various decision contexts.

Dyer and Forman (1992) outline a continuum of group decision making contexts that range from common objectives, non-common objectives to conflict in which the AHP can be applied.

(1) Common Objectives -- which is where all parties, have virtually the same objectives. They suggest that there are four ways in which the AHP can be applied under a common-objective, group decision making context:

- *Consensus*

The process of consensus can be used to persuade people that their interests have been taken into account. From the point of view of the Analytic Hierarchy Process consensus implies improving the confidence of the priority values by using several judges to bring the results in line with the majority preference (Saaty, 1990a). In this case the AHP provides one of two ways: either the group can discuss and debate the issue and seek consensus through discussion, for each judgment, or each individual member can provide their own personal evaluation.

- *Voting or Compromising*

If on the other hand consensus cannot be reached on a specific judgment, then the group may choose to vote or compromise on an intermediate judgment. They note that this works particularly well with the AHP because of the inherent redundancy in pairwise comparisons, which ensures that priorities change little with any small change to any one judgment. The point is to make sure that group members are aware of this feature (Dyer and Forman, 1992:103). This makes groups more amenable to compromising instead of being "bogged down on a particular judgment."

- *Forming the Geometric Mean*

Where there is disagreement and consensus cannot be reached, or the group is unwilling to vote or compromise on a judgment, the judgments can be combined for each question by taking the

geometric mean of members' assigned individual judgments (Saaty, 1990a; Dyer and Forman, 1992; Tone, 1996).

▪ *Combining the Results from the Individual Models.*

If group members cannot meet or have significantly diverse objectives, then each group member can provide judgments separately. These individual judgments can then be processed by the use of separate models, which are then averaged. Expert Choice performs this function with ease. Else the model could incorporate the actors or participants in the hierarchy, below the goal node, and weights assigned to the actors. This however is slightly more complex and consideration must be given on how to assign weights to the players. If soundness of judgment were a consideration for example, how would this soundness be measured? These are additional issues the group will have to discuss and possibly create another hierarchy for this purpose. The resultant actors' priorities can then be entered on the original hierarchy.

(2) Non-common objectives -- that is, where the parties have non-shared and sometimes hidden objectives. For non-common objectives it is not possible to reach consensus on all aspects of the decision and similar approaches to the above are recommended by the authors. They recommend focusing on objectives or interests as opposed to alternatives or positions. They suggest that interests are more important because they define what the problem really is. "A wise solution should reconcile interests and not positions" (Dyer and Forman, 1992:105).

(3) Conflict -- decision contexts in which the parties seek concessions from their opponents. In a conflict, particularly one of long duration, reason rarely prevails (Dyer and Forman, 1992). Positions become entrenched and "people seek not only to satisfy their own needs, but also to punish their opponents for having opposed them or at least to pay the price for their opposition" (Saaty and Alexander, 1989: - on retributive conflict resolution). In this case, there is the need, by both parties, to assess what the benefits and costs to themselves and their opponents may be for any concessions made or received on either side. These concessions may be qualitative or quantitative. However, questions on how the concession lists are to be generated i.e. how one trade-off sets off concessions that are acceptable to both sides, or in order to reach a "comprehensive" settlement. Or indeed on what is meant by a comprehensive settlement, and what the role of the mediator is in achieving a comprehensive settlement? All these are questions that remain to be answered (Dyer and Forman, 1992).

2.4.5.5. On the AHP and Group Judgments: Consensus Building

The aggregation of individual judgments or ratings into a group score has been subject to debate with reference to MCDA decision approaches and group decision making. As early as 1967, Kenneth Arrow suggested, in his impossibility theorem that, in general it is impossible to derive a rational group choice from ordinal comparisons made by individual members, implying aggregating individual preferences into a group preference is impossible. Arrow's theorem is a work on the compatibility of a social utility function with individual utilities. Arrow concludes that it is impossible that the ordering of alternatives by a group will always be consistent with the ordering of each of the participating individuals (Saaty, 1994e; Peniwati, 1996; Howard, 1992). Arrow's impossibility theorem has excited a lot of debate particularly among the proponents of the Analytic Hierarchy Process who have challenged his work, while others regard it as "seminal" (Howard, 1992).

Peniwati (1996) shows that ordinal group aggregation is problematic, complex and "procedure dependent". She demonstrates that the aggregation of ordinal preferences is subject to the paradox of voting, the Condorcet effect which occurs when the aggregation of transitive, individual ordinal preferences produces an intransitive group choice. Peniwati, further illustrates that the conditions laid out by Arrow can however be satisfied when one uses preferences that are cardinal as opposed to ordinal. More specifically, at appropriate consistency levels, the AHP negates the impossibility theorem (Peniwati, 1996). When individual vector priorities are known, the geometric mean is a way of combining them to represent a group priority in a manner consistent with the propositions of Arrows' Theorem (Peniwati, 1996; Saaty, 1994c).

Similarly, Saaty (1994c: 39) suggests the "way to analyse how individuals develop expectations about the compatibility of their rankings with that of the group to which they provide input is by assuming that each individual carries out a complete ranking of the alternatives and compares it with the originally proposed group ranking". Ranking can be performed on a cardinal scale so that "meaningful numbers are assigned to the alternatives rather than ordinals". The creation of a cardinal scale is achieved by creating a ratio scale, which according to Saaty leads to the question of inconsistency and deciding when a ranking is valid and when it is unjustified by the judgments. By allowing for specified levels of inconsistency individuals can adjust their judgments and incompatibility up to the tolerance level, so that it is possible that all individual

preferences would agree with a group decision more often than Arrow's theory suggests (Saaty, 1994c).

Individual judgments can also be elicited from each individual and these judgments can be combined using the geometric mean. "The use of the geometric mean is the only way in which to combine judgments made in pairwise comparisons while preserving the reciprocal property" (Saaty, 1990a, 1994c; Peniwati, 1996, Forman and Peniwati, 1996). The latter statement has not met with difficulties of acceptance that are articulated in the literature.

2.4.5.6. Further Additional Research on the Original AHP

The criticisms of the AHP by utility theorists have not gone unnoticed. Some proponents of the AHP have taken heed and developed extensions of the AHP that resolve the problem of rank reversal, for example the ideal mode of synthesis in Saaty (1997). Other developments that have emerged extending the AHP include issues of scale, the handling of uncertainty and interference between elements. These are briefly discussed below, although a detailed discussion of these is beyond the scope of this research. One development has been the introduction of a modified scale such as the so called "balanced scale" (Salo and Hamalainen, 1997), or the scale proposed for the multiplicative form of the AHP (Lootsma and Schuijt, 1995). Salo and Hamalainen (1997) claim the balanced scale decreases the inconsistency of the comparison matrices and the variation in weights compared to the traditional AHP one to nine point scale proposed by Saaty. No report on the basic difference between the final ordering of alternatives using the two scales exists. Poyhonen and Hamalainen (1997) report that the balanced scale produced weights for the first and second most important attributes that are closer to those derived by other MCDA approaches, while for the same weights the traditional scale produced values that were greater by as much as a 100%.

Multiplicative AHP (MAHP) evolved from the ideas of Lootsma (1993). Its foundations are laid out in an axiomatic framework developed by Barzilai and Lootsma (1995) and enhanced in Barzilai (1996). MAHP uses the same problem structuring as the original AHP. It employs a ratio scale for the preference rating of one alternative over another using pairwise comparisons to elicit the preferences. It also employs a hierarchical structure and the same questioning procedure as the classical AHP. The differences between itself and the classical AHP are in computational

methods. The most important feature about it is, it avoids rank reversal by applying the Utility Theory axiom of the independence of irrelevant alternatives, when that is considered undesirable.

Other recent developments pertain to the possibility of handling the uncertainty inherent in decision makers' judgments through interval judgments. With interval judgments, the decision maker defines an interval in which his or her judgment lies, in lieu of generating a point judgment. Other approaches have been suggested in the last ten years, including simulation and linear programming. More information on this can be found in Saaty (1994), Salo and Hamalainen (1997), Stam and Silva (1997) and Haines (1998).

2.5. On Future Areas of Research within MCDA-MCDM

In the earlier sections of this chapter, the three schools of MCDA were identified. These were explored with respect to their axiomatic foundations and frameworks, and their ability to handle multiple criteria, multiple persons, and multiple alternatives problems that exist for organizational decision makers. What emerged were some differences between the approaches about some fundamental theoretical issues. And yet besides the signs of formation of the Multi-attribute Utility Theory (MAUT), the Analytic Hierarchy Process, and the Outranking (French) schools, "we still do not have a shared view on how human preference and human value judgment should be modelled" (Lootsma, 1996:37).

On the other hand, Bana e Costa et al. (1995:271) suggest that these streams of thought should not be seen as conflicting, but rather as complimentary approaches and sources of new and rich ideas. "Under this constructive perspective, the image of the "hydra with several heads" can thus be replaced by that of a "rocket with several engines" contributing together to the success of its mission: this is what is needed for MCDA to emerge somewhere in the future, as a coherent body of tools."

The process of moving towards a common understanding of MCDM will require the resolution of some of the differences identified earlier in this chapter. One of these is to sort out the basic aim of an MCDM method or technique. Stewart (1992) suggests that "the aim of a multiple criteria decision making technique is to provide help and guidance to the decision maker in discovering his or her most desired solution to the problem (in the sense of, that course of action which best

achieves the decision maker's long term goals)." French (1984) concludes that a good decision aid should help the decision maker explore not just the problem but also himself. Howard (1992) describes decision analysis as a "quality conversation about a decision designed to lead to clarity of action." Finally, Keeney (1992) says "we should spend more of our decision making time concentrating on what is important ...articulating and understanding our values and using these to select meaningful decisions to ponder, to create better alternatives ... and to evaluate more carefully the desirability of the alternatives."

Related to this is that another fundamental objective for the future should be to explore the links between the desires for a theoretical foundation and operational validation (Bana e Costa et al., 1995). Thus the differentiation and defence of approaches on the basis that they fall within the theoretical foundations of normative or descriptive and are therefore not comparable could move towards the same end-objective, that is supporting real decision makers solve multiple criteria problems using theoretically sound and yet operationally tractable methods. Ironically, it is observed here that this in itself is a multiple criteria problem: balancing the two objectives theoretical rigor and operational tractability within MCDA.

Related to this is the notion of **subjectivity** and **objectivity** of the decision maker, the process, and the analysis. Normative theorists have argued for a purely rational approach, and proponents of descriptive theory have recognized subjectivity and intuition and the chasm would need to be resolved. Zeleny (1982:487) suggests "Both analysis and intuition are useful applied to the right problem." On the other hand, Henig and Buchanan (1996) propose a solution, which needs further practical research. They suggest that while acknowledging the existence of the inherent subjectivity of a multiple criteria problem and the need for preference elicitation, they endeavour, in their paper, to "clearly separate the objective from the subjective in the decision making process". Their proposal says solving an MCDM problem amounts to an objective investigation of the impact of alternatives on attributes; and a subjective evaluation of the decision maker's preference system. They argue that the former ought to be scientific in nature. The mapping of alternatives to attributes is the objective part of the process and is independent of the decision maker's preference. While, the mapping of criteria to attributes is the subjective part the process. They argue that some of the subjective mapping in some cases can be replaced with objective analysis by introducing aggregated attributes (Henig and Buchanan, 1996). In response to

comments by Lootsma (1996), Phillips (1996), Stewart (1996), Daellenbach (1996), they argue that too often in MCDM "the major source of bad decision making is that too much is too easily justified by causal subjectivity: intuition, culture, tradition, experience, belief etc." Their aim is to leave more room for objectivity (Henig and Buchanan, 1996).

Further research is needed on the **Structuring and Framing** of the decision process (Peniwati, 1996a). This author believes that for practical purposes, while the objective of any MCDA approach should be to provide the user of such a method with the ability to select the right or best alternative in a multiple criteria problem environment/task, in so doing, an assumption is made that the sub-objective is to clarify the problem, i.e. problem structure en-route to the solution, thus bringing better a understanding of the problem. The understanding of the problem includes having the capacity to distinguish between phantom and real issues in a decision situation. This appears to be a reasonable pre-requisite to successful problem solving within organizations. Therefore building formalized structuring techniques within all MCDA approaches is an area that warrants further research. Although the AHP provides structuring, it does so in a non-formalized manner. Is there a need to perhaps formalize that?

Another important issue, which is currently little discussed, is the selection of the appropriate *problematic* for the decision aid within the decision context (Bana e Costa et al., 1995). This issue affects the facilitator when framing a decision situation. Aiding the decision maker to solve choice problems has been the dominant decision aid. There are other *problematics* in decision aiding, such as ranking and assignment problem situations. The author believes more documentation and indeed research is needed for identifying the problem arenas for which an approach such as the AHP is appropriate. This assumes that a method extending its applicability across a large domain of task or problem types although ideal is way off. Zeleny (1982) writes about the field being far away from a method that is to the decision maker as an automobile is to a driver.

Another area for further work is **Group Decision Making**. The decision maker as a collective of individuals is a feature of business environments, which is unlikely to go away given the ever-increasing complexity of business environment. Yet, very little rigorous research has been done in the field of MCDA to aid the multiple criteria -- multiple decision maker situation. In cases where the decision maker is not a single individual or a homogenous group, but rather an

individual or group that has to make decisions for a larger group, the rationale behind the decision reached is complicated by other group-specific factors. For example, the other members with a vested interest in the decision but not involved in the decision making process require a justification that must be clearly documented (Bana e Costa et al., 1995). In addition groups present issues of culture (Lootsma, 1996; Daily et al., 1996), power and influence (Lockett, et al, 1998) which all play a part in the “subjective” content of the decision.

The above conclusions partially served as motivation for the issues chosen to be investigated in more detail in this dissertation, as discussed in Chapters Three and Four.

CHAPTER 3. A LITERATURE SURVEY ON GROUP DECISION SUPPORT SYSTEMS

3.1. A Brief Introduction to Group Decision Support System

A Group Decision Support System (GDSS) has been described as a computer-based system for supporting groups in a face-to-face, geographically and or temporally distributed meeting environments (Gray, 1984). A commonly quoted definition describes a GDSS as “a set of software, hardware and language components and procedures that support a group of people engaged in a decision related meeting” (Huber, 1984).

The complexity and difficulty of unravelling the issues surrounding GDSS research is articulated by Kerr (1982):

“Social interaction in decision making groups is characterized by such variety, complexity, and apparent disorder that it seems to defy neat analysis. The key difficulty seems to be choosing an approach aspect of the group’s behaviour for observation” (Kerr 1982:62)

This chapter is structured to first explore some of the major issues of GDSS. This is followed by an examination of the features of a GDSS that have been included in its technology. The chapter will conclude by inquiring into the outstanding issues in the field of GDSS and the possible areas of future research.

In this dissertation, group decision support systems (GDSS) and group support systems (GSS) will be used interchangeably. Stevens and Finlay (1996) in a survey of GSS research report that GSS is a wider and more modern term. Some authors also refer to GDSS as collaborative technologies (Nunamaker, 1995). Others have used Electronic Meeting Systems (EMS) (Nunamaker et al., 1989; Nunamaker et al., 1999)

GSS are an offshoot of Decision Support Systems (DSS). DSS are computer based information

systems that are designed with the purpose of improving the processes and outcomes of human decision making. In order to demonstrate the background of GSS the foundations of DSS are explored.

The imperatives that drive Decision Support Systems i.e. the foundations of decision making, including types of decisions and decision makers were discussed in Chapter One. In the following section, the characteristics and capabilities of the systems used to support decision making are overviewed.

3.2. A Brief Look at the Important Characteristics and Capabilities of a Decision Support System (DSS)

“A Decision Support System (DSS) is an interactive, flexible, and adaptable computer-based information system (CBIS) specially developed for supporting the solution of a non-structured management problem for improved decision making” (Turban and Aronson, 1998; 77). It uses data, provides easy user interface and can incorporate the decision maker’s own insights. In addition a DSS may use models, is built by an interactive process (usually by end-users), supports all phases of decision making, and may include a knowledge component. The characteristics and capabilities of a DSS are provided by its major components. In summary, the following are the characteristics and capabilities of a DSS (Turban and Aronson, 1998; Gray, 1984; Keen and Morton, 1980; Keen, 1986; Turban and Meredith, 1994).

- a) DSS provide support for decision makers mainly in semi-structured and unstructured situations by bringing together human judgement and computerized information. Typically such problems cannot be solved conveniently by other systems or by standard quantitative methods or tools.
- b) Support is provided for various managerial levels, ranging from top executives to line managers.
- c) Support is provided to individuals as well as groups. Less structured problems often require the involvement of several individuals from different departments and organizational levels.
- d) DSS provide support to several interdependent and/or sequential decisions.

- e) DSS support all phases of the decision making process: intelligence, design, choice and implementation.
- f) DSS support a variety of decision making styles.
- g) DSS are adaptive over time. The decision maker must be reactive, able to confront changing conditions quickly, and adapt the DSS to meet these changes. DSS are flexible, so users can add, delete, combine, change, or rearrange basic elements.
- h) Users must feel at home with DSS. User-friendliness, strong graphic capabilities, and an English-like interactive human-machine interface can increase the effectiveness of DSS.
- i) DSS attempts to improve the effectiveness of decision making (accuracy, timeliness, and quality), rather than its efficiency (cost) of decision making.
- j) The decision maker has complete control over all steps of the decision making process in solving a problem. A DSS specifically aims to support and not to replace the decision maker.
- k) End-users should be able to construct and modify simple systems by themselves. Larger systems can be built with assistance from information systems (IS) specialists.
- l) A DSS usually utilizes models for analysing decision making situations. The modelling capability enables decision makers to experiment with different strategies under different configurations.
- m) The DSS should provide access to a variety of data sources, formats, and types, ranging from geographic information systems to object oriented ones.

The Components of a DSS

As already mentioned the characteristics and capabilities of a DSS are provided by its major components (Turban and Aronson, 1998). Figure 3.1 shows the major components of a DSS, which are defined below.

- ◆ *Data management sub-systems.* This sub-system includes a database, which contains relevant data for the situation and is managed by software known as a database management system (DBMS)
- ◆ *Model management sub-systems.* This is a software package that includes financial, statistical, management science, or other quantitative models that provide the system's analytical

capabilities and appropriate software management. Modelling languages for building custom models are also included.

- ◆ *User-interface sub-systems.* The user communicates with and commands the DSS through this sub-system.

Sometimes a fourth component is included. It can be a mail system component (Sauter, 1997) or the *knowledge management sub-system* (Turban and Aronson, 1998)

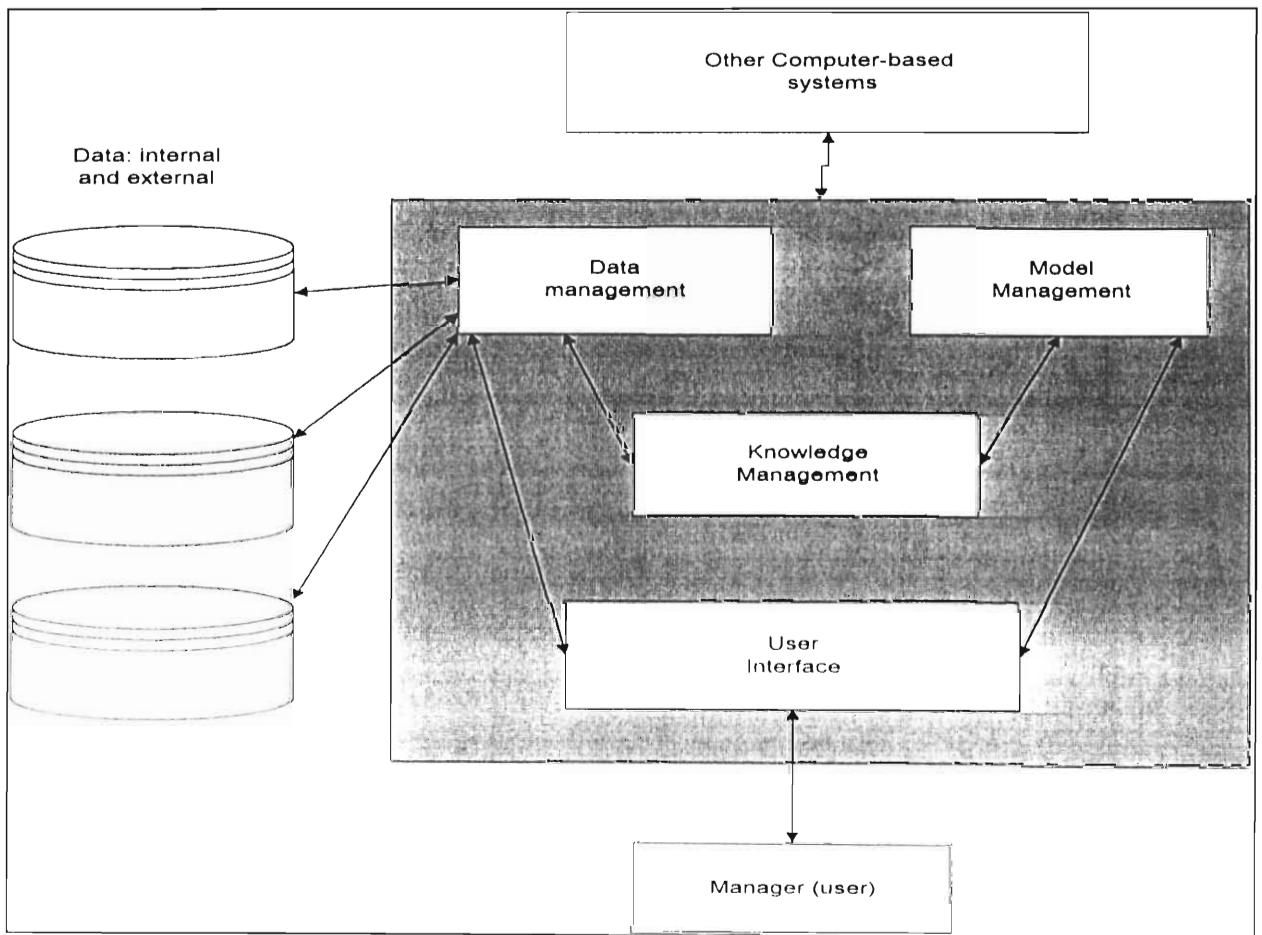


Figure 3.1 A Schematic View of a DSS – (adapted from Turban and Aronson, 1998)

Research in DSS continues to be multi-faceted. In a paper tracking the development of DSS research, Eom (1998) finds, in the five years between 1991 and 1995 DSS research areas and reference disciplines can be categorized into four different groups: *steady*, *strengthening*, *emerging* and *dying*. In the *steady* category *inter alia* is multi-criteria decision making. Two DSS research sub-fields foundations and individual differences fall into the *dying* category. Group

DSS is found in the *strengthening* category. This finding is significant for this research although not surprising given the developments in business organizations and the role that groups or teams continue to play.

3.3. The Transition to GSS

As discussed in Chapter One modern organizations have a larger pool of stakeholders that requires groups to solve problems and recommend solutions. Pumsook and Jenney, (1997:7) suggest that because of this reliance by organizations on groups to solve problems and recommend solutions: decision making groups have become ‘less like special project commando teams’ and more a part of the support that exists for a variety of end-user functions in an organization. There is a growing need for pooled interdependent decision support precisely because of the role played by groups in organizations. Group Decision Support Systems (GDSS) thus refer to specialized DSS to support teams involved in decision making (Gray, 1994).

GDSS are integrated computer-based support systems, which facilitate the solution of semi-structured or unstructured problems, by a group who has joint responsibility for making the decision (DeSanctis and Gallupe, 1985). The “ultimate” goal of GDSS is to improve decision quality and reduce meeting time in an atmosphere conducive to group member satisfaction (Vogel, et al., 1987).

In the early stages it was clear that GSS theory and practice were mainly preoccupied with the capability to alleviate the communication breakdowns that characteristically occur in group processes in a same-time/same-place environment (DeSanctis and Gallupe, 1987). However, Group Decision Support Systems have evolved with the aim of managing the processing of the increased pools of information in meetings. The introduction of group interaction introduces difficulties that are unique to a group environment. Group dynamics exist purely by virtue of there being more than one individual attempting to solve a problem: individuals have different cognitive styles, as shown in Chapter One. It is for that reason, GDSS technology faces some distinct issues of concern to DSS. In summary, the main difference between DSS and GDSS is that traditionally DSS have focused on the outcome of the decision making task (DeSanctis,

1980), whereas GDSS focus on the process of group decision making (DeSanctis, 1980).

The added trend of the increasing complexity of the environment in which managers must function has meant more and more important decisions or solutions are sought by a collective of decision makers. Organizational surveys have consistently reported that managers spend a significant portion of their time in meetings, making choices among alternatives i.e. decisions (Gray et al., 1981). Many of these surveys also report dissatisfaction with the (unsupported) meeting process. Managers cite wasted time, the feeling of achieving nothing, going around in circles as sentiments that many who have participated in regular company meetings share or are aware of. In spite of the apparent dissatisfaction with meeting processes organizations have not relented and abolished meetings completely. It is doubtful whether they can actually do so. The need to get buy-in from all stakeholders; the need to consult the people who may ultimately be responsible for implementing decisions taken in the organization and the need to pool the expertise which resides with separate individuals in order to solve problems are just some examples that demonstrate the need for group meetings.

During the late 1980s researchers embarked on examining methods designed to alleviate the archetypal communication breakdowns that are characteristic of group interaction. Members talking at the same time or waiting for one's turn while others speak (talking serially), known as *production blocking* are some of the examples of the typical communication breakdowns. These will be discussed in more detail under the section "process losses."

3.4. An Overview of the GDSS Environment

The recognition that more individuals working on the same problem are better off than any single individual working on his or her own is a well-received idea within the field of GDSS and behavioural sciences research. It is recognized that for the numerous categories of task (types) for which groups gather, they are far more effective than individuals working by themselves. This applies for example to idea generation.

Notwithstanding this synergy effect, there is the almost self-evident paradox that arises from

group interaction. The paradox has been illustrated many times through the recorded experiences of many groups. Groups are frequently observed to be inefficient (and sometimes ineffective) at completing their assigned tasks (Turban and Aronson, 1998). In more recent times this has been compounded by the fact that the persons suitable to compose the group are not necessarily physically at the same place at the same time. The case of branch managers of a big bank is a good example of this. While the bank may need to convene these decision makers regularly to formulate and implement coherent company plans, getting them together at the same place at the same time is often costly and sometimes risky for the business.

Frequently individuals that should compose a group are as illustrated in Figure 3.2 at the same-place at the same-time, at different-places at the same time; at different times at the same place; at different places at different times which all amounts to being at any place at any time.

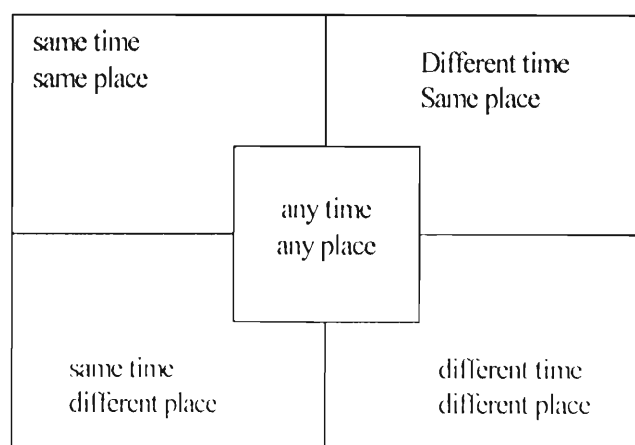


Figure 3.2 The time-place quadrant

Group support systems features and design strategies should be premised on optimising the effectiveness and efficiency of a group engaged in decision making through appropriate technological interventions. “The objective of decision support systems for groups is to discover and present groups with new possibilities and approaches for making decisions” (DeSanctis and Gallupe, 1987:592)“ They do this by acting on the information exchange.

DeSanctis and Gallupe (1987) proposed three approach-levels of systems support features. These approaches have informed a lot of the GDSS research and literature, for instance McLeod and Liker (1992). Within each of the feature levels of group support, other researchers have pursued

“sub-features” which will be examined concurrently. By way of illustration: the degree of anonymity offered by a GDSS is known as a Level 1 GSS feature. A brief summary of these is introduced hereunder.

Level 1 GDSS “provide technical features aimed at removing common communication barriers”(DeSanctis and Gallupe 1987:593). These features include such things as large screen displays, vote solicitation and compilation, the anonymous input of ideas and or preferences and electronic message exchange between members. Level 1 features ‘improve the decision process by facilitating the information exchange among group members” (DeSanctis and Gallupe, 1987:593). The degree of anonymity offered by a GSS is a feature that has been studied extensively. The capacity to contribute ideas anonymously has been shown to reduce group process losses such as evaluation apprehension, while this capacity may also enhance process gains such the equality of participation (McLeod and Liker, 1992).

Level 2 GDSS provide decision modelling and group decision techniques aimed at reducing the uncertainty and noise that occur in the group’s decision process. This may occur through the provision of automated planning tools and other aids that are commonly found in the traditional individual DSS. However, it would be designed for group members to work with and view simultaneously using a large common screen. Level 2 GDSS may provide utility and probability assessment models, risk assessment, statistical models and multi-criteria decision models (DeSanctis and Gallupe, 1987).

Level 3 GDSS features exhibit “machine-induced group communication patterns and can include expert advice in the selecting and arranging of rules to be applied during a meeting. At this level, significantly, each member represents a node in the communication network and deliberate patterns are imposed on the group by the technology” (DeSanctis and Gallupe, 1987:594). Examples of Level-3 systems are CyberQuest (CQ), a Group Support System that features computerized problem-solving techniques along with hyper-media, and multi-stimuli processes. Participants access various data bases of information and analytical tools to generate, evaluate, and implement organizational decisions. They also support same-time/same-place, different-

time/different-place, and same-time/different-place meetings. (GSS-ListServe – newsgroup, 1999).

The higher the level of GDSS, the more sophisticated the technology needs to be and the more dramatic the intervention into the group's natural decision process.

Existing research GDSS deals mainly with Level 1 and Level 2 GDSS. It identifies five interacting components that form part of a GSS environment. These are the **Group**, **Individual** (the profile of the individual members of the group); **Task** (the task with which the group intends to tackle); **Process** (the process dynamics of the interacting individuals) and the **Technology** (Huber, 1982). However, there is a nebulous line between group issues and process issues. The author has found that frequently researchers discuss the two components simultaneously. Huber (1982) is one such example. This is symptomatic of the complexity and variety of the group process, referred to by Kerr (1982). While group issues have tended to dominate research, more recently studies are starting to emerge that focus on task issues. This research focuses on the issues that have thus far received little researcher attention.

3.4.1. The Individual and Individual Characteristics

This aspect of a GDSS environment deals with the characteristics of the individual(s) participating in the group process. These include attitude, ability, background, emotional state, culture, accountability, cognitive decision making style and reasons for group membership. Here we explore some of these and briefly examine how GSS researchers have sought to understand and manage the complexities brought about by the characteristics of the individual in order to enhance the group process or experience.

Accountability is the degree to which each individual is personally accountable for the decision reached and the extent to which the members present have the authority to make a final decision (Friend, 1990). Accountability is related to stakeholding in the process.

Culture can have a strong influence upon behaviour so that the degree of technology is more appropriate for some cultures than for others. Gray and Olfman (1989) emphasize the importance of considering the culture and spoken language of potential users when designing a GSS. Here the authors consider issues of an international GSS design, which would include translation capacity. Considerations of culture in a group process are of particular interest in an environment such as the United Nations, multi-nationals, which comprise local and international management.

The Decision making style of the individual participating in the group process is perhaps a more complex issue than the ones above. Here GDSS research has not operated in isolation in attempting to unravel individual cognitive styles in order to optimise the group process. It is known that the outcome of the decision process is substantially influenced by the individual's personalized strategies and abilities for problem solving. Frequently these personalized styles differ between individuals. In particular these specialized styles of decision making may be effective in some contexts and not so effective in others (Keen and Scott Morton, 1978). Similarly with **problem structuring and framing**, the differences in cognitive abilities among individuals have been found (in image theory research) to be important variables in determining the use of imagery in problem-solving activities, particularly in problem structuring (Loy, 1991).

Consequently, profiling the individual(s) that make up the group has pre-occupied GSS researchers for some time (Dennis et al., 1987; Loy, 1991). Many studies have referred to the study of psychology for direction in this matter.

3.4.2. The Task and Task Characteristics

The task is the very reason for which the group is gathered. As introduced at the beginning of this chapter, decision makers potentially face problems (tasks) that fall somewhere between the continuous spectrum of programmed (structured) to non-programmed (unstructured) tasks. Using Simon's (1977) decision making model these tasks fall into the phases of: Intelligence, Design Choice and Implementation. Due to the tasks faced by groups being so varied, each decision making phase requires the participants to carry out different actions. These actions subsequently affect many aspects of the group process, for example the quality of the solution, or satisfaction

with the solution.

Research on the task component explores a variety of issues, from task complexity, task performance, to degree of rationality, clarity (McLeod and Likel, 1992) and others. To support group-work, collaborative technologies must possess the ability to decipher and distinguish the characteristics of the task facing the group. Moreover, these are not always the same (DeSanctis and Gallupe, 1987) so that a GSS cannot be task specific. The capacity to structure and manage tasks (efficiently and effectively) is a feature that warrants more research in GSS theory and research.

Identifying the **Nature** of the task is the first step towards problem resolution or decision making. In Simon's (1977) model this is the intelligence phase of decision making. Intelligence rests on the ability to correctly recognize the task characteristics so as to devise solutions suitable to the task at hand. This includes being able to correctly identify the decision making phase in which the task falls (Laudon and Laudon, 1996). Identifying the nature of the task includes being able to assess the structure and complexity of the task. It also implies ascertaining the **Importance** of the issue and the resulting outcomes that tend to influence group member perceptions of their responsibility for reaching a good solution (Stevens and Finlay, 1996). The **Structure** of the task relates to the degree to which one can define the conditions that allow the problem to be recognized (Keen and Scott Morton 1978). The **Complexity** of a task is a combination of several components: one is the number of alternative solutions or options available to the resolution of the problem. Related to this is the amount of information to be considered in the unravelling of the problem. Task **Uncertainty** is another dimension of task complexity, where uncertainty is associated with a lack of information regarding the environmental factors associated with the task and not knowing the consequences of implementing the task (Stevens and Finlay, 1996). The third is the number of interrelated activities required to complete the activity (Dennis et al. 1988, Martz et al. 1992).

With respect to the nature of the task, Martz et al. (1992) divide tasks into three types. They call these:

- a) Production-Oriented tasks – which require the generation and discussion of ideas.
- b) Evaluative tasks- which involve the evaluation of a set alternative issues; and
- c) Problem solving tasks – which is when a group must determine a course of action.

Similarly, McGrath (1984) presents a typology of tasks as being of four general types: Generating, Choosing, Negotiating and Executing.

The **urgency** of the task, how quickly an issue needs to be resolved (Gray et al., 1990) and task **duration**, the length of time required to complete a group process are also task characteristics that affect group performance. For example, if the perceived lack of time to resolve the issue - what Lasden (1986) calls “a beat the clock” syndrome - looms, it increases the likelihood that hasty decisions will be made to cut corners, fix mistakes or fill holes.

GDSS research and technology have responded unevenly to the variability of task types. Watson, et al. (1988:105) report that much of the intended effects or desired outcomes of GDSS technology have been demonstrated with respect to a limited number of task types. “To date positive effects of GDSS have been observed for idea generation” (Applegate, 1986, Lewis, 1982); problem finding (Gallupe, 1985); intellectual choice, which is the selection of the correct answer among a given set of alternatives (Turoff and Hiltz, 1982) and planning tasks (Applegate, 1986; Steeb and Johnston, 1981). As this is not an exhaustive list of the task types that face managers in their day to day functions within organizations, there is scope for advancing GSS research and technology with respect to the problem-structuring phase or in other words exploring Simon’s (1977) intelligence phase of problem solving. This is an important motivation for the research reported in this dissertation as it explores the issue of task structuring in more detail in an attempt to build on existing knowledge and previous research.

3.4.3. The Group and Group Characteristics

A decision making group is two or more people jointly responsible for detecting a problem; elaborating on the nature of the problem; generating possible solutions; evaluating potential solutions; or formulating strategies for implementing solutions (Jacob and Pirkul, 1992).

Group characteristics encompass the relationships that exist between group members, characteristics of the development of the group and the patterned relations among group members (McGrath: 1984; Stevens and Finlay: 1996). “The group characteristics are contingent upon the individual characteristics of the participants” (Stevens and Finlay, 1996: 226). Group characteristics and therefore issues that have been studied include the following: group size; existing social networks (Pinsonneault, and Kraemer, 1989); group norms; group-oriented motives; power relationships; status relationships; the breadth of participants; group cohesiveness; density of group; stage of group development as a result of group history.

The definition and exploration of all group characteristics is beyond the scope of this research. The aim here is to briefly survey what group characteristics have been the subjects of research, with the intention of identifying potential future research issues. In examining these issues other researchers have sought to understand them in order to formulate theories or systems of taxonomy (DeSanctis and Gallupe, 1987; Stevens and Finlay, 1996) that would bring more clarity to the field of GSS. Some issues (like group size) have lent themselves to more exploration than others. These are discussed below briefly.

Group size. The effect of changes in group-size on GSS technology, or the effect of GSS support on different group sizes is still an open issue. Most GSS research has focused on small groups of three to four individuals (Watson et al., 1988, Nunamaker, 1999). It is possible that the effect of GSS support is more pronounced the larger the group. Some researchers suggest that classifying groups on the basis of size is rather arbitrary, that it is better to think of groups as relatively small or relatively large (DeSanctis and Gallupe, 1987; Nunamaker et al. 1989). The difference between the group’s logical and physical size can be significant (DeSanctis and Gallupe, 1987). A physically large group with a common culture that has met repeatedly on a task may have a high degree of overlapping domain knowledge resulting in the group being logically small. A physically small multi-cultural group may manifest characteristics of a larger group with multiple and often conflicting perspectives, opinions and knowledge domains (Nunamaker, et al., 1989; Stevens and Finlay, 1996).

The basic principles of group dynamics apply to all groups, small and large, although the predominant activities of a group differ between small and large groups. As membership size increases, the number of potential information exchanges rises geometrically, and the frequency, duration and intimacy of information exchange decline and consensus becomes harder to achieve (DeSanctis and Gallupe, 1987).

Early research of non-supported meeting environments found group process dysfunctions tending to rise rapidly as group size increases (Midgaard and Underdal, 1977; Steiner 1972), so that larger groups do not typically generate significantly more options than smaller groups (Fern, 1982; Lamm and Trommsdorff, 1973). In addition, larger groups were typically less satisfied than smaller groups (Shaw, 1981; Hare 1981). On the other hand, later studies (Nunamaker, et al. 1991; Valacich et al., 1990; Dennis et al., 1990) of supported (EMS) groups have consistently found that larger groups were more effective than smaller groups, or nominal groups or several smaller groups combined. They also found member satisfaction to increase with group size. These experiments were however limited to option generation tasks only.

Studies of other group characteristics have produced results that exhibit little consistency across studies (Srinivasan and Jarvenpaa, 1991). The characteristics studied therein include **group cohesiveness**, the degree to which group members are attracted to each other (Shaw, 1981). Research has shown that cohesive groups are more likely to achieve their goals (Luft, 1984; DeSanctis and Gallupe, 1987). Group cohesiveness can become extremely important where strong morale, long-term cooperation and conformity to group norms are critical to the organization (Festinger 1968; Hollander 1964; Shaw 1973; DeSanctis and Gallupe 1987). On the other hand, group cohesiveness has been observed to be irrelevant in circumstances where decision quality is the primary objective (Pervan, 1998; Pervan and Atkinson, 1995).

Group norms are the set standards of behaviour, which group members, can expect from other members (Shaw, 1981; Kerr, 1979; Stevens and Finlay: 1996). Group norms are related to the “group culture” and affect group performance.

Power and status relationships: power relationships relate to the control or influence which one person has over another (Shaw, 1981); whereas status relationships refer to an individual's rank, worth or prestige in the organization or group (Mitchell, 1982). The differences in status are important as determinants of group process, because members with high status tend to participate in a greater number of interactions and initiate more ideas (Brown, 1988). Low status members may tend to defer their participation to high status members.

More recently, the **density of the group** has also attracted researcher attention. Group density is a composite factor made up of components like: the size of the group, the size of the room, the interpersonal distance (proximity) between group members (Pinsonneault, and Kraemer, 1989); and the appropriateness of group size to task (Stevens and Finlay, 1996). For instance, the combination of anonymity and low member proximity results in more member input with increased criticalness and yet low member satisfaction in the process (Nunamaker et al., 1991).

The study of and research into group characteristics remains relevant in that it brings the GSS community closer to the identification and definition of an effective problem-solving group.

Defining an effective problem-solving group

It is important to examine what constitutes an effective problem-solving group. According to Huber (1982) an effective problem-solving group must:

- Meet the requirements of the situation (i.e. accomplish its task, while making acceptable use of member time.)
- Secondly, it must complete its endeavours with the individual members being generally more satisfied than unsatisfied. However, this is a contentious point. Some researchers have argued that the satisfaction of the group is not necessarily a requirement. It would be determined by the nature of the task (Huber, 1982).
- Thirdly, the group must complete its endeavours without impairing the capacity of the group to function in the future. (Huber, 1982)

This definition of the terms of performance for group effectiveness is extended to include an

outline on how to measure group performance. Huber (1982) suggests, the problem-solving group's **Actual Effectiveness** be measured in the following way:

$$\begin{aligned} (\text{Actual Effectiveness}) &= (\text{Potential Effectiveness}) \textit{ less} (\text{Process Losses}) \\ &= (\text{Process Gains}) \end{aligned}$$

The potential effectiveness of the group follows from the combined input of its members and process losses follow from the group process *per se*. Process losses include the loss of (potential) decision quality arising from some members not being able to contribute their knowledge. Typically, *production blocking* and or *evaluation apprehension* are the main reasons for this. These are discussed later in the chapter.

The measuring of process losses and gains is an unresolved issue in GSS research. The capacity of group decision support theory and technology to define, recognize, measure and counter process losses is a major challenge for the field. Recommending and implementing GSS features that effectively minimize group process losses across task-types while simultaneously optimising group process gains is the challenge that faces current research (Huber, 1982; Nunamaker, 1999).

3.4.4. Process and Process Characteristics

It was mentioned that isolating process issues and group issues from one another is sometimes difficult. Process issues relate to the dynamics surrounding the actual interaction of the group members and that these process dynamics influence group outcomes (Huber, 1982). Process losses and process gains are next explored before investigating group outcomes.

Sources of Process Losses

There are many sources of process losses that contribute to the communications breakdowns that are characteristic of group interaction. The process losses discussed hereunder have attracted significant researcher attention in GSS.

a) The first is ***Production Blocking*** which occurs when individuals cannot express their ideas because someone else is talking. Production blocking can be overcome if group members have

the ability to both input and receive ideas simultaneously with other members often through individual workstations (McLeod and Liker, 1992; Nunamaker et al., 1989, Nunamaker, et al. 1991; Dennis et al, 1988; Nunamaker et al. 1999).

b) The second is ***Evaluation Apprehension*** which is created by the mere presence of others; this creates demands on a person to behave in a particular way in order to either not lose credibility or to gain positive evaluation from one's peers. In the first case, evaluation apprehension manifests itself through individuals withholding their input out of a concern (or fear) that other group members may not approve. The transparency of the contributor's identity in face-to-face meetings is believed to be mainly responsible for evaluation apprehension. This is known as the lack of *anonymity* of the contributor of the idea (or input). Low status members participating in groups with dominant, high status members tend to suffer evaluation apprehension more (Gallupe et al., 1987). On the other hand, the desire to gain positive evaluation may result in an enhancement of the process. Harkins (1987) showed that the presence of others and evaluation apprehension have an additive effect on performance.

c) The third is ***Social Loafing***, where members in a group do not work as hard as they would if they were operating alone. In other words, it is the attribution people make about the motivation and performance of other group members (Erez and Somech, 1996). A meta-analysis of 78 studies on social loafing found that the effect of social loafing is robust and is generalized across tasks and work populations (Karau and Williams, 1993). However there are variables that moderated the tendency to engage in social loafing. For example, when tasks were meaningful, when the group culture supported contribution to a group, social loafing was not observed (Karau and Williams, 1993; Erez and Somech, 1996).

Observations by the author, at Hulett Aluminium, where she is employed and involved in many task teams, show social loafing dominating because the organizational reward system is still based on individual performance. That is, there are no group performance measurements upon which teams are rewarded. Individuals get a salary every month regardless of the quality of their contribution to the teams they are part of. The success and failure of teams is not aligned to the reward and punishment system of the organization. This observation is validated by other studies

on social loafing and group-culture, where a distinction is made between collectivist and individualistic cultures. In these studies it is shown that in collectivist cultures such as China and Japan, social loafing does not occur because collectivists place group goals and collective action ahead of their own personal interests. In contrast, individualists are motivated by personal gain and contribution to the group is inconsistent with self-interest, unless they are held personally accountable and responsible for their group's performance (Earley, 1989, 1993; Erez and Somech, 1996). This clearly has relevant implications for individualistic societies whose organizations are intent on optimising group performance.

d) **Group-think** (Janis, 1972) is associated with the trust and mutual support among group members creating a "surreal euphoria that befuddles even the most astute decision makers luring them to conclusions that fly in the face of reality" (Lasden, 1986: 52). The "ill-fated Bay of Pigs" (Lasden, 1986) is a well-documented example of the ineptitude of group-think. The phrase Group-think tends to incorporate a large number of the observed failings of groups, three of these are briefly discussed below:

- ✓ Group members with dominant personalities or intense interests in the problem situation tend to participate more than their contribution warrants in group discussion (Huber, 1982; Jablin and Sussman, 1978; Vogel et al., 1987). This domination by a few leads to lower quality decisions - through the suppression of potential contribution of the other members. The other side of domination by the strong is deference. Lasden (1986) calls this the *wimp factor*. "The wimp factor is evidenced by the absence of criticism..." (Lasden, 1986:54). Low status members have been observed to tend to defer automatically to the opinions expressed by high status members. This may be because of group-think or evaluation apprehension. Not unrelated is the effect of group pressure for conformity which suppresses information (Vroom, 1969; Huber, 1982; Vogel et al., 1987) and results in a reduced quality of decisions.
- ✓ The actual contribution of individual members is adversely affected by miscommunications, that occur as they attempt to share their information and reason with other group members, (Huber, 1982) intimidation, blind trust and the diffusion of responsibility (Lasden, 1986).

- ✓ Problem-solving groups frequently give insufficient attention to the problem-exploration and alternative generation stages and therefore increase the likelihood that they will solve the wrong problem or choose an inappropriate or low quality solution (Huber, 1982). Lasden (1986) calls this the *right answer / wrong question syndrome*.

3.4.5. On the Decision Process in a GDSS

The objective of a GDSS is to maximize the decision process. Many of the impediments to achieving this have been well researched in the literature. The effect of the anonymity feature dominated earlier GDSS research. Other process features discussed in this section include member satisfaction, equality of participation and the time taken to reach a decision.

3.4.5.1. On Anonymity in GDSS

Typically, when groups get together the process objective is to “maximize member participation so that a broad input is obtained, ownership is established and that consensus is developed” (DeSanctis and Gallupe, 1987). Ensuring that everyone participates is regularly stymied by evaluation apprehension in normal or unsupported environments. Generally, low status members and or certain personality profiles will tend to express themselves less because of concern arising from peer evaluation. Others tend to support certain ideas purely because certain individuals, e.g. the CEO, suggest those ideas. This observed negative effect impacts on the equality of participation. A mechanism is required to protect participating individuals from the effects of perceived peer evaluation to increase participation.

Anonymity is a GSS feature, which has been well researched and successfully built into many Group Support Systems. With anonymity group members can contribute ideas and yet not be able to attribute the ownership of ideas. This is achieved through technological assistance. In the IBM field studies done by Nunamaker et al. (1989) some of the feedback on the process was specifically on the advantages of the openness of the process and its lack of intimidation as a result of anonymity. Its advantages are that it makes people freer to give ideas and discuss them openly. The participants became less apprehensive than in manual meetings (Nunamaker et al.,

1989). With Electronic Brainstorming Systems (EBS) all communication is electronic and non-verbal. Previous research shows that anonymity shifts the balance of power within groups, taking power away from some group members and giving more power to others (Valacich et al, 1992; Connolly et al., 1990).

A lot of research in the GSS field has been directed at evaluating the effects of anonymity, to the extent that, all Group Decision Support Systems have at least this feature¹. For example, Valacich et al (1992) present a conceptual framework for the study of anonymity in a GSS. They define different types of anonymity and describe the general classes of variables (and their relationships) that influence anonymity in a GSS. They also present the effects of anonymity on the message, sender, receiver, the group process and outcome. Nunamaker et al (1991) in their experiment test the ability of anonymity to separate personalities from the problem and encourage more objectivity. They observe that anonymous groups generate more comments than non-anonymous groups using similar EMS, for low-conflict tasks, although this did not lead to more unique options.

However, there are some uncertainties about the effects of anonymity. For instance Jessup et al., (1990) suggest that the effects of anonymity are less likely to be noticeable in the laboratory than in field studies and less effective within cohesive groups. Connolly et al (1990) recognize anonymity as an important factor in the process of de-individuation – the feeling of being submerged in a group. They point out that de-individuation can also lead to behaviour that under normal circumstances would be monitored or prohibited by one's inner restraints and inhibitions. Anonymity removes this check on one's own behaviour, resulting in the exhibition of socially undesirable behaviour. "The phenomenon of 'flaming' in electronic communication generally – the expression of uninhibited comments, strong language, is related to the impersonal, anonymous nature of such media" (Siegel et al. 1986). On the other hand, this should encourage the expression of unpopular, novel or heretical opinions (Connolly et al., 1990).

The effect of anonymity on group size has elicited more mixed results with previous research. In

¹ e.g. Facilitate, Group Systems, CyberQuest and others

general size-effects have been observed within EMS (Valacich, et al., 1990), that is the larger the group the more effective the interventions of an EMS. Valacich et al. (1990) found that anonymity-effects also held for larger groups, larger anonymous groups generated significantly more options of higher quality than smaller anonymous groups. Dennis, et al (1990a) increased the group sizes further and found those large groups generated more options than small groups. Anonymity has also had positive effects on member satisfaction (Nunamaker, et al., 1991).

3.4.5.2. On Understanding the Effects of GSS on Process Gains

The very objective of automated support of a group is to maximize the probability of process gains that arise from group interaction (Vogel et al., 1987). Process gains are associated with more ideas; a larger solution-space; a better quality of ideas; group effectiveness and efficiency; increased member satisfaction and the time taken to reach resolution (Vogel et al., 1987). A distinction is made between process quality and outcome quality within GSS research, although the differences are not always clear (Zigurs, 1993). The difficulty lies in the complexity of the inter-relatedness of group process variables and the varying situational dynamics of group interaction (DeSanctis and Gallupe, 1987). For example, variations in group-size or member proximity affect the quality of participation positively or negatively depending on the levels at which the former are pegged. As a result, the selection of variables to study under what conditions remains unresolved. "To study decision support systems for specific environmental settings and group tasks, a common conceptual scheme for organizing these variables is required." Further, researchers "must come to grips with what issues, among the many of relevance, they should address" (DeSanctis and Gallupe, 1987:602).

Identifying the variables to study under specific conditions is directly linked to the capacity to define and classify performance measures or indicators - and therefore defining dependent and independent variables in a study. Moreover, clarity on the manner in which the variables are measured is still required. (DeSanctis and Gallupe, 1987; Zigurs, 1993). GSS research remains at crossroads on these issues. Many researchers in the field agree at least, that only further research and proper documentation will help clarify the complexity surrounding the multiplicity of group process variables (Pervan, 1998; Nunamaker 1999).

3.4.5.3. On Process Performance

It is beyond the scope of this dissertation to explore in detail all known process variables or indicators under the varying situational factors in GSS research. The objective here is to review those that have attracted significant researcher attention; and to explore consensus, a process indicator that shows a limited body of knowledge in published GSS literature. The most frequently studied process variables include the equality of participation, the degree of task focus, task performance, and member satisfaction (McLeod and Liker, 1992). Process performance indicators can be tangible or intangible.

When assessing the **Equality of Member Participation** the number of members participating and the equality of their participation is examined (Pinsonneault, and Kraemer, 1989; Jarvenpaa et al. 1988, Hwang, 1998). DeSanctis and Gallupe (1987:604) propose that “the results of using decision support technology in groups will occur primarily through the effect these systems have on member participation.” GSS design features such as anonymity and the active solicitation of member input should encourage greater equality of participation. This is significant when contrasted against the case of unsupported environments in that greater member participation can effect decision quality and other outcomes negatively or positively. The benefits of increased member participation are self-evident; they are the very essential reason why groups get together in the first place. The full participation of members allows the extraction of resources from a group and promotes error checking, allowing for better decision making (Hackman and Kaplan, 1974; Holloman and Hendrick, 1972; DeSanctis and Gallupe, 1987). Increased participation should increase decision acceptance and a sense of responsibility for the decision; this alone is often the sole motivator for involving multiple organizational stakeholders in the decision making process (Bedau, 1984; Hackman and Kaplan, 1974).

On the other hand, other researchers have suggested that increasing member participation tends to increase the **time taken** to make the decision or complete the process (Dennis et al., 1988, Hwang, 1998; DeSanctis and Gallupe 1987). Decision time is a process indicator that has also attracted some researcher attention (Lasden, 1984; Nunamaker, 1999). The increase in decision

time is associated with the simple logistics of more airtime being utilized; members having to deal with an expanded number of issues or alternatives, and controversial views being aired freely and anonymously (Hwang, 1998).

Increasing member participation has also been observed to negatively affect **member satisfaction** with the decision process (Nunamaker, 1989). Member satisfaction is the degree of satisfaction felt by the group with the process used and or the outcome solution. Research into satisfaction has been plentiful in GSS research (Connolly et al., 1990; Nunamaker et al., 1989; McLeod and Liker, 1992). Yet, the results have been varied. For example, the decline in member satisfaction as a result of increased participation is believed to be contingent on the level of group cohesiveness (Nemiroff and King 1975). Where there is a high level of group cohesiveness, increased participation does not appear to affect member satisfaction (Nemiroff and King 1975).

Member satisfaction has generally been measured in comparative terms. Researchers have tended to compare satisfaction with a supported environment against satisfaction with an unsupported environment (Pervan and Atkinson, 1995). Laboratory studies have demonstrated mixed results in this regard: some have reported high levels of satisfaction (Nunamaker et al., 1989; Dennis and Valacich, 1993). Some have found no difference in satisfaction levels that were attributable to the presence or absence of automated support (Pinsonneault and Kraemer, 1989); others have even reported dissatisfaction with automated support processes (Gallupe 1985; Watson 1987).

Possible explanations for the above variations are found in Nunamaker et al. (1989); it is suggested that, (1) the issue of measurement plays a role. Nunamaker et al. (1989) argue that it is extremely difficult to measure differences in satisfaction unless groups have experienced both manual and automated support for equivalent tasks. (2) The dissatisfaction with the technology in general, may be the contributing factor. Many Group Decision Support Systems have been technologically unsophisticated relative to other contemporary computer systems. (3) Rarely do experimental subjects have a vested interest in the outcome of the comparative studies. Therefore, they are likely to be less enthusiastic than field study groups who maintain some level of vested interest in the process.

Some researchers believe the trade-off between member participation and satisfaction is not an issue that can be resolved by group decision support systems (DeSanctis and Gallupe 1987). In practice, the acceptance of a group's solution has little correlation with the objective quality of the solution outcome (Hoffman and Maier 1961). It is always important to keep in mind that "much of the justification for participative decision making in organizations has been to gain acceptance of ideas, rather than gain better ideas per se (DeSanctis and Gallupe 1987:606).

There are other process variables that have been measured separately that influence member satisfaction. The participants' **confidence** in the final decisions (Gallupe and DeSanctis 1988; Keen 1986); the degree to which individual participants feel they have **ownership** of the final decision; and the emotional or cognitive **commitment** of the participants to implementing the final decisions reached (Eden, 1992). In the field study conducted in this research, the issue of ownership of the final decision is set as an imperative sub-goal of the study for successful implementation.

The **willingness to work with the group again** was defined as being fundamental to an effective problem-solving group (Huber, 1982). A high degree of member satisfaction has been observed to have a positive impact on the willingness to work with the group again (Pervan and Atkinson, 1995).

3.4.5.4. On Task Performance

The task is often the main reason why groups are gathered. The ability to measure groups' performance with respect to the task is important for Group Decision Support Systems and research. The accomplishment of the task is dependent on the communication between members of the group (Katz and Kahn 1966). The patterns of information exchange in supported communications are understood to be oriented either towards the task (getting the job done) or towards group social needs (tension release, agreement/disagreement, solidarity/antagonism). It has been observed that as the meeting progresses, the relative emphasis tends to shift such that groups seek equilibrium between the need to complete the task on one hand, and the need to sustain the group on the other (Bales and Strodtbeck 1951). It has also been found that Electronic

Meeting Systems increase the degree to which group members are swung to task orientation or focus (Turoff and Hiltz, 1982; Rutter and Robinson, 1981; Gallupe, 1985).

In measuring task performance and task focus, GSS researchers have examined the **depth of analysis**, i.e. the number of alternatives generated and examined (Connolly, et al. 1990; Dennis et al. 1988) and the number and complexity of criteria used to evaluate the alternatives (Pinsonneault, and Kraemer, 1989; Stevens and Finlay 1996). **Decision quality**, the degree to which the participants feel that the decisions made are more intelligent or of better quality because of using a specific decision process (Stevens and Finlay, 1996, Dennis et al., 1996) is another task performance variable that is frequently examined in group support research. However, some debate continues on how to define decision quality (Zigurs, 1993; Timmermans and Vlek, 1996).

Consensus is the ability of the group to converge in their judgments about the relevance and importance of issues within the context of the task is also fundamental to group work (Sambamurthy and Poole, 1993). The purpose of convening a group for better resolution of a task falls flat if the group cannot ultimately reach consensus and agree on a solution. Yet, this is one task performance measure, which previous GSS research has paid little attention to. This justifies the detailed exploration of supporting consensus building later in this thesis.

It is suggested that the issue of consensus is of group relevance depending on the task type (DeSanctis and Gallupe 1987). For example, where the task is merely that of idea generation then consensus is *not* an important consideration in the process. However, where the group task is choice selection or negotiation (Shakun, 1992) then the significance of consensus is considerable. The effective management of conflict is reflected in the group's perceptions of the outcome and the decision process itself. The group's confidence in the recommendations and how they perceive the quality of the recommendations, and their general satisfaction with the decision process are believed to be important indicators of the degree to which conflict is managed. In other words, whether consensus has been successfully achieved (Sambamurthy and Poole, 1993).

3.5. Facilitation of the Group Process

Facilitation of the group process is an intrinsic component of the group process that is directly linked to group performance in terms of both group efficiency and group effectiveness. Facilitation is a field of study on its own and it is beyond the scope of this dissertation to explore the many issues surrounding both traditional facilitation and EMS facilitation. However, the facilitator skills (defined as role dimensions) discussed by Clawson et al. (1993) are important to this dissertation's field study on supporting consensus building.

In an empirical study of the human side of facilitation, 1444 different characteristics of effective and ineffective behaviours in facilitation are divided into 16 dimensions (listed in Figure 3.3 below). Although, the results were similar for both manual and electronic facilitation roles, only those relating technology, dimensions (3, 7, 14), were seen to be strictly related to EMS environments.

1. Promotes ownership and encourages Group Responsibility (58, 4%) – The facilitator helps the group take responsibility for and ownership of meeting outcomes and results, stays out of their content; turns the floor over to others.	2. Demonstrates self-awareness and self-expression (82, 6%) – The facilitator recognizes and deals with own behaviour and feelings; is comfortable being self; keeps personal ego out of the way of the group.
3. Appropriately Selects and Prepares Technology (32, 1%) – The facilitator appropriately matches computer-based tools to the task(s) and outcome(s) the group wants to accomplish; selects tools that fit group makeup.	4. Listens to, Clarifies, and Integrates Information (177, 8%) – The facilitator really listens to what the group is saying and makes an effort to make sense out of it; clarifies goals, agenda, terms and definitions with the group.
5. Develops and asks the “right” questions (42, 3%) – the facilitator considers how to word and ask the “best questions: ask questions that encourage thought and participation	6. Keeps Group Focused on Outcome/Task (86, 6%) – The facilitator clearly communicates outcomes to the group upfront; makes outcomes visible to the group, keeps group focused on and moving toward its outcome.
7. Creates Comfort With and Promotes Understanding of the Technology and Technology Outputs (99, 7%) - the facilitator carefully introduces and explains the technology to the group; directly addresses negative comments and inconveniences caused by technology.	8. Creates and Reinforces Open, Positive and Participative Environment (111, 8%) – The facilitator draws out individuals by asking questions, uses activities and tech to get people involved early on; handles dominant people to ensure that equal participation
9. Actively Builds Rapport and Relationship	10. Presents Information to Group (41, 3%)

(191, 13%) – The facilitator demonstrates responsiveness and respect for people, is sensitive to emotions; helps develop constructive relationships with and among members; greets and mingles with the group.	– The facilitator gives clear and explicit instructions; uses clear and concise language in presenting ideas; gives group written information.
11. Demonstrates Flexibility (75, 5%) – The facilitator thinks on her feet; adapts agenda or meeting activities on the spot as needed; can do more than one thing at a time.	12. Plans and Designs the meeting process (197, 44%) – The facilitator plans the meeting ahead of time; directly includes meeting leader/initiator in planning; develops clear meeting outcomes; designs agenda and activities based on outcome, time frame and group characteristics.
13. Manages Conflict and Negative Emotions Constructively (47, 3%) – The facilitator provides techniques to help the group deal with conflict; uses technology to gather and check group opinions and agreement level in disputes.	14. Understands Technology and its capabilities (64, 5%) – The facilitator knows how to operate the system; clearly understands the tools and their functions and capabilities; figures out and solves common technical difficulties
15. Encourages / Supports multiple Perspectives (42, 3%) - The facilitator encourages looking at issues from different points of view; uses techniques, metaphors, stories, examples to set the group to consider different frames of reference.	16. Directs and manages the Meetings (169, 12%) – The facilitator used the agenda to guide the group uses tech effectively to manage the group; sets the stage for the meeting and each activity; sets time limits, enforces roles and ground rules.

Figure 3.3 Facilitator role Dimensions. 1444 characters of good and bad facilitator behaviour were classified into 16 different dimensions. The numbers in brackets indicate the number of behaviours identified for each dimension and the percentage of the 1444 total behaviours each dimension represents (adapted from Clawson et al., 1993)

There are many facilitation techniques, such as the Nominal Group Technique (NGT) used in manual processes and the Delphi Technique usually provided within an EMS, e.g. Ventana Corp’s GroupSystems. The challenge for GSS has been to enhance facilitation methods using the system. The significance of using a facilitator role dimensions model or any similar checklist is avoiding the risk that too much emphasis is placed on the technology. Knowledge of the technology and its possibilities is imperative for EMS facilitators, but technology should be learnt and then “forgotten” (Clawson et al., 1993: 216). More recently there have been discussions suggesting that in the future GSS technology will see virtual facilitators (GSS-Listserve discussions, 1999).

The idea of virtual facilitators makes sense in light of the fact that the requisite combination of facilitation skills typically exceeds the capabilities of a single individual and thus usually calls for

a team effort (Clawson et al., 1993). “Multi-disciplinary appreciation of GDSS research is necessary to gain the full measure of the GDSS impact on development opportunities” (Vogel et al 1994:253). Those individuals with multi-disciplinary backgrounds and or understanding are best suited to act in facilitator roles (Vogel et. al., 1994). A virtual facilitator, backed by an expert system, is possibly the future of GSS environments.

3.6. The Technology for a GDSS

The interface of a GDSS is a “critical success factor” (Gray and Olfman, 1989). The human interface for GDSS is more complex than for individual workstations, in that it involves the dimension of public and private screens and their interaction. This also includes the physical environment of the facility, the response time of the network and the cognitive style and cultural differences among the users, where for example translation may be necessary (Gray and Olfman, 1989). The Arizona GDSS, GroupSystems, for example has the following tools: brainstorming tools, issue analysis, voting, stakeholder identification, assumption surfacing and recording what happened in a meeting (Gray and Olfman, 1989; Vogel, et al. 1994).

Technology characteristics include hardware, software and setting configuration.

Typically a GDSS has the following features (Huber, 1994)

- A (personal) CRT and input device for each participant.
- A public display screen, large enough to be seen by all participants.
- Computing and communication capability that allows each participant to link his or her input device to its respective CRT or the public CRT screen.
- Software that provides:
 - ✓ Word processing capability to each terminal.
 - ✓ Computing capability with a particular focus on drawing simultaneously on data from several or all terminals.
 - ✓ DSS graphics capability i.e. capability for constructing and altering worksheets, bar graphs and decision trees.
 - ✓ Anonymity when eliciting information from the individual participants when this is

desired.

The hardware, software, setting and “orgware” are critical to the success of any implementation of a GDSS facility (Vogel, et al. 1994). The setting of the GDSS covers issues such as room furnishings, appropriate lighting, group member arrangement and the general atmosphere. These have long been acknowledged to impact on group processes (Brembeck and Howell 1976; Gray 1981; Vogel 1986). Ignoring these may destroy the nature of the fragile group environment in which successful group decision making is facilitated (Vogel, et al. 1994). Vogel et al (1994), in a paper articulating the determinants of success in a GSS based on the experience of many researchers in the Arizona facility propose that the following be taken into account:

3.6.1. The Setting

The aesthetics in terms of comfort and familiarity should simulate that which executives are used to in their organizational conference rooms with appropriate furniture, carpeting and this author would add air-conditioning. In addition they propose that the setting be flexible with the ability to accommodate various group sizes and task environments. Finally, they emphasize that particular attention must be paid to presentation support (Vogel et al., 1994), for instance that the projector screen must be clearly visible without being “washed out” by improper lighting (Nunamaker, et al., 1999).

3.6.2. Hardware for a GSS

Hardware includes the individual workstations, the file servers, presentation media and the communications network that serve to facilitate group communication. Vogel et al. (1994) argue that group effectiveness and efficiency are enhanced in proportion to the degree of support provided. They suggest the following:

That each group member be able to interact with the GDSS, by providing an electronic interface which encourages participation thereby enhancing the efficiency of participation. Having a single workstation they argue is simply inadequate. Further, it has been recommended that each

workstation have a high degree of local intelligence; “in resident” software options that cater for end-user help and data capturing. A high bandwidth local area network (LAN) would then link the workstation to central file servers ensuring high levels of performance thus accommodating network demands by transmitting both text and screens between the individual decision makers. This feature is even more important where the decision makers are geographically dispersed. The central file servers assist in the coordination and management of input from the individual decision makers. They act as a source of organizational memory from one session to the next and would function as a knowledge base repository and access to organizational data relevant to a specific planning and decision making session. It is understood that the presentation media must support multi-media technology.

3.6.3. Software for GSS

Software for GSS “includes the spectrum of programs that interface with the communications network and system knowledge base and the individual decision makers and the group facilitator” (Vogel et al. 1994: 248). They add that additional software would facilitate summarization, consensus formulation through prioritisation and voting as well the presentation of individual and group output.

The software must be comprehensive enough to accommodate the variety of group tasks such as idea generation, the development of alternatives, choice of action, voting and ranking and consensus formulation. The flexibility of the software to support the particular purpose of the group is also important. The group should not be forced or artificially constrained to a fixed procedure or set of tools (Vogel et al. 1994). The group together with the facilitator should have the option to match the set of tools to the task. From the point of view of the individual participant, the tools must be integrated with a knowledge base that links data from one session to the next. It must facilitate the provision of organizational data and give the capacity to do analyses from various perspectives. The software cannot merely be user-friendly, it needs to be “user seductive” Vogel et al. (1994). It should encourage user interaction through the effective use of colour, windowing, on-demand help screens. (See Forrester, 1988 on the design of the user interface).

3.6.4. Orgware

Orgware refers to “the organizational data, group processes for decision making and management procedures for collaborative group work” (Kraemer and King, 1986). It includes meeting protocols regarding who participates, on what basis, with what voting rights and with what consequences and commitments resulting from the process” (Vogel et al.1994: 249). Orgware has increasingly been moving away from the domain of the facilitator to that of the system (Vogel et al., 1994).

This includes the anonymity provided by the GDSS to encourage participation. It includes periods of face-to-face discussion, which are focused around the front-screen display as a complement to the individual workstation interaction. In addition, the group and not the system should decide the question of voting rights and the associated mechanisms of scaling or weighting. The GSS should never impose a voting structure (Turoff, 1999), for there are many instances where voting is an inappropriate way of reaching conclusion. Finally, agendas are a characteristic of most organized meetings and are used to organize sessions, fostering adherence to a schedule and providing a source of continuity from one session to the next. It is for those reasons that a GSS could systematically generate an agenda that is used to initialise the tools to be used in the current sessions as well as coordinate data transfer between the tools (Nunamaker, et al., 1999).

3.7. The Context of a GSS Environment

The complexity of a group interaction environment, as outlined above, has necessitated the increasing need for GSS researchers to define and document the context of their studies. The context of a GSS environment is a composite of the specific setting where the experiment was conducted, i.e. who were the group members; were they a cohesive team; strangers or competitors; what were the site characteristics; what tools and techniques were used; what were the site tasks and processes; how many people made up the group?

The importance of context documentation cannot be underestimated. There are two reasons for this. (1) The recognition that the results of one study will not apply to all group work (Sambamurthy and Poole, 1993) Thus, it is important to explicitly consider the bounds to which the findings can be generalized. (2) Context documentation helps clarify hypothesis formulation and results expectation; moreover, it can assist in the development of standardized measurement instruments in the field (Sambamurthy and Poole, 1993; Zigurs, 1993).

The issue of context is discussed separately to precede the future challenges of group support systems research, precisely because it is so intrinsically linked to the contributions of future research.

3.8. On The Future Challenges Facing GSS Research

The major components of a group support environment presented so far are **task, process, group, individual** and **technology**. Each component has demonstrated numerous characteristics that make the group collaborative environment a complex and chaotic one (Kerr, 1982). It is therefore not surprising that GSS research is still plagued by inconsistent and sometimes contradictory results. That no general guiding theory of GSS has emerged is symptomatic of its very complexity (Valacich, et al., 1992). The difficulty in developing a comprehensive theory results from the many dimensions in which group support systems can be configured and used (Valacich, et al., 1992). In this section, the issues that contribute to the confusion and the opportunities to move group support systems research towards lesser levels of uncertainty are explored.

3.8.1. Improving the Measuring of GSS Outcomes

Traditionally Information Systems has operated on the input-process-output model, where the focus has been outputs, serving as the dependent variables. However, in GSS the link between processes and outcomes is not explicit (Zigurs 1993), although some attempts have been made to establish some linkages. For example Gouran (1988) categorizes the possible number of outcomes of a GSS into four components only:

- The correctness of a decision

- The quality of a decision
- The utility of a decision, and
- The acceptability of a decision.

Gouran (1988) also proposes the “appropriateness” of a decision as a concept, which takes into account the contextual features of a decision, such as the purpose of the group and the requirements of the task. Other researchers have argued that GSS research should be concerned with balancing both **task performance** and **member satisfaction**, where task performance includes categories such as effectiveness, efficiency, cognitive products, structural products, or artifactual products (Pinsonneault and Kramer, 1989). While satisfaction can be personal, group-related, task-related or system-related.

The most studied outcomes variables pertaining to task performance include decision quality, decision speed, and thoroughness of analysis (Dennis, George, Jessup, Nunamaker, and Vogel, 1988; Dennis et al 1990; Dennis et al., 1991; Pinsonneault and Kramer, 1989). While those relating to satisfaction have included decision confidence, satisfaction with the process, and satisfaction with the decision outcome. Other dependent variables that have been studied include equality of influence or participation, perceived quality of the solution and satisfaction with the system and consensus.

The critical difficulty however lies in the fact that where these variables have been measured, they have been measured differently across studies, or it is not documented how these variables were measured (Melone 1990). Member Satisfaction, for example, can mean a different thing to different people depending on the context. The same measurement applied to different groups may result in very different perceptions of what is being measured. It has also been suggested that the very definition of *task performance* has traditionally been narrow and that many *satisfaction* outcome variables have not been studied at all (Zigurs, 1993). Consequently, a broader view of the dependent variable would bring a richer understanding to GSS research (Zigurs, 1993; Nunamaker et al., 1999).

3.8.2. Resolving the complexity surrounding measured process variables and measurement instruments – and developing a unified theoretical framework.

Firstly, the measurement of GSS variables and the tools with which these are measured is one issue that contributes to the complexity and chaos identified by Kerr (1982). Within GSS, the issue of measurement explores questions surrounding what dependent and independent variables should be measured. Which theoretical foundations should underlie this and what measurement instruments should be used? Currently, there is little consensus in this regard.

This lack of consensus has led some GSS researchers to conduct studies that seek to synthesize and simplify the existing complexity. An example of such a study is the meta-analysis performed by Hwang (1998), which tests for the effect of task-type² on a GSS. She identifies that the impact of task-type on the use of GSS was significant in increasing *group communication*, but not significant in improving *decision quality*. The use of a GSS will improve decision quality regardless of task-type. The meta-analysis also found that task-type is not related to the improvement of *participation*, the relationships involving *participation* are complex and can be confounded by variables such as culture and leadership (Eom, 1998). The study by Benbasat and Lim (1993) found group history to be the only moderator variable for participation. No variables can yet conclusively explain the result on participation, more research is required in this area (Hwang, 1998).

On *member satisfaction* Hwang (1998) observes user satisfaction to be lowest with negotiation tasks. This implies that satisfaction should not be a GSS success measure for negotiation tasks because negotiation, by its very nature, brings about conflict and confrontation.

On *decision time*, Hwang (1998) observes that decision time was quicker with generation tasks than with either choice or negotiation tasks. This suggests that decision time should not be used as a measure of GSS success for either choice or negotiation tasks. Information richness and task interdependence are the main causes of the inefficiency of using GSS.

² Negotiation, Selection, Generation and Execution (DeSanctis and Gallupe, 1987) were identified as the four main task-types.

The significance of Hwang's (1998) research is in providing direction in the measuring of the right dependent variable for a specific decision task. Doing so should help future researchers produce more consistent results on the effectiveness of GSS. The research "clarifies" the role of task type in that it provides a basis for *a priori* reasoning for the effect of task type. This *a priori* reasoning is important in the control and measurement of task type and to the measurement of GSS effectiveness. Findings on other variables under investigation should then be explained considering the impact of task type. Otherwise, conflicting findings may be construed as a result of the variables under investigation such as *technology* and *group characteristics*, when in fact the findings are because of task type. For example, because negotiation tasks bring out conflict by their very nature and thus discourage participation, making members less satisfied. In such a case, any conclusions about the ineffectiveness of GSS, based on the decrease in participation and satisfaction would be mistaken. Similar meta-analyses on other group process variables in GSS would be instructive.

3.8.3. Improvements in the Development and Documentation of Measurement Instruments

A need exists not only for agreed upon measures but also for validated measurement instruments in GSS research. Researchers need to provide more information about the measures they are using to operationalise their constructs or variables (Zigurs, 1993; Nunamaker et al., 1999). There will always be a gap between a construct and its accurate measurement; it is only through the validation of instruments that a sense of how large or how small that gap actually is can be achieved (Zigurs, 1993). Many researchers have studied *satisfaction* but say little about the instrument used; for example in George et al., (1990). The current lack of information on measuring instruments does little to promote the greater validity and reuse of instruments. For instance, *decision quality* is one of the most important variables in (group) decision support systems, but the measurement of *decision quality* is not clear. For tasks where there is no correct answer, there is especially no consensus on the meaning of quality (Zigurs, 1993). In general the use of "expert judges" to measure *decision quality* in small group literature is prevalent, for example in (Connolly, et al., 1990; Gallupe and McKeen, 1990; Dennis et al 1996; Nunamaker et al., 1991).

3.8.4. On the Provision for Distributed Features in GSS

In reality, most organizational teams are convened and reconvened over a period to handle different issues or problems over several meetings. So for example, a management team may deal with a specific takeover issue over a two-week period. The same team may be subsequently assigned the responsibility of formulating company long-term strategy over a six-week period. In addition, a group may do work before and after a meeting. To date most GSS research, while acknowledging the importance of group history, deals with single-group/multiple task in a single meeting. Future GSS research and applications must look at the “Any Time /Any Place” dimension of the GSS environment (see Figure 3.2). That is, supporting distributed teams, where real-time communication and co-ordination is essential. Research is needed to expand this to include coordinating multiple distinct groups addressing interrelated tasks over numerous meetings (Jessup and Valacich, 1993).

The framework presented by Stevens and Finlay (1996) proposes how through feedback loops participation and outcomes from one meeting can influence member participation and the group environment for subsequent meetings. This is a significant contribution in light of the need for GSS researchers to explore longitudinal meetings in more depth. It appears the strength of GSS technology to provide simulations of a ‘across the table’ feeling for distributed groups is vital here. (Stevens and Finlay, 1996). Technology must become an enabler of more dynamic group configurations (Gersick, 1988). The role of technology as an enabler could provide settings where teams can design their “own ideal collaboration workspace without the constraints of physical reality” (Johansen, 1991: 524). This could include a virtual facilitator (Jessup and Valacich, 1993).

3.8.5. Laboratory Experiments vs. Field Studies and other Research Methods

GSS is a young field. It is not surprising that traditionally, GSS researchers have run laboratory, experimental research where specific variables are manipulated in a controlled environment.

Table 3.1 A Summary of Published Studies by Research Method

Period	Field Study	Laboratory	Design and Development	Other
1988	35%	65%		
1989 - 90	17%	30%	13%	40%
1984 -96		55.6%		

Table 3.2 above shows, in 1988, approximately 65% of published GSS studies were laboratory experiments (Pinsonneault and Kraemer, 1989). A review covering a selection of IS journals published in 1989 and 1990 shows studies published comprised: laboratory experiments [30%], field studies [17%] and design and development papers [13%] (Zigurs, 1993). In another review of GSS research for the period 1984-1996, laboratory research represented 55.6% of all GSS empirical research on events and processes (Pervan, 1998).

There are other reasons for the prevalence of laboratory experiments beyond the youthfulness of the discipline. GSS research may be more amenable to this type of research because of the diverse number of dependent variables it offers to study relating to both process and outcome. The large number of variables associated with the group, task, the process (including facilitation) and the technology that affect these dependent variables offers an enormous number of possible study combinations when one of these is manipulated while controlling the others (Pervan, 1998). Furthermore, most of the research has been conducted within US universities where arguably laboratory experiments are well accepted as a research approach (Pervan 1998).

This is not to suggest that no work has been done on field studies: Nunamaker, et al. (1989), Vogel et al. (1990) and Grohowski et al. (1990) conducted their field studies at the IBM site using Ventana Corp's GroupSystems. Other studies include a study of Groupware at the World Bank (Bikson, 1997); Post, 1993; Vogel and Vreede, 1999; Vreede and Van Wijk, 1997).

Nevertheless, field studies have been rare. There are several commercial consultancy organizations that based on the information on their websites have implemented GDSS technology on a number of organizational sites. (See www.gdss.com, www.facilitate.com, www.ventana.com)

While field studies are desirable, they are not the only other research method or approach alternative (Zigurs, 1993; Pervan, 1998; Markus 1997; Lee, 1989; Todd and Benbasat 1987; Ngwenyama and Lee, 1997; Vogel and Nunamaker, 1991). Action research; application description; case study; meta-analysis; surveys; mathematical modelling; ethnography; and conceptual or theoretical research are other suggested potential GSS research methods (Zigurs, 1993; Pervan, 1998).

There have been some meta-analyses in GSS research (Hwang, 1998). Meta-analyses have been criticized for having the problem of comparing “apples and oranges”— i.e. the mixing of data that come from studies of diverse settings. However, if it is noted that within social sciences meta-analysis is seldom used to determine the final word in a research area, but rather is best used as a means of taking stock and providing direction for future research (Hwang, 1998) then the phenomenon of mixing data becomes secondary.

It seems GSS research has almost been entirely positivist in its assumptions and approach. IS researchers have been steeped in a rationality assumption, a functionalist paradigm, an objectivist approach and a deterministic model (Weill and Olson, 1993; Zigurs, 1993, Pervan, 1998). A positivist approach is the “natural-science model of social-science research” in that it proceeds to implement, in social science, an image of how research proceeds in physics, biology, and other natural sciences (Ngwenyama and Lee, 1997:151). Social science theories based on this model must conform to the rules of formal logic and the rules of experimental and quasi-experimental design. The rules of experimental design depict the subject matter in terms of independent and dependent variables (Pervan, 1998). Interpretivist theory, on the contrary, recognizes the “life-world” of mutual understanding between the “life-world” actors (Ngwenyama and Lee, 1997).

In GSS, research methods are dominated by field experiments, where experimental controls are imposed onto the natural setting and variables are measured usually through questionnaires or positivist case studies that have no experimental design or controls (Pervan, 1998). In another literature review of effective GSS, Srinivasan and Jarvenpaa (1991) conclude that most existing empirical work can be categorized as exploratory i.e. experimental work that states no formal hypothesis or no underlying theoretical model. Although other studies have included formal hypotheses, these hypotheses have not been founded on a well-formulated theoretical model (Srinivasan and Jarvenpaa, 1991). Seldom are surveys used wherein questionnaires are sent to many organizations; rarely is instrument development applied where new measuring instruments are tested in the field (Pervan, 1998). Secondary data studies where results from previous studies are combined and analysed are scarce.

Of the 131 empirical papers reviewed by Pervan (1998), only four use an interpretive approach. This suggests an opportunity exists for GDSS researchers to advance knowledge in this field by investigating GSS use in field settings, using interpretive approaches such as phenomenology, action research, ethnography and grounded theory.

The absence of grounded GSS theory is one of major future challenges in the field. In the existing 'chaos' of knowledge it is useful to heed Dubin (1969). He suggests that when developing a theory it is often instructive to start with an author's statement of hypothesis and attempt to reconstruct his or her theoretical model from only that statement as the only available piece of evidence. Doing so for several pieces of research is particularly useful in an attempt to discover whether there is some convergence among the separate hypotheses that lead to the conclusion that they may be derivable from the same theoretical model. Srinivasan and Jarvenpaa (1991) suggest that in the myriad of 'ad-hoc reasoning' surrounding many studies the goal should be the identification of studies for re-constructive analysis.

The work of Srinivasan and Jarvenpaa (1991) deals with this process of linkages between seemingly 'ad-hoc reasoning' from previous researchers and the theories of communication, minority influence, the limitations of human information processing and computational abilities. They arrive at some useful propositions. For example, that anonymous communications will be

more useful in groups where members are reticent than where members are not reticent; or that anonymous communications will be more effective for creative tasks than for choice tasks. The usefulness of such propositions is unquestionable because existing research simply suggests that anonymity enhances participation. This statement may not be strictly true as evidenced by the inconsistencies in the many reported research studies (Nunamaker et al., 1999). The work of Srinivasan and Jarvenpaa (1991) goes one step further than the contribution of Hwang (1998) which isolates the effects of task-type. The work of Stevens and Finlay (1996) echoes similar approaches to these studies. These contributions should help researchers state their hypotheses more accurately and more usefully.

The challenges posed by critical social scientists apply equally to the future challenges of GSS research. Ngwenyama and Lee (1997), in a paper looking at “communication richness in communications media and the contextuality of meaning from a critical social theory perspective” offer some useful guidelines not only for Information Systems research in general but guidelines that can be used for GSS specifically. They propose a critical social theory (CST) perspective to research. CST “posits that there are differences between observing nature and observing people; and inquiry into social settings should focus on understanding meanings from within the social context and the lifeworld actors” (Ngwenyama and Lee, 1997: 151). This is in contrast to positivist and interpretivist approaches. The positivist type of inquiry is inadequate in an environment where the subject matter consists of a world of consciousness and humanly created meanings –a “life-world”. “Unlike atoms, molecules and electrons, people create and attach their meanings to the world around them and to the behaviour that they manifest in that world. Because of this, the social scientist may not only collect facts and data describing purely the objective, publicly observable aspects of human behaviour. These subjective meanings constitute a different subject matter from objective facts and require research methods that have no counterparts among those of natural sciences” (Ngwenyama and Lee, 1997:151).

CST researchers believe that they cannot merely be observers. They believe that their very presence influences and is influenced by the social and technological systems they are studying (Ngwenyama and Lee, 1997). Researchers less steeped in positivist tradition argue that theories generated from qualitative research must in the end be applied and extended in practice (Pervan,

1998). It is only by studying GSS in support of actual stakeholders solving their own problems that we can really appreciate the complexities of the group environment and learn how to use GSS more effectively (Pervan, 1998).

3.9. Conclusion

Since decision making is a process and not an event, this research focuses on two important components of that process: solution generation and consensus building. The practical research focuses on two distinct task-types: Generation and Selection. The Generative task, deals with problem structuring for generative tasks. The justification of this research is although a lot of research has been conducted in electronic brainstorming, to the best of the author's knowledge, only two studies have been conducted with a focus on problem structuring of the generative task (Dennis et al., 1996, 1999). The selection task is explored focusing on the issue of consensus building. While consensus is an important variable in the study of the effectiveness of GSS, it is an area that has seen little research directed towards it. This is another justification of this research. Finally, both studies are linked by the investigation of the explicit and implied need to structure the GSS environment to achieve effectiveness. The generative task is explicitly structured as discussed in the next chapter, while the selection task is structured more implicitly using the Analytic Hierarchy Process.

The identified need for more field studies (Pervan, 1998) has been taken into account in formulating the goal of this dissertation. Chapter Five will present the results of a field study on consensus building within a multi-criteria decision making group support environment.

Another conclusion that can be made concerns the need for a combination of multiple methods in group decision making, as this is assumed to provide a greater power of understanding of the socio-technical issues with which GSS deals (Zigurs, 1993). A combination of approaches aims to address the needs of different aspects of research in group decision making, this dissertation reports on a laboratory experiment related to an idea generation task and a field study on consensus building in a group multi-criteria environment involving real stakeholders.

The next chapter will argue for the appropriateness of these two approaches to the chosen research sub-goals.

CHAPTER 4. A SURVEY OF THE RESEARCH WHICH INFORMS THE DESIGN AND SPECIFICATIONS OF THIS THESIS' PRACTICAL WORK

4.1. Introduction

As seen in Chapter Three, this investigative study is informed by the need for further research in the area of problem structuring for generative tasks and consensus building within selection tasks. In addition, an undesirable decline in the number of field studies conducted within GSS research is observed. Thus while investigating two important variables in group interaction, the method of exploration is diversified to include both a laboratory study and a field study as the latter is significant in advancing the GSS field and group multi-criteria decision making. In this chapter, the main foundations of the experimental research conducted for this dissertation are explored. These are on task and time structuring for idea generation tasks and on consensus building.

4.2. On Brainstorming Research

In Chapters Two and Three it was established that to respond to today's quick-changing and highly complex business environment, not only do organizations rely on the co-operation of groups to deal and manage complex environments, organizations require their members or employees to be increasingly more innovative or creative in dealing with the challenges they face. Many of today's successful organizations attribute their success to their ability to cultivate creativity and innovation. Microsoft, Exxon Corporation and others regularly spend "corporate dollars to nurture the creative spirit of their members" (Masseti, 1996:83). In addition many techniques aimed at enhancing creativity are flourishing (see de Bono, 1993; Couger, 1995). This has grown to the extent that creativity support systems, which are computer-based tools, aimed at enhancing "boundary breaking, and insightful thought during problem-solving"(Masseti, 1996:83) have been built and continue to grow in popularity.

4.2.1. Brainstorming effects on verbal and nominal groups

Several studies have demonstrated that the use of computer-based tools leads to more ideas being generated by the subjects, the issue of the improved quality of ideas being concomitant with the process is not a conclusive one (Masseti, 1996, Nunamaker et al. 1999).

Creative responses are known to categorically result from two types of mental processes: generative and exploratory processes (Finke et al. 1992). Within the generative mode, divergent ways of thinking, including remote association and pattern switching produce novel and unique concepts (de Bono, 1993; Ackoff and Vergara, 1981). In the exploratory mode, convergent thought such as elaboration or successive refinement reformulates a unique concept into a meaningful and valuable response (Ackoff and Vergara, 1981). While both processes must occur for an individual to perform creatively, the nature of the decision task defines which mode is likely to dominate response-formation (Finke et al., 1992). Thus, depending on the whether the task is aimed at the generative or exploratory mode, the response produced will tend to be more novel or more useful.

Brainstorming has received considerable research attention. Ever since Osborn (1957) published his theory of brainstorming, the idea that brainstorming groups as opposed to individuals working by themselves producing significantly larger numbers of ideas has been traditionally well received. This synergy is premised on the perception that within groups, members hear other people's ideas, ideas they would not have otherwise thought of and that they can then build on those ideas. As a result, brainstorming groups are generally expected to be more productive than individuals working alone. The original brainstorming principle requires group members to initially just state as many ideas as possible, the wilder the ideas the better (Osborn, 1957). The second step is for members to improve on or combine previously stated ideas while suspending all judgment of those ideas. It is important that they do not criticize any ideas: "the average person can think up about twice as many ideas when working with a group than when working alone"... provided the "individual ideators adhere to the principle of suspended judgment" (Osborn, 1957:228-229).

However, research over time has repeatedly found several impediments to the synergy of brainstorming groups. Verbally interacting groups have consistently been observed to be less productive than nominal groups (McLaughlin-Hymes and Olson, 1992; Diehl and Stroebe, 1987; Dennis et al., 1990; Gallupe et al., 1991)). For the same number of individuals, more

ideas and more quality ideas have been generated by having the individuals work independently and then subsequently pooling the ideas together. This is in contrast to having these individuals verbally interact as a group. The reasons for this are many. However, four issues have been regularly identified as dominant and these are *social loafing* or *free riding*, *evaluation apprehension*, *production blocking* and *cognitive inertia*. Since these issues are central to this discussion, they are briefly redefined. Social loafing is where group members do not work as hard as they would when working alone. Evaluation apprehension is the concern group members get about how other members of the group are going to react to their ideas in spite of the brainstorming instruction to suspend all judgment. Production blocking is as a result of the serial nature of communication within group interaction in that only one person can speak at a time. Members cannot necessarily express their ideas as these occur to them but must await their turn, resulting in either them forgetting their ideas or making ideas appear irrelevant by the time they are expressed (attenuation blocking). The serial nature of communication also contributes to cognitive inertia, because at any moment in time only one line of ideas is being generated or explored, groups tend to pursue fewer different kinds of ideas.

Production blocking and limited airtime appear to be the dominant reason why interacting groups are out-performed by nominal groups (Diehl and Stroebe, 1987). For the comparison of nominal groups and interacting group the results have been consistent. Nominal groups consistently and regularly outperformed verbal groups. Furthermore, the differences appeared more pronounced for larger groups (Gallupe et al., 1991; Gallupe et al., 1992a). It appeared that Osborn (1957) had been too generous about the benefits of interacting groups. When groups interact there is a balance of forces between process losses and process gains. It seems that the process losses usually overwhelm the process gains. It is reported that during the last three decades, more than 50 studies have made the comparison between nominal brainstorming groups to verbal brainstorming. (McGrath, 1984; Dennis and Valacich, 1993; Dennis, 1993)

“For this comparison, the evidence speaks loud and clear: Individuals working separately generate many more, and more creative (as rated by judges), ideas than do groups, even when redundancies among member ideas are deleted, and, of course without the stimulation of hearing and piggybacking on the ideas of others. The difference is large, robust and general” (McGrath, 1984:131).

4.2.2. The Introduction of Computer Supported Brainstorming Groups

With the emergence of group support through computer-based tools, the scenario has changed somewhat. The introduction of electronic brainstorming computer-mediated communication replaces verbal communication. Each member anonymously enters his or her ideas into a computer workstation, which records them and sends them to the “workstations of others”. The other members can then in turn read the ideas and respond by building on them to create new ideas or by ignoring them and generating unrelated ideas or by doing nothing (Dennis and Valacich, 1993). These tools contain features designed to reduce if not eliminate process losses. Electronic brainstorming can affect process gains and losses in at least three ways: (1) through enabling parallel communication, (2) through the provision of group memory and (3) through facilitating anonymity. Parallelism mitigates the effects of production blocking. It may also mitigate the losses resulting from free riding, caused by competition for airtime. In this way electronic brainstorming assimilates nominal group brainstorming. The group memory made available through the recording of all ideas is observed to reduce the incidence of redundant ideas building on synergy because members can see the ideas that have already been contributed (Dennis and Valacich, 1993; Nunamaker et al., 1999).

However, anonymity can also increase the incidence of free riding. It becomes difficult to determine who is and who is not contributing. Evidence shows that anonymity has had little effect on low threat tasks, but can be important in settings with conflict and where power and status differences exist (Nunamaker, et al., 1991).

The possibilities made available by the ability to electronically support brainstorming groups shifted researchers focus to comparing electronically interacting groups with nominal groups. The expectation was that electronically brainstorming groups would outperform nominal groups because electronic brainstorming exhibits characteristics of both interacting and nominal groups by allowing ideas from one participant to stimulate ideas in others and through anonymity and parallelism (Dennis and Valacich, 1993, Nunamaker et al., 1991). However, earlier studies (Gallupe et al, 1991), comparing nominal groups and electronic brainstorming groups, found no significant differences in performance, although the authors speculated that the results could have been different for larger groups. Later studies found that larger electronic brainstorming groups generated more ideas than nominal groups (Valacich et al., 1994, Dennis and Valacich, 1993) and that there was no difference in performance between the two types of groups for smaller groups of six members and less. Other studies

(McLaughlin-Hymes and Olson, 1992) found somewhat contradictory results, although under different conditions.

Although the results of such comparisons have not always been conclusive, they have been revealing and some consensus about the effects of electronic brainstorming is starting to emerge. These results have demonstrated that electronically interacting groups are at least as effective as nominal groups and in some cases perform even better than their nominal counterparts (Nunamaker et al., 1999).

4.2.3. The Effect of Group Size on Brainstorming Groups

The emergent consensus is particularly prevalent around the effect of group size with respect to electronic brainstorming. The disparity between nominal and verbal groups is observed to increase with group size. In general, while the number of ideas generated by nominal groups increases rapidly with group size, the number of ideas generated by verbal groups typically does not (Dennis and Valacich, 1993). For larger group sizes, nominal groups outperform verbal groups, often generating three to four times as many ideas (Dennis and Valacich, 1993; Diehl and Stroebe, 1987).

Similarly, the magnitude of process losses or process gains is affected by the size of the group. The synergy that results in process gains is likely to occur more with larger groups because members are more likely to have different information and skills. Production blocking however, is more severe in larger groups simply because blocking is more likely and because when one member speaks more members are blocked (Lamm and Trommsdorff, 1973). Evaluation apprehension may be stronger in larger groups, as there are more opportunities for members to disagree and become antagonistic toward others ideas (Dennis and Valacich, 1993). Free riding also increases in larger groups because one's contributions are more dispensable and there is more competition for airtime. In the more than 50 empirical studies conducted by the same authors, at no stage did the verbal groups outperform nominal groups. Instead, in a few cases there was no recorded difference in performance (Dennis and Valacich, 1993).

Empirical studies have shown electronic brainstorming groups of larger sizes generating more ideas than verbally brainstorming groups, especially for larger groups (Gallupe et al., 1991;

Gallupe et al., 1992). They were also found to generate no fewer ideas than nominal groups for smaller sizes (Gallupe et al., 1991). For larger sizes electronic brainstorming tend to generate more ideas than nominal groups (Valacich et al., 1994).

4.2.4. Task, Process and Time Structuring in Brainstorming Environments

The mere provision of computer-support for group brainstorming is therefore not sufficient for optimizing group creativity and idea generation. More is needed from technology-based support beyond merely eliminating process losses. Features that actively direct group brainstorming in a way that enhances the number and quality of ideas generated must be incorporated. Research into task and time structuring for generative tasks is a recognition of this need. It is also in line with the proposals of DeSanctis and Gallupe (1987) on the development of Level 3 Group Support Systems.

Although the results on previous research on idea generation may not be sufficiently conclusive, it has however become clear that research in the field is moving past the point of comparing manual brainstorming groups to electronic brainstorming groups or nominal groups. The findings of McLaughlin-Hymes and Olson (1992) comparing both supported, nominal and interacting brainstorming groups are helpful in this regard. The challenge is for researchers to enhance the electronic brainstorming environment towards Level 3 systems. This may mean intervening in structuring the electronic brainstorming session in specific ways to optimize the group's performance (Dennis et al., 1996). It also means understanding the role, played by the nature of the task in the brainstorming setting.

The very idea of structuring a brainstorming session, in any way, intuitively sounds like a contradiction in terms. Ironically, according to the original foundations of brainstorming principles, "anything is possible"; therefore even considering structuring a brainstorming session is a concept that possibly should have emerged a while back. This nonetheless is not the case. The idea of structuring brainstorming sessions was first introduced by Dennis, et al., 1996, to this author's best knowledge. Dennis, et al. (1999) pursue the same issue further.

One aspect of brainstorming that has received little research attention is how the brainstorming problem should be presented to the group (Dennis et al., 1996, 1999). In that regard the authors present two groups with the same brainstorming problem. The first group is

presented with an intact problem question and the other with a series of separate questions each focusing on a sub-aspect of the problem.

The thinking behind the decomposition of a problem into sub-categories is based on theories of cognition and problem structures. Most problems have a hierarchical or tree-like structure (Rosch, 1978). The highest level in the structure, its root, is known as the “super-ordinate level”. The super-ordinate can be decomposed into a set of more specific categories known as the “basic level”. The basic level can in turn be decomposed further into more specific categories known as the “subordinate level”. These levels are relative, as one organizational level may view the super-ordinate level as the highest level, while another, higher, organizational level may view the same problem as a subordinate within a more complex, holistic problem. The issue is: which leads to more ideas, posing the problem to a brainstorming group at the highest level as one all-encompassing question or at the basic level as a series of distinct questions each addressing one sub-category of the overall problem (Dennis et al., 1996)?

4.2.5. Problem Structuring and the Cognitive Phenomena related to the Individual Decision Maker

While group brainstorming is influenced by both cognitive phenomena and social or group phenomena (Nagasundaram and Dennis, 1993), social phenomena have dominated previous research, although cognitive factors are still important (Dennis et al. 1996). Theory on human cognitive phenomena suggests, when presented with an all-encompassing problem, individuals will produce a set of related ideas focusing on only a small set of problem subcategories (Dennis et al. 1996, (Anderson, 1983, 1987)).

Cognitive phenomena are related to the production rules that control cognitive behaviour through the specification of cognition steps that in turn produce ideas when activated. These rules are activated automatically by input stimuli without human conscious control (Anderson, 1992). So for instance, for any given stimulus, there are several rules that can be activated, but the rules that are more closely related to the stimuli (and to each other) are most likely to be activated. These closely related rules are likely lead to the production of closely related ideas. Thus each individual is likely to produce a set of closely related ideas (Dennis et al., 1996; Anderson, 1987). To that extent, individuals presented with an all-encompassing

problem would tend to focus only on a small fraction of the potential solution space while believing themselves to have produced a comprehensive set of solutions (Dennis et al., 1996; Connolly et al., 1993; Gettys et al., 1987). They explore a few related sub-categories in depth rather than contemplate a broader range of sub-categories in the overall problem. “The result is individual problem solving often misses key solution opportunities because of this narrow focus” (Dennis et al. 1996: 269).

Problem structuring is the activity of identifying the relevant variables in a problem situation and the important relationships among those variables (Pitz, et al., 1980). It is closely related to “act generation” which is the process of generating actions that might solve ill-defined decision problems. Because problem structuring occurs in the early stages of problem solving, it has considerable effect on the direction and successes of the succeeding stages. (Mintzberg, et al., 1976; Winkler, 1982; Mitroff and Linstone, 1993; Ackoff, 1974). Although there are many examples that show that incorrectly defined problems can lead to problem solving ineffectiveness and significant monetary losses (Jennings and Wattam, 1994), decision makers as well as analysts seldom use problem-structuring strategies (Bell, 1982). Related literature descriptions of problem structuring heuristics can be organized in a continuum of expansion-reduction Volkema (1983).

- On the Expansion end there are problem structuring heuristics which start with a problem that is small and specific, which then broadens the problem definition to be more expansive.
- On the Reduction end there are those problem structuring heuristics that start with a global objective and narrow the focus to smaller, more manageable objectives until a cause effect relationship is defined.

Similarly, there have been studies that have explored problem structuring techniques based on the *divergent* and *convergent* heuristics. Problem structuring heuristics are decision aids designed to help people structure problems. This taxonomy is appealing because it is parallel to two known types of thinking: divergent or expansionist and convergent or reductionist or thinking (Abualsamh et al., 1990). These studies have shown that divergent approaches to problem structuring are most effective (Jennings and Wattam, 1994). Further, people with high levels of divergent thinking are better at act generation (Abualsamh et al., 1990) and at

hypothesis generation (Manning et al. 1980), which is associated with creativity. On the other hand, convergent approaches to problem structuring are most efficient (Maier, 1970; Abualsamh et al., 1990) and are associated with the straight-line application of standard knowledge. Intellectual tasks would be more suitable to convergent heuristics.

An individual's ability to structure a problem is largely dependent on and limited by his or her cognitive abilities. For the purposes of creatively solving problems, some intervention is necessary. Since solutions are based on conceptualisation, the ability to solve problems depends on how well the problem structure is conceptualised (Loy, 1991). Therefore, if the conception of the problem structure is wrong or incomplete the decision maker will fail to solve the right problem (Loy, 1991). It is precisely because of such errors of conceptualisation that it has frequently been observed that we fail to face the right problem as opposed to failing to solve the problem we face (Ackoff, 1974). For complex problems, a construction of a good mental model i.e. conceptualisation is critical for successful problem solving (Loy, 1991).

The objective of a computer-based decision support system is to provide support to human decision makers dealing with unstructured and semi-structured problems in all phases of decision making. In particular, to provide support for problem representation or problem formulation processes, there is a need to develop problem-structuring tools with the understanding of the mental processes and abilities involved in human problem solving.

A proposed solution is to adopt process structuring techniques that attempt to change the individual's focus on the problem, either by decomposing it into sub-categories or expanding it into a higher level problem (Volkema, 1983 and Dennis et al., 1996). Volkema (1983) provides some evidence that problem decomposition can improve the number of solutions identified. There is also evidence that decomposing the problem by breaking it into a set of sub-categories which are then considered separately improves performance, because it encourages individuals to devote their attention to the entire set of categories more evenly (Pitz et al., 1980; Dennis et al., 1996; Dennis et al., 1999). Even a modest amount of decomposition should lead to better performance (Samson, 1988).

4.2.6. On Problem Structuring and Nature of the Task

It is intuitively appealing that the nature of the task will have some effect on structuring efforts; and that some thinking or cognitive skills would be suitable to certain types of tasks, while others to different types of tasks. More specifically, for generative tasks, what are the cognitive abilities that a computer-based solution should seek to enhance? Therefore, what would be the measure of success (effectiveness) for an electronic brainstorming support system? Using the meta-analysis by Hwang (1998) discussed in Chapter Three is relevant here.

There are two variables that GSS can affect in generative tasks; the first is *decision quality* and the other is *decision time*. Although Hwang's (1998) work, a meta-analysis, is based mainly on studies comparing the supported environment and non-support environment, these effects can be extended to comparisons of supported environments. That is seeking to impose further GSS capabilities (through task and time structuring) to enhance both decision quality and decision time is appropriate. However, the issues surrounding *participation* and *member satisfaction* are still unclear, so that for generative tasks, formulating hypothesis about the effect of GSS around these variables would not be appropriate.

4.2.7. Problem Structuring and Group Phenomena

It was noted earlier that groups tend to suffer from cognitive inertia, a phenomenon similar to individual cognitive limitation. This is the tendency of the group to focus their discussion to a limited line of thought in one sub-category of an issue. As groups interact they may consciously or unconsciously adopt behaviour norms. These norms or structures may constrain behaviour (Giddens, 1984). One of the structures typically found in groups is not "changing the subject" (Lamm and Trommsdorff, 1973:382). Repeatedly changing the subject to look at new ideas becomes socially undesirable. Members may think of unrelated ideas but it becomes socially undesirable to contribute these ideas to the discussion. This behaviour has been observed within electronic brainstorming groups and is associated with the generation of fewer ideas (Dennis and Valacich, 1994, Dennis et al., 1996).

That which is achievable through problem decomposition for the individual may be partially achieved by the formation of a group for that same problem. Groups are partly formed to

provide a diversity of approaches to a problem in order to counter the potential narrowness of any one individual's perception. The diversity of ideas proposed by the group can overcome the cognitive limitations faced by individuals. However, cognitive inertia can counter these efforts. Problem structuring for a group environment must then employ methods that are effective for both the individual and the group. Problem decomposition recommends itself for these purposes.

4.2.8. Time Structuring with Problem Decomposition

Decomposing the problem into sub-categories that are addressed sequentially divides the amount of time available to solve the problem into several smaller intervals of time, each devoted to one problem sub-category. There is an adage that work expands to fill the time available for it. McGrath et al. (1984) observed that when groups had short time limits imposed, they solved problems faster than when they had more time. Breaking the problem down into several categories, each addressed under tighter time constraints may encourage the group to work faster, resulting in better group productivity i.e. more ideas than when presenting the group with the problem framed as a single question with more time available.

The goal of task structuring is to encourage members to allocate their effort more evenly over the individual sub-categories within the task. With time structuring members are forced to break their work pattern and think about something unrelated and this is designed to break the cognitive inertia (Dennis et al., 1996; Dennis et al 1999). When the individuals resume work they may focus on a different part of the task and in this way they may direct their efforts to different sub-parts of the task that were previously overlooked (Dominowski and Jenrick, 1972).

There is evidence that externally imposed time constraints affect the pace of group work (Gersick, 1988). If groups perceive that they have a short period relative to the task, they work more quickly to accomplish the task (Kelly, 1988; Kelly, et al., 1990; Locke and Latham, 1990). The reverse is also true; if groups perceive that the time period is sufficient to complete the task, they work more slowly. A shorter time period may increase the rate of task performance resulting in more ideas but quality may suffer. This is because time pressure tends to focus attention more narrowly so that some sub-parts of the task are overlooked (Kelly and Karau 1993; Kelly and McGrath, 1985). To some extent, the perception of time

available may be more important than actual time available (Dennis et al., 1996; Dennis et al., 1999).

Decision time, as a measure of effectiveness for a GSS that supports generative tasks is a relevant independent variable in the design of experiments (Hwang, 1998). This notion is included in the hypotheses of Dennis et al (1996) and Dennis et al (1999).

It is reported that the “results from both experiments were clear and consistent: decomposition lead to more ideas. For two different tasks, subject populations, and settings decomposing an idea-generating problem into subcategories and directing subjects to work sequentially on each generated some 60% more ideas than did presenting them with the same problem as one question” (Dennis et al., 1996:274). However, decomposition had no effect on the subjects’ satisfaction or perceived effectiveness.

Dennis et al. (1999), find somewhat different results under slightly varied circumstances and different hypotheses. They divided their brainstorming groups into those tackling intact tasks and those tackling the decomposed tasks. In addition, those working on the intact task had 30 minutes to work on the tasks, while those working on the decomposed tasks had 10 minutes for each of the sub-tasks. In this study, it was found that the decomposed task treatment group generated 40% more ideas. However, no time effects were found in this study.

On the other hand, there are risks to using task structuring that researchers and practitioners need to take into cognisance. Dennis et al. (1999) found that the subjects in the single intact-question treatment were more likely to produce ideas that fell outside of the three pre-defined main categories. Although it is not clear what the quality of those same ideas were from their paper. They conclude that one risk of problem structuring is that the structure may not completely cover the problem space; that is, it may miss important sub-categories (Dennis et al., 1999). In other words, the constraining of the ideas to predefined categories may result in the group intentionally or unintentionally missing ideas that lie outside these categories. This point is important and needs to be tested by further research, which justifies this research.

A second risk is, it may be more difficult to create good, holistic solutions without considering all sub-categories of the task simultaneously. For instance, the ideas developed when focusing on one sub-category may violate constraints imposed by the requirements of another sub-category thus compromising the overall usefulness of the solution (Campbell,

1988, Dennis et al., 1998).

In this dissertation, the methodology on problem structuring by Dennis et al. (1996) is used as a starting point. However, the questions asked are different in content.

In the decision making process, brainstorming or generating ideas is an activity characterized by the stimulation and support for divergent thinking by the decision making group. It was noted that people with high levels of divergent thinking are better at act generation and at hypothesis generation (Abualsamh, et al., 1990). The next stage in the decision making process is convergent thinking. Building consensus is associated with convergent thinking (Abualsamh, et al., 1990).

4.3. On the Issue of Consensus

An outstanding group-generated solution can rarely be implemented if the group, or other stakeholders with a vested interest in the decision, cannot agree and reach consensus on the solution. For today's organization creativity is essential; however the ability to get buy-in for those creative solutions is equally important. The second part of this research examines consensus building in a group multi-criteria decision making.

4.3.1. What is Consensus, and why is it Important?

In Chapter Two, group decision making contexts and how the AHP facilitates them were briefly explored. The contexts defined were common objectives, non-common objectives and conflict. In this section, focus is turned onto the group decision making context of common and non-common objectives, the latter being where parties have some non-shared and sometimes hidden objectives. The purpose of this section is to explore the attendant strategies that can be employed to assist the group in reaching a consensus decision where they are starting from non-shared or hidden objectives. The strategies mentioned in Chapter Two included voting, compromise and consensus. It was discussed that in the AHP, consensus can be arrived at through the discussion of the hierarchy and the judgments (Saaty, 1991). However, discussion may not be adequate, possible, or even desirable in a decision making situation. In such cases, there is a need to be able to facilitate consensus with the employment of other useful strategies.

There have been several field and laboratory studies conducted by GSS researchers testing the efficacy of group support systems on group consensus. The results however have been less than consistent. In some cases, they have been conflicting and contradictory. For example, there are studies that have reported negative GSS effects on group consensus (George et al. 1990; Ho and Raman, 1991; Watson, et al, 1988; Hwang, 1998). Although, this inconsistency in findings has been attributed to the differences in research methodologies (Dennis, et al., 1991); differences in technology (Kraemer. and Pinsonneault, 1990); differences in the adaptation of technology by groups (Poole and DeSanctis, 1989); a lack of theory (Rao and Jarvenpaa, 1991) and low statistical power in MIS (Baroudi and Orlikowski, 1989), there remains sufficient cause for further investigation, which justifies this research.

Yet, one may ask is there consensus on the very definition of consensus? Some researchers have defined consensus by juxtaposing it with polarity (Coman 1996:247). Coman defines polarity as “the level of conflict associated with an issue” and consensus as the “the compliment of polarity”, although he suggests consensus is often confused with position or opinion. Explicitly differentiating between the position that the group holds and the extent to which the group is polarized on the issue is important. Consensus is the level of agreement associated with an issue (Coman, 1996). Consensus has also been defined as a collective opinion or accord (Zeleny, 1982). Accord means agreement. This is distinct from a compromise, which is a solution or settlement of differences in which each side makes some concessions. Accordingly, there may be several compromises but only one consensus (Zeleny, 1982).

Consensus is a process of general agreement on public issues (Bazak and Saaty, 1993). This begs the question: how many individuals must agree in order to carry the group? In practice one or several people can dictate decisions for a group, from within or outside the group, or by partial or total participation of the group. When the decision is made through participation, Bazak and Saaty (1993) propose that there are at least three known types of consensus – spontaneous, emergent, and manipulated consensus.

Spontaneous Consensus is exhibited in traditional communities, with very few public issues, who change their decisions as a collective entity.

Emergent Consensus occurs only in non-traditional societies, which are relatively secular and urbanized. Typically, after all points of view have been considered, each individual weighs

and judges the ideas and then draws a rational conclusion. The crystallization of these judgments becomes public opinion. If the emergent majority is sufficiently forceful, the minorities would adopt its view and emergent consensus arises with the viewpoint of the majority.

Finally, Manipulated Consensus exists in societies in which emergent consensus can theoretically occur, but general agreement then depends on who controls the means of power or persuasion.

Given that there are various types of consensus and different definitions of what consensus is, in this research consensus will refer to a generally agreed upon level of agreement by the group. That some members of the group may need to make compromises in order to arrive at that level of agreement is viewed as part of the consensus building process. In other words, this investigative study on consensus examines a type of *emergent consensus* as described by Bazak and Saaty (1993).

4.3.2. Group Decision Support and Consensus

The important role that groups play increasingly in organizations was discussed in Chapter Three. The economic successes of Japanese firms had an effect of inducing western organizations to replace their authoritarian management structures with the consensus seeking management structures that are common in Japan (Ouchi and Price, 1983). Total Quality Management (TQM) is one such example that gained popularity in the west, employing quality circles or teams charged with both the initiation and implementation of quality improvement (e.g. see Deming, 1986). Ouchi and Price (1983) examine Japanese decision making practices that are ‘polarity-averse’. They describe how information is assembled from as many as 60 to 80 stakeholders who are directly involved in making the decision. A process of decision structuring is re-iterated until true consensus is reached.

Making a decision in this way takes a very long time; however once the decision is made, everyone affected by it is likely to support it (Coman, 1996). How often in western societies does one hear “that is such a good idea, they just don’t know what is good for them.” The advent of Group Support Systems “facilitating solutions of unstructured problems by a set of decision makers working together as a group” (Huber, 1988) brought new promise to the ability to effectively enhance consensus. Polarity is described as an eminent metric of the

decision process (Coman, 1996:247). In their paper, DeSanctis and Gallupe (1987) identify communication and consensus as a capability and feature of a Level 2 GDSS. Collaborative technologies offer other features such as anonymous communication and voting, real time feedback and group memory (discussed in Chapter Three) which facilitate more sophisticated decision models, processes and structures that can serve to enhance the building of consensus (Sambamurthy and Scott-Poole, 1992).

Why do organizations and groups insist on consensus for some decision contexts? It has been frequently suggested that consensus in decision making is important because of the belief that groups interacting together can synergise to produce more and better quality solutions (Saaty, 1994; Coman, 1996). The basic notion underlying consensus is, human wisdom is worthy of aggregation in making a decision (Basak and Saaty, 1993). As illustrated with creativity and idea generation, and the greater productivity and effectiveness of group interaction *versus* individual contribution, it is argued that consensus decision making is associated with the effectiveness of (or lack thereof) group processes. For Basak and Saaty (1993), “the aggregation of the preference rankings of individuals into a consistent group ranking is the most important problem” in group decision making. In other words the derivation or measurement of the consensus vector or group preference mean vector is the most important consideration.

Groups are sometimes convened to make decisions that promote wider acceptance of and greater commitment to the results (Tan, et al., 1995). To meet this objective, groups often need to achieve an acceptable or predefined level of consensus. Further, “in many decision situations there is no objective measure of decision quality available. Rather the group must reconcile differences in opinion, personal preferences, or judgment and achieve consensus about a particular mode of action” (Watson et al. 1988: 463).

Face-to-face meetings can be very time-consuming even though this is one feature of organizational life that is used over and over again. This is an attestation of the critical role meetings play in communication (Anson, et al., 1995). With Group Decision Support Systems, face-to-face meetings have been made more effective. Past research has found, there are certain types of interventions in group processes that improve meetings by structuring the group interaction process. This intervention has been tested by way of both introducing GSS software tools and or human facilitation (Anson, et al., 1995). The results of such

interventions have varied across research, ranging from improved participation to reduced consensus (Benbasat and Lim, 1993).

However, consensus is not always the best way to obtain a group decision (Saaty, 1994). Disagreement within groups can be either an asset or liability (Maier, 1970). *Groupthink* for example is consensus, which is as a result of a strong desire to preserve harmony within the group environment or as a result of a strong manipulative group (Janis and Mann, 1979). In the study by Janis and Mann, evidence is given showing that cohesive groups sometimes reach decisions that are inferior to less cohesive groups.

Intuitively the proposition found in the study of Ouchi and Price (1983) is appealing. They suggest that good decision making is the product of a heterogeneous group that deliberates until disagreements have been resolved. High polarity at the beginning of the decision process and low polarity towards the conclusion of the decision process would be characteristic of the process. The reduction in polarity comes about through conflict moderation, so that a general decline in polarity over time would be indicative of a productive decision making process. On the other hand, processes that start at a low level of polarity (i.e. high consensus) could indicate an exceedingly homogenous group or the presence of manipulative individuals. Equally, decisions reached with a high level of polarity (low consensus) are likely to fail in the implementation phase as dissenting group members actively or passively sabotage the process. (Ouchi and Price, 1983; Coman, 1996).

In reality groups are sometimes convened for the purposes of making decisions that require wider stakeholder consultation. In South Africa, from a public and business point of view especially, consultation of stakeholders or lack thereof is often reflected in the reception or rejection of the end product. In situations like these, particularly ones that are characterized by high levels of polarity in the initial stages of the decision process, consensus building and achievement by the group, and by extension consensus facilitation are issues that warrant some attention. Group Decision Support Systems offer ways that bolster consensus. More specifically, most GSS offer mechanisms to address *evaluation apprehension* or the pressure to conform through anonymity. A decision arrived at through domination by a minority, or as a consequence of pressure to conform is unlikely to be accepted and committed to in the implementation phases of the process (Tan et al. 1995). The perceived quality of a decision reached with consensus is higher than that which is not.

The act of voting is often used to determine or arrive at group consensus, although voting itself is not consensus. The point at which a voted solution becomes a consensual solution is something that the group must define upfront, before the decision process begins. “Current voting mechanisms operationalise polarity aversion in the group through preferred majority requirements in the group (as applied in many important decisions) or through full consensus (as applied by juries)” (Coman, 1996:247). However, with the kind of tasks that groups tackle, it is difficult to know when a high quality outcome has been reached through the defined consensus (Hart, 1985). Many voting models incorporate the intensity of the individual positions into a weighting mechanism, for example the Analytic Hierarchy Process. A major body of research employs Bayesian probabilities as measures of correctness (Ahituv and Ronen, 1988; Hanson, 1998). The study of the value of an additional information source is characteristic of Bayesian decision making. Each information source is described by the probability that its forecast is correct. All sources are then aggregated under the assumption that they are independent of each other (Ahituv and Ronen, 1988). In practice and in realistic situations it would be impossible to assess the probability that a group member’s position is correct, or that every two group members are independent of each other (Coman, 1996).

4.3.3. Some Group Support Frameworks for Calculating and Measuring Consensus

Several frameworks have been investigated in pursuit of estimating or measuring group consensus. These are required in view of the following conclusion:

“The present approach of using the technology to mechanize group processes such as voting, Delphi and the Nominal Group Technique is crude and rudimentary at best. We anticipate that new ways of gaining group interaction and group consensus will develop that take advantage of the capabilities offered by GDSS” (Gray and Nunamaker, 1989:283).

Very little research has been undertaken that explores the process of consensus building (Bryson, 1996). In the next section, the specific features of the AHP that can be used in estimating and measuring group consensus will be discussed. In addition two models, namely Coman’s (1996) Intensity-Polarity-Voting-Model (IPVM) model and the framework by Ngwenyama et al. (1996) on consensus relevant information will be examined. The latter will be examined in more detail for the reason that more research has been done and written on it.

In Chapter Five this framework will form the basis, together with the Analytic Hierarchy Process, for the practical investigation of supporting consensus building and measurement.

4.3.4. Consensus Priority Weights within the AHP

When several people are involved, working closely together, they usually justify their judgments in a reasoned debate (Saaty, 1991). Often consensus may not be reached and one must synthesize the judgments (Saaty, 1991). When all the voters in the group are of equal importance, the Analytic Hierarchy Process can use the deterministic approach wherein the individual judgment matrices are synthesized using the geometric mean of the entries. In this case the geometric mean is the “proper way to synthesize group judgments given by the voters as reciprocal matrices” (Aczel and Saaty 1983). Alternatively, if the participants are believed to have unequal importance, then a weighted, synthesizing method would be appropriate (Saaty, 1991, 1992; Hamalainen et al., 1992). In either case, the eigenvalue method is used to find consensus priority weights of the alternatives in a specific level of the hierarchy. These priority weights are then aggregated for an overall judgment.

Basak and Saaty (1993) discuss consensus within the context of the AHP and its implementation. They also propose two different approaches, the deterministic and stochastic or statistical methods of consensus with respect to the preference rankings of individuals in applying group decision making. One method is applicable to small groups and the other to opinions at large where one cannot deal with the people on an individual basis. Basak and Saaty (1993) consider the case of deriving the consensus vector for both ‘face-to-face’ and geographically distributed groups. In the case where the group is small with individuals interacting ‘face-to-face,’ thus influencing each other, Basak and Saaty (1993) propose that the deterministic approach is appropriate. Here the judgments are synthesized by using the geometric mean. In the case where the group is large and geographically scattered, they point out that the inconsistency between the individuals providing judgments is far more important than the inconsistency of a single one of them. Therefore, there is a need for a statistical procedure to deal with the variation among several people to surface a single ranking for the weights of the alternatives.

4.3.4.1. Coman's Intensity-Polarity-Voting-Model (IPVM) for Estimating and Measuring Consensus

Conventional measures of consensus have traditionally excluded both the amount of dispersion surrounding an issue and the intensities associated with it (Bryson, 1996; Ngwenyama et al., 1996; Coman, 1996). In his model Coman (1996) seeks to provide a measure of intensity that is simple and inexpensive to use. A member's intensity is defined as a function of both competence and power in a group. In fact, the model is restricted to issues of competence. It assumes that problems are a function of knowledge and expertise.

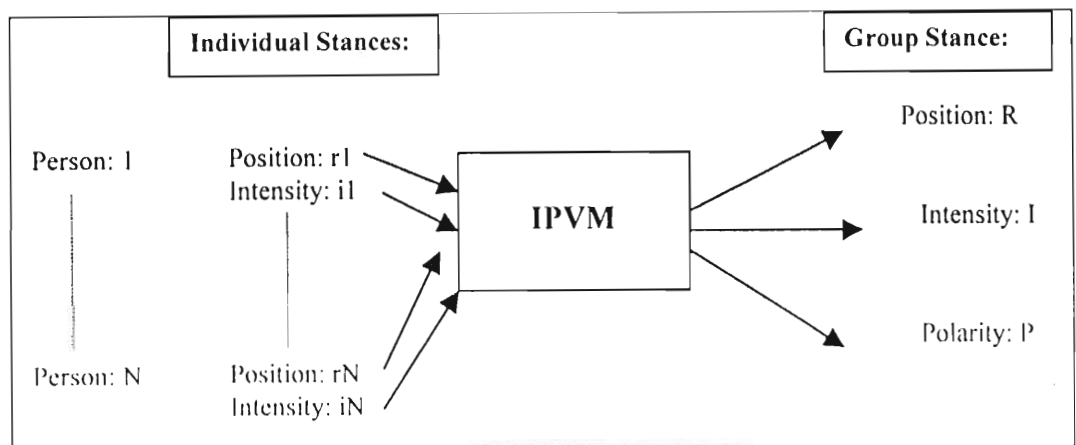


Figure 4.1: Intensity-Polarity-Voting Model (IPVM) individual input and group output. (Adapted from Coman, 1996:249)

Most decision making models assume that preferences are given and prescribe how to use them when dealing with a set of alternatives (Coman, 1996). In this model the intensity measure enables group members to position themselves anywhere between the two extremes of 'vote' or 'abstain'. The polarity measurement allows a conflict-averse group to position itself anywhere on the continuum between a simple majority and full consensus (Coman, 1996).

Coman's model, the IPVM addresses all stages of decision making in Simon's (1960) model: Intelligence, Design (using an MCDM framework), Choice and Implementation. However in this study it is of interest in as far as it provides decision makers with a set of variables that describe the group's stance over an issue at any given moment in time. That is, it can be used to facilitate the process of consensus building.

The IPVM deals with the aggregation of individual stances into a group stance. Two metrics that define the **individual stance** are described:

1. *Position* – which indicates what the individual thinks on the issue and
2. *Intensity* – which is an indicator of the weight associated with that individual's position in the group context.

Members can vary in stance for various reasons, for example due to differences in competence, power or commitment (Coman, 1996) or vested interest in the specific issue under discussion. Individual stance is calculated through representation on a three dimensional cube, with alternatives on the X-axis, attributes on the Y-axis and group members on the Z-axis. Each cell on the XY-plane represents the rating of one alternative with respect to a specific attribute, and the number of XY-planes equal the number of group members and each XY-plane contains the total set of positions expressed by a specific member. Each YZ-plane represents all the data relevant to a single alternative (the rating of that alternative, over all attributes by all group members).

If there are N-members discussing A-alternatives broken into M-attributes, then there are $N \times A \times M$ cells in the cube.

A similar cube is used to depict intensity, (intensity, attribute, alternative) where intensity is given as function of the individual's expertise or experience, that is the individual's influence on the decision outcome.

The function of the model is to aggregate the individual stances into group stances and to aggregate attribute data in alternative data. (See *Figure 4.1 – above*)

Individual stances are concluded on to a two-dimensional space, where a member's position on a specific issue is presented on the Y-axis, while the intensity is presented on the X-axis (Figure 4.2 below).

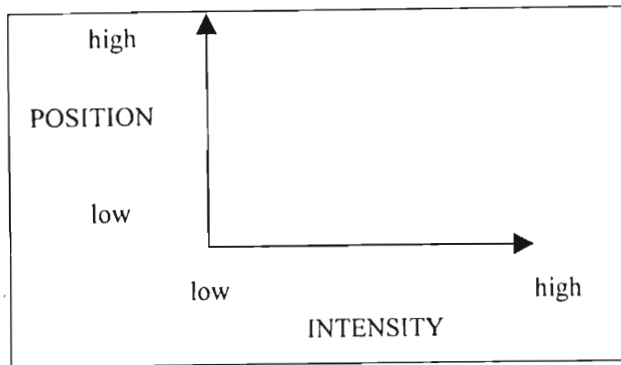


Figure 4.2 Individual stance: position and intensity space (adapted from Coman, 1996:250)

Three metrics are used to define the group stance:

- (1) *position* – what the group thinks on that issue,
- (2) *intensity* – how firm the group is on that issue and
- (3) *polarity* – the conflict or controversy associated with that issue.

The description of the group's stance is richer, according to Coman, because the group is the source of controversy. The question of interest is how can the group stance be synthesized? He argues that "this resembles the question of where the centre of gravity for a group of objects can be found"(Coman, 1998:250). Each object has a distinct position, and an intensity; in addition for every attribute, each member carries a different weight as a result of their competence.

Coman computes the group's position as the 'centre of gravity'. For example, on attribute j the group position would be described by a $1 \times M$ matrix vector generated from the j group positions- individual intensities for that attribute. Group intensity for the attribute, j is defined as the sum of the individual intensities. Group polarity on the other hand, is similar to the conventional disensus measure of the proportional head count or the ratio of opponents to proponents. When there is full consensus, polarity equals zero. The amount of disensus is a function of dispersion and intensity (Coman, 1998). This makes intuitive sense, the more apart group members are on an issue, the higher the disensus and the stronger they hold on differing positions, the higher the disensus. With this in mind one would expect that for groups with a vested interest in the outcome and therefore a higher intensity will exhibit more disensus, while those who are indifferent to the outcome would exhibit lower levels of conflict.

Coman uses the physics analogy of the second moment around the centre-of-gravity to compute polarity. The second moment around the centre-of-gravity is defined as the sum over all elements of the product, of the squared distance between the element and the object's centre-of-gravity times the elements mass. By analogy, member q 's contribution to the polarity surrounding issue j (denoted as p_{qj}), is a function of the member's distance from the group's position and of the intensity with which the member holds to that position (Coman, 1996).

The polarity contributed by a member to a given attribute is defined as

$$P_{qj} = i_{qj} \times (r_{qj} - R_j)^2 \quad (1)$$

where i_{qj} is the intensity of member q with respect to issue j and

r_{qj} is the position or rating of member q with respect to issue j

Group polarity is then defined as the sum over all N members of the contribution to polarity

$$\sum_{q=1}^N P_{qj} = \sum_{q=1}^N i_{qj} \times (r_{qj} - R_j)^2 \quad (2)$$

where N is the number of members

Polarity can also be totalled for a given member thus providing that member's total contribution to controversy.

The model generates measures of polarity among pairs of members of the group. This information can be used for example to exclude pairs of members that historically have been systematically adversary or those that are redundant i.e. whose polarity is low, when task-groups are formed. Coman proposes his model as a support tool for analysis and feedback on group states throughout the decision making life cycle (Coman, 1996). This model is also based on dyadic discourse, which is explained further in the next section.

4.3.4.2. Measuring Consensus using the Analytic Hierarchy Process and a framework for consensus relevant information

Ngwenyama et al (1996) and Bryson (1996) propose a method that is conceptually similar to Coman's (1996) in as far as the measuring of consensus information is concerned. Ngwenyama et al. (1996) quite aptly describe theirs as consensus relevant information. It is this framework, articulated by Ngwenyama, et al. (1996); Bryson (1996); Bryson (1996a), Bryson et al. (1994) and Bryson (1997), that is investigated with reference to its practical usability in this research. Firstly, the framework and its mathematical foundations are described in this section. In the next chapter the framework is applied to a real life group decision making environment in a field investigation.

With Group Support Systems the rating and ranking features are well supported by existing software, arguably because preference tasks occur frequently in organizations (Bryson, 1997). However, Bryson argues that this area of research has not received the attention it deserves in that ratings in group decision making contexts require techniques for synthesizing individual scores into group judgments. Yet the application of these techniques is only meaningful where there is a relatively high level of consensus that is obtained through human interaction and there is the need for techniques to assess the level of the group consensus, and for building consensus (Bryson, 1997).

The framework is motivated by the need to possess the capacity to identify avenues of consensus building and to explore these opportunities constructively in order to improve the productivity of the group and the outcomes of the meeting. The question is: how is this done? For real life groups where decision consensus is an issue, normally some protocol already exists in terms of what constitutes consensus. For example American juries must reach a unanimous verdict, while in most western democracies a two-thirds majority is considered group consensus. Therefore in using the framework defined by Ngwenyama et al (1996) and Bryson (1996, 1997) the starting point is for the facilitator to establish what the desired level of consensus is, within the group. That is, what is the stopping rule? At what stage could one say that a sufficient level of consensus has been reached? In the investigative study of this research the stopping rule was established as a two-thirds majority.

The second thing with respect to the framework that needs to be established is defining what the authors call the threshold values of agreement and disagreement. These values will be

used to evaluate the level of agreement or disagreement between pairs of decision makers or between any decision maker and the group as a whole, through its group preference mean. The meaning of these threshold values becomes clearer in context with a similarity function defined later in this section. Strong agreement is set to (α) and strong disagreement is set to (β) .

The framework relies on the generation of individual preference vectors derived from pairwise comparisons and the calculation of the group preference mean vector through the geometric mean. For example, where t is each individual decision maker with T being the index set of the group of decision makers, i.e. $(t \in T)$ and M is defined as the total number of decision makers. For example, $M = 8$ in this study's investigation.

To define the individual preference vector from the pairwise comparison information entered by each individual on all the problem criteria and sub-criteria. The matrix:

$$A^t = \{a_{ij}^t\} \quad (3)$$

is first formed (as already seen in the discussion on the Analytic Hierarchy Process) and then the preference vector:

$$w^t = (w_{1}^t, \dots, w_{N}^t) \quad (4)$$

is calculated for each group member. This preference vector is essentially the priority for each (sub)criterion. Accordingly, w^t would be generated within a pre-defined level of consistency of usually less than 0.2.

Having defined the individual preference vector or sub-criteria priorities, the framework defines three indicators which are used to estimate group consensus (Bryson : 1996, Ngwenyama et al. :1996, Bryson : 1997). These are:

- a) The Group Strong Agreement Quotient, GSAQ
- b) The Group Strong Disagreement Quotient, GSDQ and
- c) The Group Strong Disagreement Indicator, GSDI.

The GSAQ and the GSDQ identify the *percentage of pairs of group members* who have a reasonably strong level of agreement or disagreement respectively, whereas, the GSDI value estimates the *breadth or dispersion* of opinions within the group. The GSDI shows the worst disagreement between a pair of individual group members.

The use of these group indicators however requires the definition of what the authors call a Similarity Function,

$$S(w^t, w^r), \quad (5)$$

where t and r are a pair of the individual group members.

The Similarity Function allows for the comparison of the level of agreement between any pair of preference vectors. It also allows one to answer the question: when are two members said to be in strong agreement or strong disagreement. That is, the definition of interpretable threshold values for strong agreement (α) and strong disagreement (β) can be defined, so that two individual group members can be said to have strong agreement if their Similarity Function,

$$S(w^t, w^r) \geq \alpha \quad (6)$$

In other words if the similarity function is greater than some pre-defined level α , then the interpretation is that, strong agreement exists between members t and r . On the other hand, where the similarity function is less than some pre-defined level β then the interpretation is that strong disagreement exists between members t and r .

$$S(w^t, w^r) \leq \beta \quad (7)$$

This is different to inquiring about the level of consensus existing within the group. This merely sets the scene for defining and subsequently identifying pairs of members who show pre-defined levels of agreement (or disagreement) that can be used in the process to build further agreement. In the case of strong disagreement it allows for the identification of those members who may serve as obstacles to reaching consensus. In the latter case, for example,

the facilitator could identify members who consistently show high levels of disagreement with each other and be able to recommend that during task group formation these members be substituted, as in Coman’s model.

Finally, the similarity function needs to be calculated and this is done as follows:

$$S(w^l, w^r) = 1 - \sin(w^l, w^r) \tag{8}$$

where the sine is used a preferred method of estimating the similarity of the pair of vectors w^l and w^r . It takes on values between [0,1]. It is also independent of the magnitudes of the vectors (Bryson, 1996). Various measures have been proposed for estimating the similarity of a pair of vectors, these include the Euclidean distance, L-1 norm distance, the cosine and sine of the angle between the vectors (Bryson, 1996). He adds that “none of these measures, however, offer obvious choices for α and β , and at this point, it is not clear if any of the measures is better than the rest”. Accordingly, Bryson (1996) and Ngwenyama et al. (1996) give no indication which suggests what the optimal value for α and β should be. They only state that reasonable values of α and β should be set.

For any given similarity measure $S(w^l, w^{GM})$ the Group Strong Agreement Quotient (GSAQ) is defined as follows:

$$GSAQ_{\alpha} = \sum_{(t \in T)} \Gamma(t, GM) / M \tag{9}$$

where

$$\Gamma(t, GM) = 1 \quad \text{if} \quad S(w^l, w^{GM}) \geq \alpha$$

$$\Gamma(t, GM) = 0 \quad \text{if} \quad S(w^l, w^{GM}) < \alpha$$

and w^{GM} is the current group preference mean vector. The group preference mean vector is derived from the geometric mean of the individual preference vectors. In other words if an individual’s preference vector, w^l when compared to w^{GM} is greater than the pre-defined level of strong agreement then $\Gamma(t, GM) = 1$, otherwise $\Gamma(t, GM) = 0$.

Similarly, for practical purposes one can also calculate the Group Strong Disagreement Quotient as follows:

$$\text{GSDQ}_\beta = \sum_{(t \in T)} \Phi(t, \text{GM})/M \quad (10)$$

where

$$\Phi(t, \text{GM}) = 1 \quad \text{if} \quad s(w^t, w^{\text{GM}}) \leq \beta$$

$$\Phi(t, \text{GM}) = 0 \quad \text{if} \quad s(w^t, w^{\text{GM}}) > \beta$$

The rationale behind these variables is that consensus only exists if at least a specified proportion of the individual members of the group have strong agreement with the group mean preference vector, w^{GM} , and no more than a specified proportion of the group members have strong disagreement with the w^{GM} (Bryson, 1996, 1997). However, it is obvious that the GSDQ is an alternative measure to the GSAQ.

Finally, the measurement of the dispersion of opinion within the group on an issue, the Group Strong Disagreement Indicator (GSDI) is defined as follows:

$$\text{GSDI}_\beta = \min\{s(w^t, w^r) - \beta, \text{ over all } (t, r)\} \quad (11)$$

These Group indicators are useful in as far as they can be used for the purposes of estimating the existing level of group consensus. There are additional indicators that serve to identify individual group members who have the highest capacity to serve as consensus builders. In that for instance some members may form sub-groups of agreement among themselves. For such individuals the framework proposes individual consensus indicators.

These are, namely:

- a) The ISAQ, Individual Strong Agreement Quotient.
- b) The ISDQ, Individual Strong Disagreement Quotient.
- c) The ISDI, Individual Strong Agreement Indicator.

These are defined similarly to the group consensus indicators.

where

$$\text{ISAQ}_\alpha^t = \sum_{(r \in T)} \Gamma(t, r)/M$$

$$\text{ISDQ}_\beta^t = \sum_{(r \in T)} \Phi(t, r)/M$$

$$\text{ISDI}_{\beta}^t = \min\{S(w^t, w^r) - \beta, \text{ over all } (r \neq t)\}$$

$$\Phi(t, r) = 1 \quad \text{if} \quad s(w^t, w^r) \leq \beta$$

$$\Phi(t, r) = 0 \quad \text{if} \quad s(w^t, w^r) > \beta$$

The similarity function upon which they are based is of the form $S(w^t, w^r)$ where t and r represent a pair of individual group members. The objective is to identify any existing subset of members whose current position makes them likely agents of consensus building. There are questions that one may ask in order to establish this (Bryson, 1997; Bryson, 1996) For example,

1. Is there a member who shares strong agreement with an overwhelming majority?
2. Is there a subset of the objects such that if this subset were removed the agreement quotient between a given pair of individual group members would be increased and therefore the group's consensus index would be increased? (Bryson, 1996)

To achieve the identification of such individuals and objects, Bryson suggests that there is a specific type of individual that should be of interest:

- Those individuals whose preference vector w^t , is in strong agreement with w^{GM} AND whose ISDQ_{β}^t value is less than the disagreement threshold. Thus, of interest is the pair: $[S(w^t, w^{GM}), \text{ISDQ}_{\beta}^t]$. These individuals are to be encouraged to express and promote the *compromise* group mean position.

This concludes the definition of the framework as defined by Ngwenyama et al (1996), Bryson (1996), Bryson (1997) and Bryson et al. (1994). In the section on the conduct of the field study, this framework is used to facilitate and build consensus.

4.3.5. On Problem Structuring and Facilitation of the Group Process

A facilitator is someone from outside the group who has skills in assisting the group interaction “while remaining neutral as to the content of the discussions” (Anson et al., 1995).

The facilitator role dimensions identified by Clawson et al (1993) are observed when conducting the field study and the investigation follows a facilitation framework, which consists of the following three phases.

1. Process Planning and Design

This phase of getting together with the group leader(s) and others to design group process:

- ◇ Defining process ground rules and participator roles.
- ◇ Problem formulation and identification of desired outcomes
- ◇ Developing and agenda.

2. Preparation and Setup.

- ◇ Selection of appropriate technology, and preparation for group process by facilitator.

3. Process Management.

- ◇ Managing group process and promoting effective task behaviour.

No attempt in this section is made to define in detail the procedure followed for this would amount to a repetition of the investigation procedures.

There are several difficulties with field investigations. One being, for instance, if one wanted to test for propositions expounded by Adaptive Structuration Theories (AST), it would not be feasible to do so. According to AST, over and beyond the role of exchanging information, group interaction is also a means to appropriate technology-based and non-technology-based structures to guide further group interaction (Poole and DeSanctis, 1989).

Structures are formal and informal procedures, techniques, skills, rules, and technologies that organize direct group behaviour processes. “Appropriation is the fashion in which the group uses, adapts, and reproduces a structure.” (Poole and DeSanctis, 1989)

This theory presupposes that groups that are supported be it through facilitation or GSS software or both would derive certain benefits of appropriation that an unsupported group would not derive. This issue is easy to prove within controlled experimental environments. The experiments could be repeated, varying only certain test variables. In this investigation

this is not possible because real life stakeholders have no vested interest in repeating the study. The extent of appropriation can only be speculated. The probability of finding real life actors with exactly the same problem in the same vicinity at nearly the same time is very low, so that direct comparative studies cannot be performed. Only similar future research elsewhere can form a basis for comparison.

There is ample evidence suggesting that each type of intervention i.e. facilitation and GSS can improve meeting productivity (Nunamaker, 1999). However prior research is incomplete in certain critical areas. Firstly, both have not been evaluated side by side under the same conditions i.e. where GSS and human facilitation have been put side by side and evaluated. Secondly, numerous GSS researchers (Vogel et al., 1987; Kraemer and King, 1988) have stressed the importance of including facilitation in GSS settings, as is the practice in real applications (McGoff and Ambrose, 1991) However, there has been little empirical assessment of their combined effectiveness (Nunamaker, 1999).

Another problem in research is how facilitation is applied. Most GSS and group dynamics experimental studies examine how a given procedural structure e.g. the nominal group technique or a specific GSS tool or tool set, is used. The facilitator or experimenter follows a pre-written “script” of what to say and how to act when applying the treatment structure. This scripted or fixed approach enhances internal validity by controlling the facilitator as a source of confounding variance. However the fixed approach sacrifices external validity regarding facilitation in real settings. Normally facilitators act with flexibility to help the group select and adapt procedural structures to meet their specific needs. Hirokawa and Gouran (1989) argue that a scripted approach is inappropriate for studying process interventions, given the fluidity and unpredictability of typical group interaction.

4.3.6. On the Challenges facing the investigation of field studies and Participant- Observation Type Studies

The participant-observation method described by Yin (1984) and employed in the field study of this research is used in cultural and sub-cultural groups. It creates the following opportunities –

- ability of an investigator to gain access to events or groups that are otherwise inaccessible to scientific investigation. For some things there may be no other way of collecting data
- ability to perceive from the viewpoint of someone inside the case than outside of it. This is valuable to the 'accurate' portrayal of the case.
- Investigator's ability to manipulate events or situations.

On the other hand, it creates the following problems –

- Potential biases are likely to be generated – the investigator has less ability to work as an external observer and may at times have to assume positions or advocacy that is contrary to the interests of good scientific practice
- The investigator is likely to follow a common phenomenon of becoming a supporter of the group being studied if such support did not already exist
- This role may require too much attention relative to the observer role and therefore allow little time to take notes and to raise questions about the events and the different perspectives (Yin, 1984)

4.4. Conclusion

This chapter has explored the detailed foundations for both divergent i.e. idea generation and convergent i.e. consensus building activities within the group decision making process. Chapter Five will use these in experimental and field conditions aiming to provide evidence for the practical validation of the theories discussed in this chapter.

CHAPTER 5. DEFINITION, DESIGN AND FORMULATION OF EXPERIMENTS

In this chapter the definition, design and formulation of the electronic brainstorming and consensus building experiments are explored in detail. These are based on the theoretical foundations and the scope of this research addressed in the previous chapter. Two tasks are performed. The first task is an experiment on the effect of task structuring in idea generation and the second is a field-study of consensus building in a multi-criteria GSS.

5.1. Task One: The Idea Generation-Electronic Brainstorming Laboratory Experiment

This part of the research partially replicates the work done by Dennis et al. (1996) and Dennis et al. (1999) on task and time structuring in an electronic brainstorming environment. An information systems analysis and design problem was selected and presented to *two* homogenous groups of post-graduate information systems students for brainstorming, using Team Expert Choice, a multi-criteria group support environment.

5.1.1. The Design of the Experiment

The first treatment group was presented the problem as a single, all-encompassing problem. The second treatment group was given the same problem in two distinct categories. In addition, the second group was given fixed and shorter time slots to solve each category of the problem. It was hypothesized that the second group would produce a larger quantity and a better quality of ideas measured using three separate measures. The latter group was expected to be able to focus more definitively on the problem at hand and to perceive the time constraints inducing its members to work more efficiently.

5.1.2. Hypothesis Formulation

There are three factors that affect interacting brainstorming groups: *cognitive factors*, *social factors* and *time effects*. The theoretical research about the three factors suggest that presenting a group with a single intact problem should produce fewer ideas than presenting a group with a series of questions, with each question focusing on one sub-category of the total problem (Dennis et al., 1996; Dennis et al., 1998). In the first instance, *cognitive factors* are believed to encourage individuals to focus only on a few sub-categories of the problem, thereby overlooking other factors. Secondly, *social factors* within the group are believed to encourage group members to work on the same area of the problem rather than exploring the problem from multiple angles all at the same time. The effects of time structuring are not tested in this research. The idea behind time structuring is, when presented with a series of shorter time intervals as opposed to one single large time interval individuals may perceive the time constraints. The perception of time constraints may cause the group to work faster. However, neither Dennis et al (1996) nor Dennis et al (1999) confirm time effects. Testing for time effects was considered beyond the scope of this research largely because of the inherent complexity of testing for time effects as distinct from task structuring effects. This requires the performance of many iterations which is beyond the scope of this thesis. The exclusion of testing for time effects is also justified by the fact that Dennis et al. (1999) conclude that the contribution to performance lies in task structure and not time structure. “Merely separating the ideas into the topic pools is sufficient to induce participants to allocate their effort more evenly; placing additional time restrictions does not improve performance” Dennis et al (1998:6).

Finally, it is postulated that the decomposed task formulation should also result in a higher quality of ideas. Previous research has consistently found the number of ideas as a reliable predictor of the overall quality of ideas (Nunamaker et al., 1999).

Stated formally, it is hypothesized that:

Hypothesis 1: *The decomposed task formulation will stimulate groups to produce more unique ideas than the intact task formulation.*

Hypothesis 2: *The decomposed task formulation will stimulate groups to produce ideas of higher quality than the intact task formulation.*

5.1.3. Subjects: Profile

The subjects were from the Computer Science and Information Systems Honours class at the University of Natal Pietermaritzburg. Their participation in the experiments formed a part of the requirements of the Decision Support Systems course module. The group was familiar with Systems Analysis and Design issues and methodologies, to the level taught during the undergraduate years and their current year of study. Nonetheless, in order to simplify the requirements of the task for its intended audience, the task-handout given in Appendix A contained leading information on the structure of the business environment, thus requiring no remembered knowledge from the participants (Haines and Amabile, 1988). Finally, all participants were familiar with the Team Expert Choice environment, having used it for problem structuring purposes in the same course.

5.1.4. The Group

The flexibility offered by Team Expert Choice allowed for an optimised configuration of the process. A combination of levels of interaction was practiced consistently throughout the experiment. During the first half of each session the groups electronically operated like nominal groups, where no verbal communication was allowed. In the second half of each session, they operated as fully interacting groups allowing for both electronic and verbal interaction. The latter was however not mandatory. This condition was applied consistently to both treatment groups. This is important to the objectives of this research in supporting the move away from comparing nominal groups to interacting groups. The results of such previous comparisons have been consistently reported, as discussed in chapter three.

The group was divided into two sub-groups of six members each. The division was random; it was based on the availability of the participants at the designated times. Dennis et al (1996) use group sizes of eight and nine members, and most small group research in GSS has experimented

with group sizes of between four and nine. For this reason, the group size in this study was considered comparable to the study of Dennis et al. (1996) and similar research.

It can be argued that the groups thus formed are biased as they are drawn from a small section of the student population, studying towards an Honour's degree in Information Systems or Computer Science. Achieving representativity of the group is not an easy task, given the time constraints of this research, and the South African context, as the University of Natal is one of two institutions that possess a GDSS of this nature. The goals here are to partially emulate the experimental work on GDSS carried out by others and compare the outcomes for the purposes of finding possible common features.

In addition, there are some likely nuisance variables in the sense that the groups were not identically paired for gender or previous educational background in the streams of Computer Science or Business Information Systems. However, the given task was so constructed that the participants only required knowledge of systems design and analysis and decision support system. Both modules are studied equivalently in both streams. Secondly, research into computer science education in South Africa shows that at undergraduate and Honours levels, the pass rates for men and women are similar (Sanders, 1992). Age was not an issue with this group as the participants were of the same age group, without any prior work experience.

Lastly, because the sizes of the two groups are small, one needs to use small sample tests based on the *t*-distribution.

5.1.5. The Role of the Facilitator

The author acted as facilitator in both sessions. The facilitator's role was limited to explaining the task, re-explaining the objective of the sessions, explaining the principles of brainstorming and how the Team EC brainstorming environment works. She was responsible for administering the process in terms of time keeping and ensuring the participants moved onto the next phase when required to do so. The facilitator was not to arbitrate on idea disagreements between group members. She merely observed the process and arbitrated on procedural issues. The facilitator was also required to explain the questionnaire.

5.1.6. A Description of the Technology

The experiment was run within a client-server environment running the following operating systems: Windows NT on the server side and Windows 95 as the client using Team Expert Choice software. The problem structure was set-up prior to the actual sessions. On arrival into the GSS room participants were required to merely log onto the Team EC brainstorming module and the login process called the brainstorming task onto the first screen.

The hardware environment was as follows: each group member was assigned an individual Desktop PC, connected to the Local Area Network (LAN). The facilitator used a separate PC to administer and manage the group process. A group screen was not physically necessary and therefore was not used. The software manages and delivers a “group view” to each PC when required.

The Team (EC)’s Electronic Brainstorming Module presents the user with the brainstorming question centred horizontally and vertically across the screen with a bright, colourful desktop background when using the Single Question Mode. Alternatively, all items are listed on the same scrollable screen.

Team EC fully supports *anonymity*, and the parallel entry of ideas by participants. Subjects were explicitly made aware of these features. However, subjects also understood that the software had the ability to privately attribute ideas. This was necessary for the analysis of the equality of participation, for example.

Team EC also supports the generation of ideas by category. This feature was used with relative ease for the decomposed task, whereby merely switching category for the task, subjects could enter their ideas related to the next sub-category and these would be logged separately.

5.1.7. The Task.

The experimental task was extracted from a Systems Analysis and Design text case study (O'Brien, 1992). With respect to the design of creativity experimentation tasks, Haines and Amabile (1988) suggest, that to decrease the potential for response bias, tasks requiring no specific knowledge or training should be used, ones where common knowledge would suffice for solution formation. Given the subject's knowledge of systems analysis and design issues no additional training of the participants would be required.

The subjects were asked to design a system that would support the business imperatives facing a virtual company, Fields Cookies. Fields Cookies is described as a medium sized chain of biscuit stores, which employs managers whose commitment levels are high on customer service issues and necessarily low on business, financial and administration issues. They therefore require compliance measures to support the financial and administrative aspects. The system analysis and design imperative is to optimise the balance between the compliance-commitment dichotomy of its store managers abilities given specified objectives and constraints. More details can be found in the experimental Task Handout in Appendix A.

In this experiment, the first treatment group was presented with a single, intact problem. The subjects were required to consider the facts about the business and identify the requisite support features of system. The brainstorming task was deliberately set out so that the functional components of a business entity were outlined explicitly. This was anticipated to simplify the task for all subjects, see Appendix A.

The all-encompassing, intact question was phrased as follows:

*"What characteristics and components should the Fields Cookies business system have to support and enhance managers' **commitment** to customer service; plus support and enforce **compliance** to sound business practices in the administrative-financial aspects of running the business?"*

The intact question and the decomposed questions were designed to be consistent in terms of style and scope. So that the decomposition was constructed into two sub-categories, as shown hereunder:

- i. *"What characteristics and components should the Fields Cookies business system have to support and enhance managers' **commitment** to customer service?"*
- ii. *"What characteristics and components should the Fields Cookies business system have to support and enforce **compliance** to sound business practices in the administrative-financial aspects of running the business?"*

The task was explained to the groups before they were required to embark on solution generation.

5.1.8. Treatment

Both treatment groups were given fifteen introductory minutes to understand the task and to clarify any issues or questions with the facilitator regarding what the task entailed and what was expected of the group.

The first treatment group worked on the intact (single-question) problem and was given 40 minutes to generate idea solutions using Team Expert Choice. The forty-minute session was split into two sub-sessions. In the first 20 minutes, the members of group were instructed to anonymously enter their ideas into the system without any verbal communication and without posting their ideas to the central database representing group memory. During this period, verbal communication was limited to clarifying individuals' understanding of the task, where this was still required. At this initial stage, no single group member was aware of what the other group members' idea solutions were. All individual idea solutions were saved onto the individual client PC's.

Once the first 20 minutes had lapsed, group members were then requested to post their individual ideas to the central database to be immediately viewable by all. Members could then discuss the

contributions of other members and enter more ideas arising from the discussion and or the group database. At this stage, subjects post their entries immediately upon entering them. This part of the session also lasted 20 minutes.

The *second treatment group* worked on the decomposed (multiple-question) problem. This treatment group was given 20 minutes to fully explore each question. Each 20-minute session was divided into two sub-sessions of ten minutes each. The participants were instructed to silently brainstorm for the first 10 minutes of the session (on just the one question).

Similarly, once the first ten minutes had lapsed, members posted their ideas to the group database and the session was opened for participants to view or add to other group members' contributions on that single question. The interactive session lasted ten minutes for the sub-category question, making up the total required twenty minutes to tackle the first sub-category question. The second sub-category question was then introduced to the group and treated in exactly the same way as the first one. Note that while the group was brainstorming on the second sub-category, they were not allowed to nor could they revert to the first sub-category question.

5.1.9. Measures of Performance

Two dependent variables were observed in this experiment – the number of unique ideas and their quality. The first variable is self-explanatory while the second can be defined in terms of their relevance to problem facing Fields Cookies. A final transcript of the ideas generated from both treatment groups was collated and given to an expert judge¹, who was blind to the treatment of the groups. He had first eliminated all redundant ideas within each treatment group's solution-space. He also grouped the generated ideas by category i.e. commitment vs. compliance support. The following was used to identify the categories:

Category code		Task sub-category
2	=	Commitment Support
4	=	Compliance Support

¹ The expert judge was selected because he instructs the subjects the Systems Analysis and Design and DSS Courses

Finally, the judge was asked to apply the following measures of performance similar to (Dennis et al., 1996).

- ✓ The total number of unique ideas
- ✓ The total number of good ideas
- ✓ The total number of good ideas by category
- ✓ Total Quality.
- ✓ Mean Quality

□ For each unique idea generated, the following scale is applied to rate its quality.

Quality Rating:		Meaning
1	=	Very Poor
2	=	Poor
3	=	Average
4	=	Good
5	=	Very Good

□ For the second *dependent variable*, quality, three measures of quality were used:

- ✓ Total Quality, which according to Dennis et al (1996) has proven to be the most reliable measure across most studies. Total quality is the summation of all quality scores for each unique idea generated by a group. This measure rewards groups for all ideas generated including very poor ones.
- ✓ Mean Quality, which according to Dennis et al (1996) has been most unreliable across studies. This measures the average quality of ideas generated by a group. It is the total quality score divided by the number of ideas. This measurement is biased towards groups that generate high quality ideas and against groups that generate poor quality ideas. So for instance a group that generates one high quality idea (score = 5) would have a mean score of 5. Whereas a group that generated 3 high quality ideas (score = 5) and 3 neutral

ideas (score = 3) would have a mean score of 4, less than the group that generated just a single idea.

- ✓ The Number of Good Ideas, that is ideas scoring at three or above on the defined five point scale. This measure tries to strike a balance between the total quality and mean quality measures (Dennis et al., 1996). This measure rewards groups for all ideas generated, except those ideas that are poor or very poor. This measure had an intuitive or common sense appeal to this author.

Finally, a post-session questionnaire given in Appendix B was conducted to measure the participants' perception of the time-pressure with respect to the task and the available time. The questionnaire also assesses the subjects' perceptions of the effectiveness of the process and satisfaction with the process. In the second case no hypotheses are made with regard to these variables, for that is beyond the scope of this research. However, general reflections will be made partially guided by the future challenges of GSS research as discussed in chapters three and four. It is hoped that the recording of these variables may serve as a basis to ask more questions about this type of research. In addition, Dennis et al. (1996) measure member satisfaction and perceived effectiveness, and Dennis et al. (1999) also measure satisfaction in a post-session questionnaire without providing a detailed justification.

5.1.9.1. Post-Session Questionnaire Measures

In the post-session questionnaire outcome and process variables were measured.

- **The Effectiveness of the Process.** Two components, the quality of the session process and the quality of the outcome are measured. The quality of the process includes a measure of the *equality of participation* through log files, the questionnaire and facilitator observations. In addition *member satisfaction*, *production blocking*, *evaluation apprehension* and the *effects on individual cognition* are included in the questionnaire for the purposes of comparison of this study with the studies of Dennis et al (1996) and Dennis et al. (1999).

No differences are expected with respect to member satisfaction in the process, process effectiveness as reflected by equality of participation, production blocking, and evaluation apprehension. Both groups used equivalent features of Team EC; the GSS environment was equal in all but the presentation structure of the problem task. In addition, Dennis et al. (1996) do not report any differences in the post-session questionnaire measures (of effectiveness and satisfaction) for both experiments.

5.1.10. Analysis and Results of the Idea Generation Experiment

Upon analysis of the results by category it became apparent to the expert judge that some of the proposed ideas although not invalid to the solution did not apply strictly to the two pre-defined categories. There appeared to be a “both” category, whose application was holistic and system-wide. This did not strike as an aberration to the results. It has been suggested in the literature that one risk of structuring is that “the structure may not completely cover the problem space” (Dennis et al., 1999:6). In this research, the phrase “solution space” is preferred to “problem space”. The reason for this is while the scope of the problem was clearly delimited with relatively fixed constraints, the provision of a good creative solution, an “imaginatively gifted recombination of known elements into something new” is not limited (Hwang, 1998).

The experiment results are shown in Table 5.1 below.

Table 5.1 Results comparing actual results data from the two treatment groups

	Intact Task Treatment		Decomposed Task Treatment		Difference
	Number	%	Number	%	
Total Number of unique ideas	32		52		38.5%
Total Quality (index)	124		184		32.6%
Mean Quality	3.88		3.54		-9.6%
Number of good ideas	27	84.3	45	86.5	40.0%

Table 5.1 shows that the treatment group brainstorming on the decomposed task generated more unique ideas. This group generated 38.5% (i.e. 20/52) more unique ideas than the single-question treatment group. They also generated 40% (i.e. 18/45) more good ideas and 32.6% (i.e. 60/184)

more ideas of higher total quality than the single-question treatment group. These results compare favourably with the results of Dennis et al. (1996) and Dennis et al. (1999).

5.1.10.1. Effect on the Number of Unique Ideas Generated

Although, the multi-task group generated 38.5% more unique ideas than the single task-group, the question whether the results are due to the decomposition of the task or merely because of chance must be addressed. This is done by way of the t-test for two independent samples with equal variances (Pollard, 1977).

This test is robust for moderate departures from the assumption that the populations are normal. It is also robust for the moderate departures from the equality of variance assumption, when the sizes of the samples are equal (Pollard, 1977:160).

The assumption of equal variances needs a little discussion. In most applications, this assumption is satisfied (Alder and Roessler, 1977:178; Pollard, 1977). Thus, the assumption is not a severe restriction. However, when questioning the validity of the assumption that two given samples are drawn from two populations of identical variances or standard deviations, one can use a test for the homogeneity of two variables (Alder and Roessler, 1977:314; Pollard, 1977). (See Appendix C where it is shown that the differences in the variances of the two sets of data used for testing the Hypothesis below, are not significant)

Hypothesis 1: *The decomposed task formulation will stimulate groups to produce more unique ideas than the intact task formulation.*

By Let X denote the single-task treatment sample and Y the multiple-task treatment. The assumption for their respective populations are that X and Y are two normally and independently distributed populations having the means m_x and m_y respectively. The procedure for statistical verification of the hypothesis will be applied (Pollard, 1977:133-134). We inquire if the mean number of unique ideas in the multiple-question treatment (Y) is significantly higher than the mean from the single-question treatment (X). This corresponds to the alternative hypothesis, H_1 in the formulation below.

Thus, we define

$$H_0: m_x \geq m_y$$

$$H_1: m_x < m_y$$

(where m_x and m_y define the means of the X and Y data sets respectively –see Table 5.2)

The null hypothesis will be tested using the t-test for two independent samples. Since it is a test for inequality of the two means, the critical region is less than the lower 5 percent point of the t-distribution with (n_1+n_2-2) degrees of freedom (Pollard, 1997:160). It is extracted from the statistical Student’s table that for the t-distribution with the degrees of freedom equal to 10, the critical value of t at the 5% level of significance is equal to -1.812 (Pollard, 1997).

Table 5.2 Analysis of the test statistic on the number of unique ideas generated².

	Number of Unique Ideas					
	X	Y	X-X	(X-X) ²	Y-Y	(Y-Y) ²
Member 1	5	9	-0.333	0.111	0.333	0.1111
Member 2	7	7	1.667	2.778	-1.667	2.7778
Member 3	11	7	5.667	32.111	-1.667	2.7778
Member 4	3	7	-2.333	5.444	-1.667	2.7778
Member 5	2	13	-3.333	11.111	4.333	18.7778
Member 6	4	9	-1.333	1.778	0.333	0.1111
	10					
Group Total	32	52.00	0.000	53.333	0.000	27.333
Mean	5.333	8.667				
Standard deviatio	3.266	2.338				
Variance	10.667	5.467				
For t						
<i>Numerator</i>	-10.54093		-10.54093			
<i>Denominator</i>	0.44721	12.04990	5.38888			
t			-1.95605			
t-statistic			1.18120			

(For $v = 10$, $t_{0.05} = 1.812$ (Pollard, 1997:327) where the degrees of freedom $v = n_1+n_2-2$, n_1 and n_2 being the samples of the first and second group respectively).

The test statistic,
$$t = [(5.333-8.667)(10)^{1/2}] / [(1/10 + 1/10)^{1/2} (9*10.6667+9*5.4662)]^{1/2}$$

$$t = -1.95605$$

² Table 5.2 was generated using Microsoft Excel

Since, $t < t_{crit}$ it is significant (Pollard, 1977) and the null hypothesis is rejected. Therefore, we conclude that by breaking the task into subtasks (corresponding to data set Y), we can achieve a greater number of unique ideas on average, at the 5% level of significance. This leads to the conclusion that for the original hypothesis, *Hypothesis 1: The decomposed task formulation will stimulate groups to produce more unique ideas than the intact task formulation* is accepted at the 0.05 level of significance.

5.1.10.2. Effect on the Quality of Ideas

Hypothesis 2: The decomposed task formulation will stimulate groups to produce ideas of higher quality than the intact task formulation.

For the second dependent variable, quality, the following measures: total quality, mean quality and the number of good ideas are analysed. For all three measures, the null hypotheses are tested using the same statistical method as shown above. The detailed results showing the calculation are set out in Appendix C. Underneath follows a summary.

a) For the Mean Quality of Ideas (see Section 5.1.9)

The mean quality of ideas was found to be seemingly marginally higher for the single-question treatment group at [3.88 against 3.59] as shown in Table 5.1.

We defined as

$$H_0: u_x \geq u_y$$

$$H_1: u_x < u_y$$

(where u_x and u_y refer to the mean quality of data sets X and y respectively)

By analogy to the previous case, $t_{crit} = -1.812$. The critical region is the lower 5 percent region of the t_{10} -distribution: that is less than -1.812 . The test statistic was calculated as $t = 0.83005$. Since $0.83005 > -1.812$, we conclude that this value is not significant. Details of the calculation are shown in Appendix C.

Therefore, we accept the null hypothesis, H_0 , at the 5 percent level of significance. We can conclude that the mean quality of data set (X) is higher than that of data set (Y). Thus, by original hypothesis, decomposition did not result in a higher quality of ideas, as measured by the mean quality.

b) For Total Quality of Ideas (see Section 5.1.9)

We define the null hypothesis similarly

$$H_0: u_x \geq u_y$$

$$H_1: u_x < u_y$$

Again the critical value of the t-distribution is -1.1812 .

The test statistic was calculated as $t = -1.41229$, therefore it is not significant. Therefore we accept the null hypothesis, H_0 , and reject the alternative hypothesis H_1 at the 5 percent level of significance. It can therefore be concluded that the average quality of ideas for the multiple-question treatment [the (Y) data set] is not higher than that of the single-question treatment group [data set (X)]. This result is important because as mentioned earlier it is known as the most reliable measure of quality; it rewards both good and poor ideas (Dennis, et al., 1996).

c) For the Number of Good Ideas

Again, similarly a null hypothesis is defined as

$$H_0: u_x \geq u_y$$

$$H_1: u_x < u_y$$

Again, the critical value of the t-distribution for 10 degrees of freedom is -1.1812 . The test statistic was calculated as $t = -1.93167$, therefore it is significant. Hence, the null hypothesis, H_0 is rejected, and the alternative hypothesis H_1 accepted at the 5 percent level of significance. It can be concluded that using the number of good ideas as a measure, decomposition of the task produces more good ideas than the intact task treatment at the 5 percent level of significance.

For two of the three defined measures, the results lead to the conclusion that, the original hypothesis, **Hypothesis 2: *The decomposed task formulation will stimulate groups to produce ideas of higher quality than the intact task formulation*** cannot be accepted at the 0.05 level of significance. However, the number of good ideas increases with task decomposition, according to the above results. It can be noted that our results regarding Hypothesis 2 coincides with those of Dennis et al (1996) who found no differences in the mean quality in their experiments.

These results compare favourably to the work of Dennis et al. (1996) and Dennis et al. (1999), with their results possibly getting more smoothing by virtue of the large number of groups whose aggregated mean quality is reported. The interpretation of the mean quality score suggests that

the multiple-question treatment group “did not resort to poor ideas to any greater extent than the single-question group” (Dennis et al., 1996).

5.1.11. The Distribution of Ideas Across Sub-Categories

The task had two defined sub-categories to the solution space, *commitment* and *compliance*. In practice, a third sub-category emerged which addressed the problem more holistically, a *both* category. This phenomenon is mentioned in Dennis et al. (1996) and Dennis et al. (1999). In this section, the issue and results surrounding the *both* sub-category are explored in more detail.

Table 5.3: Analysis of the number of ideas generated by sub-category

	Intact Task Treatment		Decomposed Treatment		Difference
	Number	%	Number	%	
Total Number of Unique Ideas by sub-category:	32	100	52	100	35.8%
Commitment	2	6.3	8	15.4	75.0%
Compliance	23	71.9	13	25.0	-76.9%
Both	7	21.9	31	59.6	77.4%

5.1.11.1. Interpretation of the results from the intact treatment group

The treatment group dealing with the intact problem appears to have interpreted the task to relate predominantly to one sub-category of the problem. 72% of the total number of unique ideas generated related to “*compliance*” issues and measures. Only 6% related to the “*commitment*” sub-category while 22% could be generalized as system features that applied to “*both*” sub-categories (see Table 5.3). Two factors from the theoretical framework, discussed above, may contribute to members exploring only a single line of thought. The first is members’ individual cognitive behaviour; the second is (group) social norms that can inhibit the contribution of ideas that are not related to the “subject being discussed”.

Dennis et al (1996) report that this treatment group should be more inclined to viewing the problem more holistically as they are presented with a complete problem. The results in this experiment however show the contrary as only 22% of the ideas could be classified as of the “*both*” category.

5.1.11.2. Interpretation of the results from the decomposed task treatment group

For the decomposed task treatment group, it was expected that their contributions would be more evenly spread across the two sub-categories and they would be more inclined to view the problem in chunks missing out on a holistic solution. The analysis of the results, shows their ideas to be biased towards the “*both*” category, with 60% of all unique ideas generated falling into this category, 25% being *compliance* ideas and 15% being *commitment* ideas.

The nature of the “*both*” category ideas requires some elaboration. The ideas falling under the “*both*” category were superior ideas to the other sub-categories. It is assumed that they show that the problem is considered more holistically. They were idea solutions that contributed to solving both *commitment* and *compliance* issues. A sample of a “*both*” category ideas is:

“Provide a simulation of customer buying habits to determine the future stock levels, to always provide what the customer wants and when.”

The system function suggested above enhances knowledge about time-related customer buying habits and needs, which in turn would improve customer service (*commitment*). It also strengthens stock control measures by setting stock holdings and re-order points (*compliance*). Hence, this idea was rated as a “*both*” idea.

In most cases, the ideas falling into the “*both*” category were of higher quality. Analysis of the *both* sub-category idea scores for the multiple-question treatment shows the following: The total quality of ideas is 115 (versus 184 for all generated ideas), a contribution of 63% to overall Total Quality. In addition, the Mean Quality of these ideas is higher at 3.7 (versus. 3.5 for the entire solution space for this group).

5.1.11.3. Discussion and Facilitator Observations

The *single-question group* was hesitant to verbally interact, although members were informed they could do so. Members were content to merely interact through the group support system. Group members were happy to read each others contributions and respond by adding or more ideas electronically. On the other hand, the *multiple-question group* made use of the opportunity to verbally interact once allowed to do so. Members articulated their disagreements both verbally and through group support system software. The verbal discussion was observed to have specifically led to the following: initially a number of the members had trouble interpreting the meaning of the phrase "system characteristics and components" as opposed to the actual environment in which the system would operate. For example an idea advocating "a policy of hiring and firing inefficient workers" was considered (verbally and electronically) irrelevant to the task by the group so that individual members who misunderstood the task changed their ideas to make them more relevant.

Although the *single-question group* also shows having had similar difficulties of understanding, no group effort at clarifying the problem were observed. It is unclear why the two groups were different in this specific way. It can only be speculated that decomposition brought about clarity and that human beings are far more at ease verbalizing what they understand without fear of peer evaluation, than that which they are unsure of. Further research is required in this regard, to test for example for the effects of decomposition on group cohesion.

The *single-question group* appears to have interpreted the task to be concerned primarily with the support or enhancement of managers' *compliance* to the financial and administrative procedures. Only 6.3% of their ideas address issues of *commitment* and 22% are more holistic in nature. The restricted problem exploration seems to have also led to limited problem understanding. Cognitive inertia appears to have taken over within the group even with interaction.

By contrast and surprisingly, the *multiple-question group* generated more ideas that were of the "both" type. It was earlier noted that with decomposition there is the danger that in restricting ideas generated to a sub-category, the group may become self-censoring from producing ideas that are not immediately related to the sub-category being examined (Dennis et al., 1996).

However, in this research decomposition appears to have instilled a better understanding of the problem as a whole. On observation of their verbal interaction particularly, this group deliberately sought solutions that addressed both categories, especially during the second session. Consequently, the occurrence of holistic idea solutions is at 50% of all ideas generated during their second session. This group produced more “*both*” idea solutions than *commitment* and *compliance* solutions combined.

The *multiple-question group* appeared more concerned about the quality of their output. For example, when brainstorming on the second sub-category, members often wanted to discuss with each other whether a generated idea was in the right sub-category. This observation is supported by the output ideas, no occurrence of “off target” ideas is observed for this group. That is, no ideas were generated in the second sub-session that strictly related to the first sub-session. The surprise however, was the intention of the group to refine their ideas making them globally applicable to the problem, especially with respect to the second sub-session.

Finally, the *single-question group* appeared to have run out of ideas in the last ten minutes of the session judging from the fact that all but two members had stopped typing into the system. The multiple-question group complained about not having enough time to complete the task. These complaints were also articulated in the post-session questionnaire.

Comparing the results between the two treatment groups in whichever way, one condition remains consistent; the decomposed task treatment group outperforms the intact task treatment group overall and by category. The superiority of results produced by the decomposed task treatment is comparable with the results of Dennis et al. (1996). They found “this superiority also appeared in all three sub-categories, suggesting that the decomposition had its intended effect” Dennis et al. (1996:274). They also observed that the decomposed task treatment developed a greater number of ideas for two of the three sub-categories and no differences for the third category. Groups in the decomposed task treatment generated ideas more evenly among the three categories (Dennis et al., 1999).

5.1.12. Other Post-Session Questionnaire Results and Conclusion to the Idea Generation Task

Significant differences between the two groups for the post-session questionnaire results were not expected. The questionnaire measures *member satisfaction* with the process; process effectiveness as reflected by *equality of participation*; *production blocking*, and *evaluation apprehension and perceptions of time constraints*. The results can be found in Appendix C. Both groups used equivalent features of Team Expert Choice. The GSS environment was equal in all but the presentation structure of the problem task.

In general on the satisfaction measures, the multiple-question group reported being marginally more satisfied than the single-question group. Both groups observed that having to write their thoughts down meant they had to be more careful about what they were trying to say. The effect of the GDSS on the member's cognitive phenomena is reported as positive for both groups.

Dennis et al. (1996) do not report any differences in the post-session questionnaire measures effectiveness and satisfaction for their experiments. On perceptions of time constraints, 67% of multiple-question group report feeling "there was not enough time to complete the task" whereas 33% of the single-question group report the same. Nonetheless, no conclusions can be drawn about time effects in this research.

The results of this research show the decomposition of the task in the brainstorming session led to 40% more unique ideas. These results are consistent with the results of Dennis et al. (1999). They observed "decomposing an idea generating problem into sub-categories and directing the subjects to work sequentially on each, generated some 40% more ideas than did presenting them with the same problem as one question". Dennis et al (1996) show the effects of decomposition resulting in 60% more ideas for the multiple-task treatment than the single-task treatment.

As with the studies of Dennis et al (1996), the results of this research suggest that individuals tend to explore only a few sub-categories of the solution space rather than examine a broader range of sub-categories. An illustration of cognitive activity tending to favour the processing of related concepts rather than unrelated concepts. The single-question treatment group in this

research directed 72% of its effort towards *compliance* factors and only 21% of their total effort provided for holistic solutions (the “*both*” category). Decomposition has the effect that “forces the subjects to focus on new and other potentially profitable sub-categories” (Dennis et al. 1996). The multiple-question treatment group appears to have accomplished this with a better spread of solutions across the problem space.

5.2. Task Two: On the Facilitation of a Group Decision Task with AHP and Supporting Consensus Building Using Consensus Relevant Data

5.2.1. Introduction

Idea generation creates solution possibilities. However the solutions are of no use to the group if the group cannot reach agreement on adopting them. Reaching consensus on solutions is as important as being able to generate possible solutions for the measured effectiveness of groups. This is why strategies around building consensus are important for group work. Task two of this research is a consensus-building field study conducted with the Students' Representative Council (SRC) of the University of Natal, Pietermaritzburg (UNP) over a period of six months.

This study is of the participant-observer nature as discussed by Yin (1984). This author recognizes that for that reason it provides several major challenges as well as many opportunities, the details of which have already been discussed in the previous chapter. It presents problems of the unsettled "dilemma" of the value of quantitative research as opposed to qualitative research in Information Systems. It is, however beyond the scope of this research to expound on the merits and shortcomings of each. Suffice it to say that the original goals and objectives of this research rest mainly on reflecting a study, which focuses on, (but not exclusively), quantitative foundations. This is not to discount or invalidate the qualitative characteristics and issues that this study has had to confront in the pursuit of a complete study.

Secondly, it is important to note that although this part of the research focuses on the consensus-building phase of the group exercise, in reality the entire exercise is a resource-allocation task incorporating all aspects of group problem solving: starting from problem identification and definition, idea generation, selection, evaluation and implementation. The focus on consensus is justified by the fact that GSS research has paid little attention to this important aspect of group work.

The goals and sub-goals of this part of the research

The goal of this study formulated in preparation for the field study is to facilitate and support the resource-allocation, decision problem faced by the UNP's SRC using a formalized multi-criteria decision approach, the Analytic Hierarchy Process, as it were using GSS software. This includes the following sub-goals:

- a) To systematically go through the decision phases of Intelligence, Choice, Evaluation and Implementation (Simon, 1957), by identifying the goal of the decision makers, generating the criteria and sub-criteria upon which the alternatives would be evaluated, structuring the goal, criteria, intensities and alternatives into a problem hierarchy using the AHP. Finally, to rank the criteria, intensities and alternatives to allocate the resources to the alternatives on the basis of the standards established during the evaluation process.
- b) To conduct the intelligence phase unsupported, and to use Team EC in the choice and evaluation phases.
- c) To evaluate through the gathering of field data the use of consensus relevant information as defined by Ngwenyama, et al. (1996); Bryson (1996) and Bryson and Mobolurin (1995) as a tool for facilitating consensus building during the decision making process. The consensus relevant information would be used in the evaluation of the criteria and intensities, which form the basis upon which the alternatives will be evaluated.
- d) To conduct the study with the objective of providing a usable solution. More specifically, to endeavour at all times to ensure that the decision makers are not alienated from the process by the tools and techniques used to support the decision making. To this end, no time and effort would be spared explaining the tools, techniques and the underlying concepts to the decision makers. The evaluation and selection phase would not begin until all decision makers understood and accepted the proposed methods, tools and techniques.

The above objectives together with the setting of the study inevitably imply that the study contains both quantitative and qualitative research aspects. As a result, documentation of the study contains both positivist and interpretivist approaches.

The successful completion of this study would contribute some experiential evidence of the application of multi-criteria decision methods using multi-criteria group support software and support strategies in a “live” decision making environment. This is in order to propose that these methods are not restricted merely to theoretical expositions, descriptions and discussions but can be successfully applied to practical decision situations, such as the one facing the SRC.

On some background on the SRC and its decision objectives

The Students Representative Council is a parent body of all other recognized student organizations, clubs, societies and faculty councils at UNP. These will be referred to as SRC sub-structures. On an annual basis, the University Administration allocates a grant to the SRC with the objective that the SRC, through its structures and processes, identify and allocate portions of the SRC Grant to registered sub-structures.

Any student is free to form an association or organization of any kind. However, in order to get university (SRC) funding for such an association, one has to demonstrate three basic facts. These are, firstly the association has a definite purpose as expressed in the association’s constitution. In theory, the requirement is that the association is of benefit to some members of the student body. Secondly, the association must have duly elected officials who are accountable for the association’s activities. Thirdly, the association must have a demonstrated membership of at least two persons in the initial stages. As a result, there are several different types of organizations, ranging from political, to religious, to purely entertainment-based associations, registered with the SRC.

The SRC has recently come under pressure from both the University Administration and the student body because the basis upon which the SRC allocates funds to its sub-structures is at best, unclear and at worst, arbitrary. The SRC now seeks to specify definitive criteria for the allocation of its funds. The SRC also seeks to document the allocation criteria and make them available to

all interested parties. The ability to justify and defend its ultimate allocation decisions is a related requirement. In the history of the SRC these decisions have never been systematic; hence, the SRC was unclear on how to go about duly performing this task.

It is important to note that the SRC is a democratic institution. It strives for full consensus in the decisions it makes, although this is not always possible. Prolonged debates or discussions leading to decisions are characteristic of this organization. The current SRC president describes these as “prolonged acrimonious discussions” (SRC President, 1998/99). This is not surprising because the SRC is a diverse group of individuals with different political affiliations. The imperative to solve the problem in a sound manner is induced by the fact that the University Administration has declared that the SRC Grant will not be released prior to the SRC formulating clear budgetary allocations for its administrative expenses and sub-structure allocations. This study however will report on the allocation to sub-structures, because of the perceived contentiousness of this part of the problem by the decision makers.

This author was approached to facilitate the process with the SRC. This presented itself as a suitable opportunity to conduct a longitudinal field study with real stakeholders.

Techniques employed in this part of the research

In pursuit of the goals and objectives of this research task, several techniques are applied. They relate to the application of the principles of facilitation discussed in the previous chapter to problem structuring using the Analytic Hierarchy Process and reaching consensus by identifying the avenues and opportunities for consensus building (using consensus relevant information). The study uses the Team Expert Choice to support the group decision making process and to serve as a database for group memory as well as a database for the purposes of recording and documenting the decision making process.

In the previous chapter, the phases of facilitation were defined. In this section, these phases are documented as the foundation defining the process of facilitation for the decision task. The three phases are: Process Planning and Design; Preparation and Setup and Process Management.

5.2.2. Phase One: Process Planning and Design- Getting together with the SRC.

Two informal, exploratory meetings were held with the SRC Executive* to establish *inter alia*: what the problem task as perceived by the SRC was; the perceived needs of the task, what would constitute resolution of the problem, timing, required resources, available resources, and the number of players involved. During this phase the facilitator set out to clarify what SRC expectations were. These meetings were typically defined by: the SRC providing information on what was expected of it by its various stakeholders and the facilitator mainly listening and taking notes. The facilitator was restricted to merely asking questions of clarity. This phase was important for building rapport, relationships and trust between the facilitator and the SRC. The value of this cannot be over-stated, in view of sub-goal (d).

During these meetings two issues became apparent. Firstly, the desire to provide a respectable solution was strong. The SRC expressed a strong desire to distance itself from the perceptions of financial corruption. Its expectations meant the final solution had to be “transparent to our constituency” (Zondi, 1998). However, the group had almost no idea of how to solve the problem. Some of their recorded feelings on the issue were:

“We don’t know how many sub-structures are going be there this year, how can the University expect us to know how much we are going allocate to them.”

“Some may not even exist anymore?” (Shangase, 1998)

“I am sure this is just a ploy not to give us the grant, this year”

The lack of structured thought regarding the task stood out as the main issue to tackle for the facilitator. The next immediate step was getting the group to identify and formulate the problem and the desired state objectively.

Defining the Process, Ground Rules and Participator Roles

Stage One: Defining the role of SRC Executive, the facilitator and the rest

During this stage it was agreed that the SRC Executive would present the problem to the facilitator, “seek a way forward, from the facilitator,” and evaluate any proposals. If satisfied with the facilitator’s proposals, the Executive would convene a full SRC meeting and present the

*The SRC Executive comprises the President, the Deputy President, the Secretary General and the Treasurer of the organization.

proposals to the rest of the SRC. Should the group endorse the approach, the facilitator would be invited to continue the process with the entire group.

The first formal meeting was a structured verbal, face-to-face discussion attended by the SRC Executive. The purpose of this meeting was for the facilitator to propose a method(s) for approaching the problem having understood the issues around the task. From a facilitation point of view, two objectives were to be accomplished:

- Getting the SRC Executive to view their problem from a different angle, away from the evaluation of alternative sub-structures, to the definition of the problem; this required problem exploration. The facilitator had prepared questions to pose to the group to induce problem exploration.
- Secondly, the facilitator had to introduce the Analytic Hierarchy Process as an approach in a simple, context-related manner, to ensure that the subjects did not lose ownership of the solution and its derivation. In other words, the AHP was not to dictate or prescribe a solution and neither was the software nor the facilitator.

Stage Two: the problem formulation and identification process for the desired outcomes

This phase had two distinct sessions. The first session was dedicated to “asking the right questions” in order to induce the group to arrive at a definition of the problem. The questions were posed informally in a manner familiar to the group. Some of the questions asked are documented in order to illustrate the facilitation process and the feasibility of breaking down a problem into a hierarchy in a user-friendly way. Some questions that were asked of the group were:

*What is the end result (i.e. **Goal**) of what you are supposed to be doing?
What ultimately do you have to do? Is there anything else?*

From the above interaction the group initially settled on: “To allocate funds to the various sub-structures” as its definition of the goal. Through further probing and discussion it was apparent that this definition was incomplete because of the budgetary constraints that are beyond the SRC’s control. The goal was re-defined to: “To allocate funds to the various sub-structures, given a limited budget (R60, 000)”

The next challenge was to allay the group's persistent concerns about not knowing who the sub-structures seeking their funds were. This concern alone posed the single most difficult obstacle to getting the group to think differently about the nature of problem. A considerable amount of time was spent illustrating that this was least important. The important question to answer was "*Why do you want to give sub-structures hard-earned taxpayers' money?*" When the answer eventually came out as "because they have some contribution to make to campus life", the perception of the problem became more systematic. The group was able to discuss more specifically what the nature of contribution could possibly be and therefore the nature or general characteristics of the different sub-structures. Key to the progress of the session was steering the subjects away from thinking about "how much money would be given to any particular sub-structure". This is something the participants consistently wanted to do. This point is important because the answer to this question was the ultimate solution to the problem; something that the group was still a long way from being able to do. It illustrates the tendency of groups and individuals to frequently circumvent the problem-solving process thus affecting the final output and the ability to implement the solution.

The following were provisionally agreed as being the things the SRC would want to know about any sub-structure applying for funds: In other words these are the base **criteria** for evaluating any sub-structure.

The Sub-Structure's Stated Constitution/Objective: i.e. its contribution to campus life.

The Sub-Structure's Current or Estimated Membership Size.

The Total Amount Requested for the Current Budget.

The Total Amount Awarded in the Previous Year's Budget.

The History of Expenditure Management, with specific reference to the previous year.

Perceptions about the said sub-structure(s).

History of Income (Membership Fees and Sponsorships).

The **intensities** were elicited in a similar manner. Participants generally relied on their knowledge of existing sub-structures to generate the intensities. This concluded the first session of this phase.

The second session with the SRC entailed the introduction and explanation of the Analytic Hierarchy Process to the group using the problem definition generated by the participants in the first session. With this, the problem was hierarchically structured into **goal-criteria-intensities-alternatives**. Although, the alternatives could not be specifically enumerated at this stage, the AHP approach could be easily mapped to the problem as defined during the first session. This is the significance of the first session; without the systematic facilitation of the first session the application of the AHP to the problem in a manner easily understandable to the participants would have been very difficult. This would have violated one of main sub-goals of this research i.e. ensuring that the decision makers are not alienated from the process by the tools and techniques used to support the decision making.

Stage Three - Expanding the involvement of SRC Stakeholders

Thus far the process had by design included a small portion of the decision makers within the SRC, the executive. The time was right to involve the entire SRC because the process to be followed had become clear. Two meetings were held without the facilitator being present. In the first meeting the executive reflected on the process and on whether they were satisfied with it. In the second meeting, they convened the entire group, explained the adopted approach and communicated their reflections on the process. The purpose of both meetings was for the SRC to decide on whether to continue with this process. They decided to continue. Secondly, the entire group decided to change the proposed hierarchy slightly.

The significance of the absence of the facilitator at these meetings relates to sub-goal (d) in ensuring that the ownership of the problem and process remain with the decision makers. The confidence of the executive to explain the approach to the rest of the group was a positive signal in this regard.

Stage Four – Data gathering –getting to know the alternatives

With the problem hierarchy agreed, with respect to the **goal-criteria-intensities**, it was time to understand the alternatives, the individual sub-structures. A new request for funds (RFF) application form was drawn up to capture the required data. The application form would provide

sufficient information to evaluate the sub-structures with respect to the defined criteria. The questions asked of the applicants included the following for example: *what is your constitutional objective; how many members does your organization have; How much was allocated to your organization last year; Give a clear account of how that money was spent; How much did you raise by way of membership fees and sponsorships.* The new application form was important in that it represented the first tangible output of the process after weeks of meetings. There was observed satisfaction with this achievement.

However, from an AHP point of view the hierarchy was incomplete. The relative importance of each criterion or intensity with respect to the goal had not been ascertained. Several meetings were held to explain how the AHP concept of pairwise comparisons, its nine-point scale, inconsistency and absolute ratings work. This was the first time the group was being introduced to the details of the approach. The significance of this is that the group was not frightened off by unnecessary technical detail in the initial stages. At this stage the group had “bought into” the method and had demonstrated satisfaction with it.

5.2.3. Phase Two: Preparation and Set-up using Team EC

To capture the pairwise judgments of the individual members, the problem hierarchy was set up within the Team EC environment assuming equal importance of members. A people database was set up so that each individual was allocated his or her own “model”. Each individual would enter his or her own judgments about the criteria and intensities separately. A synthesis of these would then be performed to arrive at a group score.

For this study, the following Team EC **hardware** was used because the participants, although computer literate expressed discomfort about working with computers.

- The Radio Frequency (RF) Receiver, which connects to the serial port of a computer.
- Eight individual wireless keypads that are used by the group members to input their judgments. These keypads have internal identification numbers. The numbers are programmed through the software before the group session begins

- A single-barrel, lens-style projection system that connects to the laptop computer and projects the proceedings onto an overhead screen.

The use of keypads to enter judgments is relatively more simple and intuitive than the use of the mouse or keyboard. The keypads look like calculators with half as many buttons, whose size is at least three times that of a normal calculator. The software was run on *questionnaire mode* in order to capture the decision makers' preferences.

5.2.4. Phase Three: Process Management

Facilitation theory guides the facilitator to engage in managing the group process and promoting effective task behaviour; to skilfully and unobtrusively steer the group towards the desired outcomes, through being able to identify and understand the positions of the participants. The facilitator must also be able to identify opportunities for dialogue in pursuit of being able to move the participants towards consensus and commitment (Ngwenyama et al., 1996). This requires a high level of skill (Hoffman and Maier, 1959), using appropriate methods, techniques, and software tools (Jarke et al., 1987). This phase includes preference elicitation: the ranking of alternatives and providing comparison data; the definition of thresholds of agreement i.e. defining the stopping rules that will determine when consensus has been reached. Data analysis and reporting: identifying sub-groups, key individuals and or problematic options during the process is included during this phase.

5.2.4.1. The use of pairwise comparisons to evaluate the criteria and intensities

Team EC produces eight different "models", one for each participant and records or tracks each individual's judgments separately. It also generates a group model. During the judgment elicitation session, members were given instructions regarding the capturing of their judgments into Team EC. They were instructed not to worry about the inconsistencies of their judgments. Where necessary the judgments would be revisited and changed. This is, notwithstanding the fact that the facilitator had explained the concept of inconsistency at length. Again, it was important not to confound the group decision making process with the technicalities associated with the Analytic Hierarchy Process or the software support. Although the consistency of judgments is

recommended within the Analytic Hierarchy Process, it is by no means a requirement (Saaty and Foreman, 1996).

The SRC elected to run the evaluation session in anonymous mode with judgments entered sequentially until the last pairwise comparison in the hierarchy is made. The session was then reconvened to give members a break, and the facilitator time to analyse the results using the consensus relevant indicators.

5.2.4.2. Using Consensus Relevant Data

In order to facilitate the building of consensus use was made of the agreement and disagreement quotients as described by Ngwenyama et al (1996) and Bryson (1996, 1997). These were used in conjunction with the data generated by Team EC. The analysis of consensus relevant data is restricted to the prioritisation of the criteria. No consensus measure is required for the rating of the alternatives, because the alternatives are evaluated using the criteria and intensities as the standards of measure. Team EC derives the priorities from the simple pairwise comparisons, which are synthesized to obtain overall priorities for the intensities at the bottom of the tree. The result shows the ranking of the intensities, and provides a meaningful ratio scale measure of the differences between the intensities. The evaluations of the individual members are combined using the geometric mean to derive a group preference vector.

After the judgments for each node are entered with respect to the goal, Team EC calculates the derived priorities with respect to the parent node. The method of evaluating consensus relevant data was used once the priorities or vector preferences were calculated through Expert Choice. The results were given back to the group members. In practice the data given to the group members was in mainly graphical form, which proved quicker to understand and interpret.

In general, the SRC functions on the basis of full consensus. However, the SRC President has formal authority to elect to call for a poll of votes. Where this is the case, sufficient majority is deemed a 2/3 majority. In this research the facilitator was requested to assume a 2/3 majority as the requisite level of consensus. For ease of reference the consensus indicators are briefly restated in this section:

The **Similarity Function** which calculates the level of agreement between consecutive pairs of preference vectors is calculated as follows: $S(w^t, w^r) = 1 - \sin(w^t, w^r)$. It is used to identify strong agreement between any pair of members (t, r) for any criteria (a_i), where $\alpha = 0.25$, so that for any $S(w^t, w^r) \geq \alpha$, relatively strong agreement is said to exist between those members.

The **Group Strong Agreement Quotient (GSAQ)** identifies the percentage of pairs of group members who have a reasonably strong level of agreement. This stems from the idea that consensus develops from pairs of group members who are engaged in a dyadic discourse. Consequently, the objective is to measure the agreement in the opinions between each pair of group members. The GSAQ is an indicator of strong agreement in a dyadic discourse (Ngwenyama, et al., 1996). The Group Strong Disagreement Quotient (GSDQ) is an equivalent and alternate indicator.

The **Individual Strong Agreement Quotient (ISAQ)** of an individual is a measure of the agreement of that individual's preference rankings with each of the other group members. It is used as an identifier of individuals who share a fair level of agreement with other group members who in addition do not have any "apparent insurmountable barriers" as identified by their Individual Strong Disagreement Indicator (ISDI) value (Ngwenyama, et al 1996, Bryson, 1996). The ISAQ and the Individual Strong Disagreement Quotient (ISDQ) mirror each other (Ngwenyama et al., 1996).

The **Group Strong Disagreement Indicator (GSDI)** value, on the other hand, provides an estimate of the breadth of opinions in the group.

In this study α and β , were set at the following levels:

$\alpha = 0.25 \rightarrow$ strong agreement threshold (i.e. sufficient consensus)

$\beta = 0.17 \rightarrow$ strong disagreement threshold.

The justification for the above is in the fact that these correspond roughly to the sine of 15° and 10° degrees respectively, which are the values used by Ngwenyama et al (1996) and Bryson

(1996; 1997). The **GSAQ** and **ISAQ** were set at 0.667, which reflects the required two-thirds majority in the first instance and a 67% strength of agreement between any pair of members. The latter measure is guide to indicating the strength of agreement between any two members; in theory it could have been set at 51% for example, it's significance becomes apparent when sets of measures between different pairs of members have been taken. Those pairs that exhibit relatively higher ISAQ act as sources of opening and pursuing dialogue towards agreement.

How the consensus relevant data were used in practice

During the analysis phase of the process, group members were given both their own individual "models" and the group "model." From these most members simply examined their own preference ratings and compared them to the group preference mean. On the basis of any similarity or variation, they tended to object to or support the group position. This naturally stimulated discussion, although the facilitator directed the process. The consensus data models were used in the following manner. Prior to the start of the session, the facilitator calculated and analysed all indicators. A summary of key indications was compiled, especially in cases of strong disagreement. This information was then used to support the consensus building during discussion.

In general, the first consensus indicator assessed was the group strong agreement quotient (**GSAQ**) shown in Appendix D in the last column. The criteria were examined one at a time; the similarity functions and the individual strong agreement quotients (**ISAQ**) were examined thereafter, if there was not enough group consensus as reflected by the GSAQ.

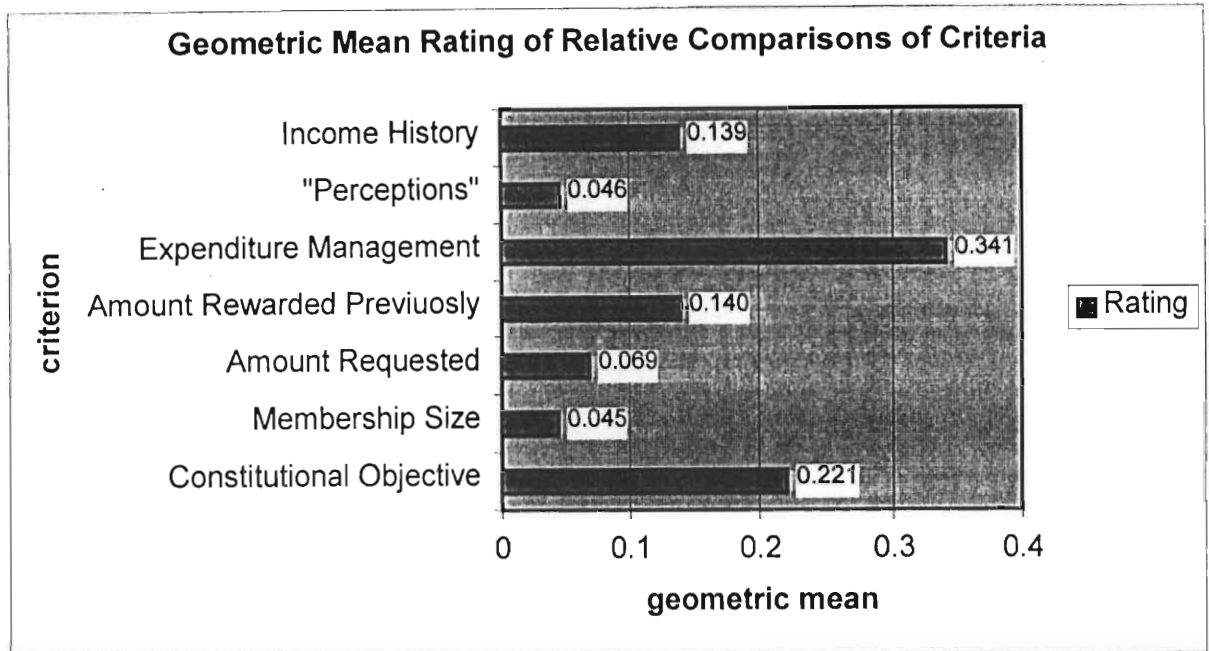


Figure 5.1 The synthesis of the individual pairwise comparison into a group score.

It is beyond the scope of this research to demonstrate every single instance of the use of the consensus indicators and the concomitant facilitation strategies therefore followed. Such a detailed documentation is a dissertation topic in its own right. Rather, one example is selected to illustrate which consensus indicators were used, how they were used and what the outcome of their use was on the group position or polarity. A summary of the results for all criteria and intensities is given in Appendix D. Further, it is not the purpose of this section to re-define the definitions of the consensus indicators; this was accomplished in Chapter Four.

The important factor to note is that the consensus indicators were calculated and used by the facilitator to identify those individuals and or sub-groups that posed as obstacles to reaching consensus or alternatively that presented an opportunity to build group consensus around themselves. Upon identification, these individuals or sub-groups were encouraged to speak and lead discussion, in the cases where they presented opportunity for consensus building. They were strategically softened, challenged or ignored where they posed as obstacles to reaching consensus. The fact of the participants understanding in principle the existence and use of these indicators cannot be overstated, this knowledge by the participants contributed positively to the facilitation of the process.

In order to illustrate by way of example, the intensity named “diversity promoting,” which is an instance of the criterion Constitutional Objective, is discussed in detail. It is necessary to put it within the context of the entire hierarchical model showing how the synthesized group judgment had been ranked using the geometric mean to illustrate the initial positioning, the process and the resolution. Figure 5.2 below shows the hierarchical model. As can be seen “diversity promoting” is an intensity of the constitutional objective.

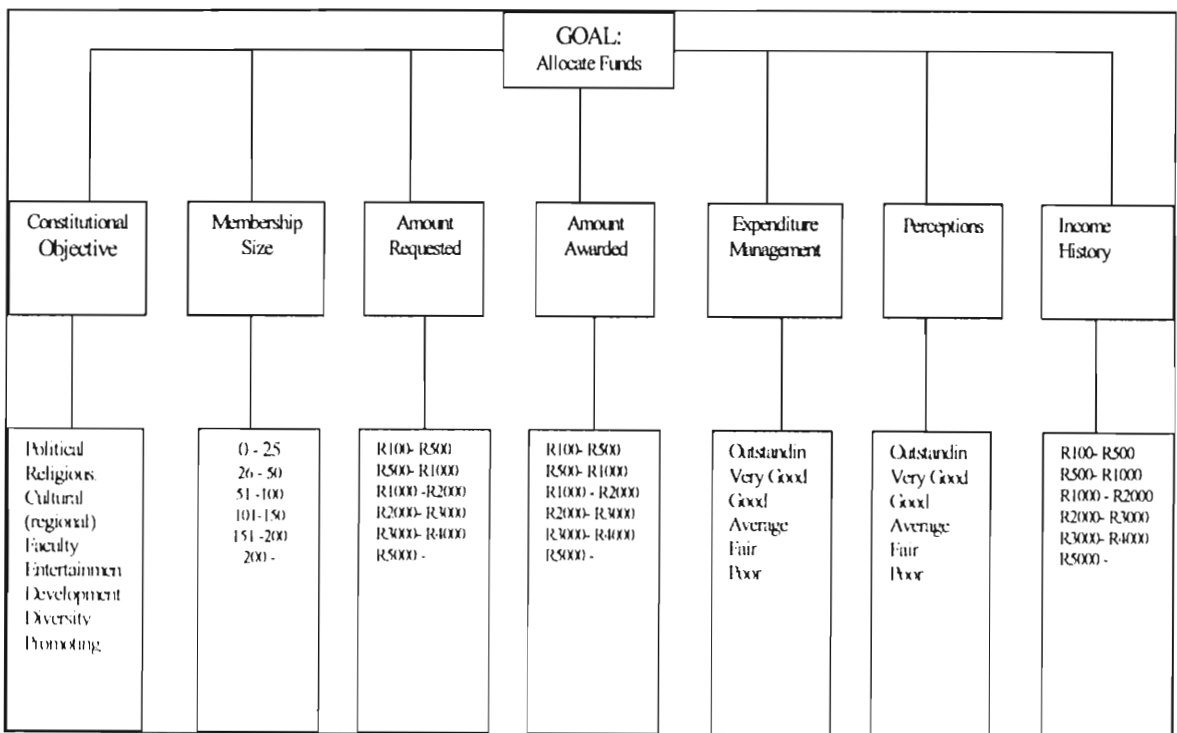


Figure 5.2 Problem Hierarchy for the SRC Allocation of Funds Task

After all the pairwise comparisons had been performed, the criteria ranked and discussed the constitutional objective was agreed as the second most important criterion after the ability to manage expenditure (see Appendix D).

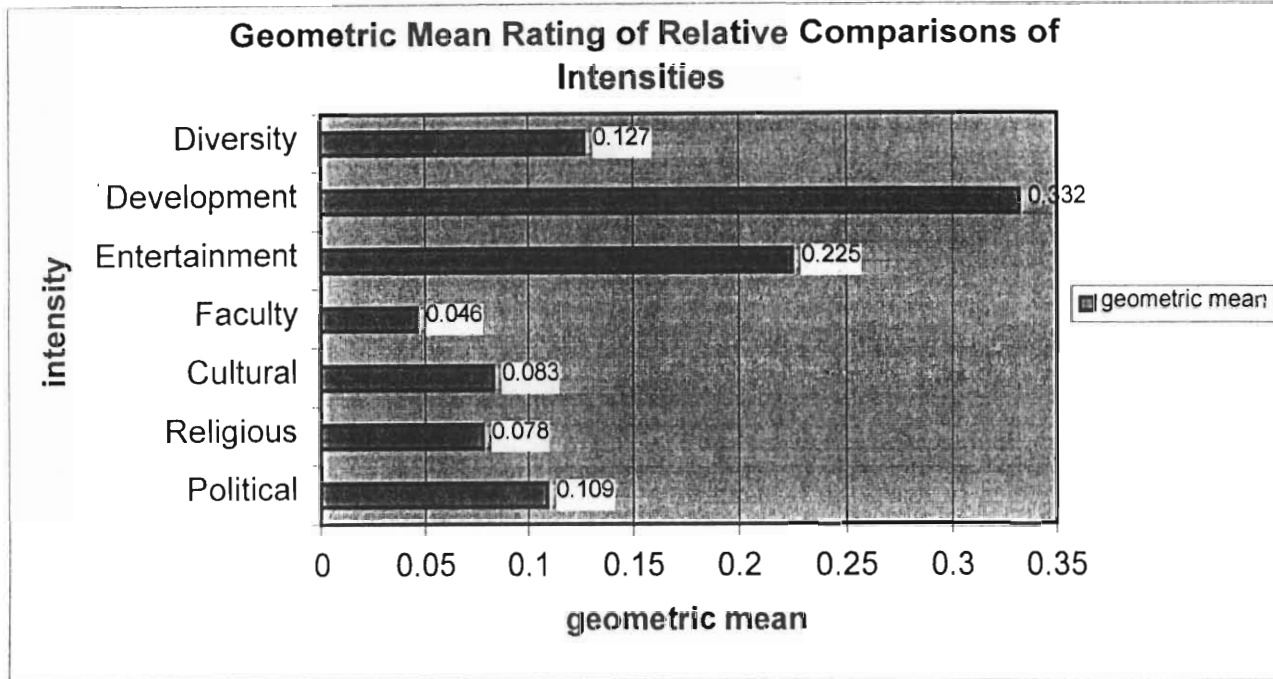


Figure 5.3 The synthesis of the individual pairwise comparison into a group score for the intensities of the constitutional objective

Figure 5.3 shows that the intensity, “diversity promoting” was ranked as per geometric mean as the third most important intensity with respect to the constitutional objective. However, the results and subsequent discussion show that the group aggregated ranking was extremely controversial. The Group Strong Agreement Quotient (GSAQ) examined first to ascertain the percentage of pairs of group members who have a reasonably strong level of agreement was equal to a lowly 13%, against a required 67%. Only a single member’s own rating (w^l) demonstrated a level of agreement above the defined threshold when compared to the (w^{GM}) to give rise to the GSAQ of 13% (The formulation of the GSAQ was discussed in detail in Chapter Four). This member was the SRC President.

The objective is to answer the question of whether there is a member who shares strong agreement with an overwhelming majority? The answer to this question is not in this case. To answer the question, Bryson (1997) suggests, there is a specific type of individual that is of interest: individuals whose preference vector w^l , is in strong agreement with w^{GM} (The SRC President in this case); **AND** whose $ISDQ^l_{\beta}$ value is less than the disagreement threshold. The latter was not the case for the President his $ISDQ^l_{\beta}$ value was much higher than the disagreement

threshold. Where this is the case, these individuals are to be encouraged to express and promote the *compromise* group mean position.

From a facilitation strategy viewpoint, the information on the GSAQ was important but not sufficient on its own. Other indicators were required to ascertain which individuals exhibited more agreement with other individual members of the group, even though not with the group position per se. The ISAQ provides more information in that it shows specifically those individuals who share a fair level of agreement with other group members. Notice from Chapter Four, the ISAQ is aggregated using the similarity functions. In this case, the level of disagreement was so strong both the ISAQ and ISDQ merely confirmed this, given the agreement and disagreement thresholds. Hence, a direct examination of the similarity functions is more revealing. To recap as in Chapter Four:

“The Similarity Function allows for the comparison of the level of agreement between any pair of preference vectors. It also allows one to answer the question: when are two members said to be in strong agreement or strong disagreement. That is, the definition of interpretable threshold values for strong agreement (α) and strong disagreement (β) can be defined, so that two individual group members can be said to have strong agreement if their Similarity Function : $S(w^t, w^r) \geq \alpha$ ” where t and r are the individual members.

Accordingly, the highest similarity functions were in order of strength of agreement the following:

$$\begin{aligned} S(w^2, w^7) &= 0.81 \text{ ----- (1)} \\ S(w^5, w^6) &= 0.42 \text{ -----(2)} \\ S(w^1, w^5) &= 0.39 \text{ -----(3)} \\ S(w^3, w^6) &= 0.34 \text{ -----(4)} \end{aligned}$$

Out of these identified members the support goal is to find those members that are likely agents of consensus building. These members have to also demonstrate that they do not have any “apparent insurmountable barriers” as identified by their ISDI value. An examination of their respective ISDI for all of the above pairs did not show “insurmountable barriers” (see Appendix D). However, in this case members 5 and 6 appear to present more opportunity³. Also noted before the discussion, were members showing high levels of disagreement, from their ISDQ: Members 4, 8 and 3 particularly.

³ References to members in this section is made by numbers

Discussion was resumed when the facilitator had examined the above data. The strategy was to allow everyone an initial say for two reasons. (1) To fulfil the desire to be heard for each member. (2) For the facilitator to verify or discard the information revealed by the consensus indicators. The latter is important in practice, especially where high levels of disagreement exist. It places the paired agreements or disagreements into a contextual meaning. For example, while Members 2 and 7 may be seen to agree strongly with each other, their opinion or position may be diametrically opposed to the other pairs of members who show relatively strong agreement.

The discussion showed that the consensus indicators were a relatively accurate reflection of the existing controversy and the high levels of polarity. It emerged for the first time, that a member with a hidden agenda had proposed the intensity. Whoever mooted the idea in the first place was in the process of lobbying for a “diversity promoting” sub-structure. The group was aware of this but the facilitator was not. The dilemma with the intensity was its intrinsic goodness or appeal as a desirable concept for campus life. The apparent conflict of interest created by the member caused consternation. Consequently, the group was divided into a sub-group that was completely “horrified” by such questionable ethics (Members 3 and 4 were a vociferous part of this sub-group) and another. The latter sub-group held firmly that the proposal was a highly desirable one and had to be attributed objectively without recourse to who had suggested it and why (Members 2 and 8 formed part of this sub-group). These two sub-groups represented the polar positions about the group.

Where did the President, Member 1, stand? When airing his views it became clear to see why his indicated function $S(w^1, w^{iM})$ showed the most agreement with the group. In practice he said while he felt that objectively the intensity was more important than entertainment for example, he had compromised, for ethical reasons to give it an average rating. There were two other members who had also compromised. These were Members 6 and 5. This confirmed the similarity functions observed earlier.

All three members could be purposefully directed to lead discussion. This was done. After some further discussion, Member 7 was the first to decide he was persuaded to join the compromise position, by changing his vote. Member 2 and 8 then agreed to join the compromise position in

principle. Discussion around this issue could have carried on to sway the other two, but it was not necessary, as the required level of consensus had been reached.

A similar approach was taken for the discussion on all criteria and intensities. The results are summarized in Appendix D. Once all of the ratings of the criteria and intensities were finalized, only the group “model” was changed to effect the changes and absolute ratings used to evaluate the sub-structures that eventually submitted application forms for funds. The actual individual amounts allocated were calculated from the ratings (see Appendix D).

The issue of “diversity promoting” is a good illustration of why the consensus indicators were instructive in supporting the building of consensus. Pre-planning and understanding the indicators beforehand enabled the facilitator to identify the areas of agreement or disagreement, verify these through dialogue and embark on strategies to promote the more agreeable or compromise solutions. The indicators were observed to be accurate most of the time, particularly because there are several indicators offering measures. This justifies the practical use of the model.

5.3. Discussion of Process and Results

In this section, some observations are made about the Analytic Hierarchy Process and the consensus indicators.

The first round of getting the group to brainstorm the possible criteria and subsequently structure the problem hierarchy was successful. The difficulty with a field study is balancing the needs and objectives of the decision makers under observation and the objectives of the study. For example, the consensus stopping-rule was initially defined as a 2/3 majority; however during discussion the group did not deem it necessary to physically re-enter their ratings in order to reach the required level of consensus. Time considerations meant the group was satisfied with discussing apparent disagreements with the view of arriving at consensus through principled agreements. This obviated the need to physically alter individual ratings in most cases. The principled agreements became actual votes for the purposes of the group so that a state of 50% agreement easily becomes 75% agreement on the strength of discussion alone. The study is then presented with the

dilemma of whether to go back and actually change all the ratings to effect the initially agreed upon level of consensus or does one leave the results as is and document accordingly. This author chose the latter option. The results are left in the way the group initially entered them and changes made through discussion are documented.

The general use of the consensus indicators was instructive. However, it is speculated that using them without understanding the group dynamics could be misleading. The similarity function and the ISAQ were used to identify members who were prime candidates around which to build consensus and such members were appropriately encouraged to lead discussion. In so doing, they expanded on their opinions or positions. However, in practice when the identified candidates have a non-constructive history with the group for instance, the attempt to use them as vehicles for building consensus can be counter-productive. In this study, for example, Member 8 illustrates the point. On many occasions he was identified as a suitable candidate around which to build consensus through virtue of the relationship between his rating and the group rating $S(w^I, w^{GM})$. Yet, using him was often counter-productive, because the group considered him immature and playful.

On the contrary, knowing who the individuals with power were was also useful. Understanding the dynamics and history of the group was just as important as using the consensus data to support the building of consensus. Certain members of the SRC commanded respect for different reasons, be it formal authority as in case of the President; referent power or expert power as in the case of Members 2, 3, and 4. These individuals could provide opportunities for building consensus, even where statistically they were not first choice candidates. While the indicators assisted particularly in the planning and anticipation of the consensus building sessions, there appears to be no substitute for the facilitator spending a lot of time in the early stages with the group in order to understand important group dynamics and member roles.

At the same time, there is a caveat that by spending too much time with the group the facilitator can willingly or inadvertently become part of group or part of the solution. This author experienced many a time being consulted formally or informally outside of the meetings on what she thought was the better way of doing this or that. It seemed some members were prone to losing sight of the role of the observer-facilitator. The group had to be consciously and

persistently reminded that the facilitator was merely facilitating the process and had no role to play beyond that.

Finally, a post-session questionnaire was designed to test for satisfaction with the process, effectiveness of the process, and ownership of the problem. The test for ownership of the problem entailed testing for facilitator effects, technology effects and decision approach i.e. AHP effects.

In sum, all the members felt that the process had been effective and would recommend it for future use. In addition, all participants felt that the technology did not affect their ownership of the solution. Similarly, everybody felt the decision approach had no effect on their solution. We interpret this to mean that the methods applied to support the group were successful, in assisting the group to explore the problem and build consensus, without jeopardizing the ability of the group to work together again. However, on facilitator effects, the results were not as straight forward. On average, on a score of 1-7, with 7 being no effect, 6.13 was awarded to facilitator effects. (See appendix E, for the detail post-session questionnaire and results). The post-session questionnaire also inquired for a general feeling of ownership. The overall feeling of ownership scored an average 6.5. The average value for the supported process' effect on the future ability of the group to work together was 7. It is observed that in this study the facilitator introduced the participants to both the decision approach and technology for the first time. The combination of results, between feelings of satisfaction and some anxiety about the structured facilitation process, indicates that further research might be useful in providing more understanding on how to achieve the often conflicting goals of the structured facilitation process toward reaching consensus.

5.4. Conclusion to the field experiment

The field study had both certain research goals and a responsibility to assist the participants to make an important decision in a systematic defensible way. The implications were articulated as sub-goal (a) of this part of the research: undertaking the entire decision making process until a final decision was made and amounts allocated to the more than 20 sub-structures. This was accomplished. The use of the Analytic Hierarchy Process to structure the problem into a

hierarchy model proved successful as the participants who had never used the AHP responded well to its application. The responsibility to the participants meant sub-goal (d) of this part of the research was of paramount importance. By all accounts verbal and questionnaire, feedback from the participants indicates that sub-goal (d) was accomplished.

From a theoretical point of view, this part of the research set out to support consensus building by applying consensus relevant information as defined by Ngwenyama, et al. (1996); Bryson (1996); and Bryson and Mobolurin (1995). The implied use of the consensus indicators is to test whether or not the indicators can work in practice. The significance of this study is that the application and therefore testing of these indicators is performed within a live environment of real stakeholders. Real stakeholders have a vested interest in the decision making process (Banville, et al, 1998) and building and reaching consensus is therefore not a contrived exercise. Under such conditions, the test is a justified one. In this study, the consensus indicators were found to offer a largely accurate interpretation of the polarity or consensus around issues. However, caution is made that these indicators should not be used in isolation, understanding group dynamics and member roles is essential if these indicators are to be applied efficiently.

5.5. Conclusion

In this chapter, the theoretical assumptions about the effect of task structuring on creativity in a group session and about supporting consensus in a multi-criteria group support system were explored in practice. The results that were obtained in the creativity experiment compare favourably to those in the recently published papers by Dennis et al. (1996) and Dennis et al. (1999). The framework for supporting consensus by Ngwenyama et al. (1996) was originally tested by them in a laboratory experiment. This study provided further evidence for its usefulness in real life, field conditions.

CHAPTER 6. CONCLUSION

The aim of this research was to investigate two important aspects of multi-criteria group decision making: the role of task structuring on a generative task and ways of supporting consensus building. To conduct this study within an appropriate context of the existing body of knowledge in Multi-Criteria Group Decision Making, literature surveys of both MCDM and GDSS were undertaken. This was done specifically to:

- Present an overview of the state of both MCDM and GDSS in a world that increasingly requires groups of individuals to solve unstructured and semi-structured problems.
- Examine the theory and techniques in group support for creative tasks and consensus.
- Survey future research opportunities in the field of multi-criteria group decision making.

How the Goals of this research were implemented

Two practical tasks were performed. The first was a laboratory experiment exploring task structuring in a brainstorming sessions. Two treatment groups were set up. The first group was given the problem in a single question. The second group was given the same problem as a decomposed task, made up of multiple questions. The objective was to test whether decomposition positively affects both quantity and quality of ideas generated. Both variables quantity and quality of ideas were measured. The measurement of quantity was simply the total number of ideas generated by the group. Quality was assessed using three measures: total quality, mean quality and the number of good ideas. This first investigative task was a partial replication of the work done by Dennis et al. (1996) and Dennis et al (1999). The interpretation of the results in both studies led to similar conclusions.

The second task, a field study, investigated the effect of implementing strategies to support consensus building in a multi-criteria group decision making environment. A group of decision makers was required to make a fairly complex and contentious resource allocation decision. Although, the decision makers were supported throughout the decision process from Intelligence to Implementation (Simon, 1960), only the consensus building phase and techniques are mainly

reported in this study. Consensus building support techniques identified by Ngwenyama et al (1996); Bryson; 1996; Bryson, 1997 and Bryson et al. (1994) were implemented into the decision support process and used to identify avenues, individuals, issues or sub groups that lent themselves to consensus building and compromise positions.

Characteristics of the main outcome of this research

There were three main outcomes to the research, relating to the current state of multi-criteria group decision making, the effects of task structuring in generative tasks and consensus building.

With respect to the literature survey, it is evident that multi-criteria group decision making is still in its infancy. Some fundamental theoretical issues remain unresolved in both the fields of MCDM and GSS. In a world where the general level of complexity and the costs of making errors have increased, the requirement for groups to solve organizational problems has also increased. Research in MCDM needs to grow significantly if it is to support group decision making. At the same time, GSS research and technology, in the main, needs to build a strong theoretical foundation upon which to conduct systematic studies.

The difficulty with studying group interaction is that unlike atoms and molecules, it defies neat analysis of the scientific method (Ngwenyama and Lee, 1997). GSS research needs to utilize more of other research methods, other than laboratory experiments that use subjects without a vested interest in the process or results. It appears more meta-analyses, action research, field studies and others are required to grow the field. Consensus is starting to emerge among GSS researchers that a judicious combination of multiple methods has the most potential, for a multi-methodological approach provides the greatest power of understanding of the complex socio-technical issues with which GSS deals (Zigurs, 1993).

The results on task structuring were consistent with previous similar research. In this dissertation the decomposed task treatment group generated 40% more ideas than the intact task treatment group. The results on the quality of the ideas also reflect that the *multiple-question group* did not resort to poor quality ideas, the total quality, mean quality and the number of good ideas were found to be higher and statistically significant.

These results confirm that

“Using a GSS with task structure adds no measurable cost compared to using no task structure, but produces a significant improvement in performance.... Task structure has received relatively little attention compared to other factors in GSS use (e.g. anonymity). A recent meta-analysis found GSS use without this task structuring to increase the number of ideas produced compared to verbal brainstorming by a mean effect size of 0.80 (Dennis, et al., 1996). In our study, the effect of size due to task structure (compared to no structure) was 0.95. In other words, the use of this simple task structure had about the same effect on performance as the mean effect of using a GSS in the first place! This suggests that there may be considerable opportunities for even greater performance improvements from GSS use through more sophisticated applications” (Dennis et al., 1999:18).

Within the field study of supporting consensus building, it was observed that the use of the consensus relevant data indicators as defined by Ngwenyama et al (1996) was fairly accurate in identifying the issues, individuals and sub-groups about which there was polarity or agreement. This enabled the management of the decision process in such a way as to strategically solicit those elements in the quest for reaching a consensual decision. These indicators were also useful in determining the intensity of polarity.

The brainstorming task has some weaknesses. The first is, because of structural time restrictions the laboratory experiment considered only one group each for the single-question treatment and the multiple-question treatment, whereas, Dennis et al. (1996) and Dennis et al. (1999) consider 18 groups and 40 groups respectively. However, they have significantly larger teams working on these. The second weakness is the experiment is limited to an idea generation task, whereas this could be expanded to other group tasks. However, this is justified by the fact that GSS research in task structuring is still new. To date to this author’s best knowledge Dennis et al (1996) and Dennis et al. (1998) are the only similar studies to be conducted, and both are based on the generation task. This research is intended to add to this new body of knowledge, however there is scope for future research to expand task structuring to other task types. The third weakness relates to the limitations of all laboratory experiments in general, such as the lack of a vested interest in the task and process (McGrath, 1982; Dennis et al., 1991), although to date no

empirical evidence exists suggesting that laboratory studies with students produce different conclusions than similar studies with managers (Dennis et al., 1996). In this study, the use of a laboratory environment was justified by the need to make comparisons that require two distinct treatment groups. This was not practical within the field study, precisely because the vested interest of participants required all of them to participate in the idea generation at the same time and same place. Dividing the members into two groups for the field study would have compromised the main objective of the study (building consensus) at the start of the process. However in the problem-exploration phase of the study the group was directed to de-chunk the problem.

What is the theoretical and practical contribution of this research to the field of GSS, MCDM?

An important feature of the laboratory study is that it is the first of this type to consider an information systems and analysis task. At the same time, there are no similar studies, to the best of this author's knowledge being conducted in South Africa. The most important practical outcome about this study is, similar to Dennis et al (1996) and Dennis et al (1999), the results send at least one message: where the opportunity to decompose a problem into sub-categories exists managers should use that opportunity.

The field study builds on the decomposition of the problem in the problem-exploration phase as part of the facilitation process of generating effective solutions and building group consensus around those solutions. In addition, the field study is a contribution to the field of GSS in that it adds to the body of knowledge on strategies to support consensus building, within a field study of real decision makers with a vested interest in the process and the outcomes of the decision process. This is significant, when considered against the background that this body of knowledge remains small in the field of multi-criteria group decision making.

Possible Directions for future research.

In this research, the author decomposed the idea-generation task into two sub-categories. There are other options regarding how far the problem is decomposed and who decomposes it. For instance, the problem could have been decomposed into more sub-categories. There may be an optimal point of decomposition, a point beyond which further decomposition would have diminishing returns, or there may be a minimum number of sub-categories that should be presented. On what basis are sub-categories selected to decompose the problem? Should there be a method for decomposing a task or is it strictly problem context dependent? These questions require further research. The group could have decomposed the problem with the sub-categories nominated by the group itself. It is likely that clearer understanding of the problem by all group members would result from this and thus more ideas could be generated per member. Further research is also needed in this regard.

Another conclusion on this research relates to the main challenge to GSS research in general. The need for more studies involving real stakeholders is unquestionable. However, until well-accepted methods of documenting and reporting on studies are developed, the real value of conducting field studies will be lost. The report of the field study contains some exclusions. The study contains other factors of a more interpretivist nature. These were excluded to some extent, precisely because no well-acceptable method of documentation exists within the field of MCDM or GSS. New methods of analysis and documentation of Group DSS processes are required and possibly critical social theory could be of assistance in this regard.

In conclusion, it can be stated that the practical results of this research, as well as the theoretical investigations support the idea that Group Decision Support Systems and Multi-Criteria Group Decision Support Systems can contribute to the enhancement of the effectiveness and efficiency of organizational decision making.

References

Abualsamh, R. A., Carlin B. and McDaniel, R. R. Jr., (1990). Problem Structuring Heuristics in Strategic Decision Making, in *Organizational Behavior and Human Decision Processes*, 45, 159-174.

Ackoff R., (1974). Science in the Systems Age: Beyond IE, OR and MS, *Operations Research*, 21, 661-669.

Ackoff, R. L. and Vergara, E., (1981). Creativity in Problem Solving and Planning: A Review, *European Journal of Operational Research* 7(1), 1-13.

Aczel, J. and Saaty, T. L. (1983). Procedures for synthesizing ratio judgments, *Journal of Mathematical Psychology* 27, 93-102.

Adler, H.L. and Roessler, E.D. (1977). *Introduction to Probability and Statistics*, W.H. Freeman and Company, USA.

Ahituv, N and Ronen, B. (1988). Orthogonal Information Structures – a model to evaluate the information provided by a second opinion, *Decision Science* , 19, 255-268.

Anderson, J. R., (1983). *The Architecture of Cognition*, Harvard University Press, Cambridge.

Anderson, J. R., (1987). Skill Acquisition: Compilation of Weak Method Problem Solutions, *Psychological Review*, 92, 192-210.

Anson, R., Bostrom, R. and Wynne, B., (1995). An Experiment Assessing Group Support System and Facilitator Effects on Meeting Outcomes, *Management Science*, 41(2), 189-208.

Anthony, R.N., (1965). *Planning and Control systems: A Framework for Analysis*, Harvard University Graduate School of Business Administration.

Applegate, L. M. (1986). *Idea Generation in Organizational Planning*, Ph.D. Dissertation, University of Arizona.

Bana e Costa, C. A., Stewart, T.J. and Vansnick, J-C. (1995). Multicriteria Decision Analysis: Some Thoughts Based On the Tutorial and Discussion Sessions of the ESIGMA Meetings, in Slowinski, R. (ed.) *Semi Plenary papers by EURO Working Groups*, 14th European Conference on Operational research, Jerusalem, 261-272.

Banville, C., Landry, M., Martel, J. and Boulaire, C., (1998). A Stakeholder Approach to MCDA, *Systems Research*, 15 (1), 15-32.

Baroudi, J. J. and Orlikowski, W.J., (1989). The Problem of Statistical Power in MIS Research, *MIS Quartely*, 13(1), 87-106.

Barzilai J., (1996). On the Derivation of AHP Priorities, in *Proceedings International Symposium on AHP 1996*, Simon Fraser University, Vancouver, 244-250.

Barzilai, J. and Lootsma, F., (1995), Power Relations and Group Aggregation in the Multiplicative AHP and SMART, Technical Report, Delft University of Technology, April.

Basak, I. and Saaty, T. L. (1993). Group Decision making Using the Analytic Hierarchy Process, *Mathematical And Computer Modelling*, 17(4/5), 101-109.

Bedau, H., (1984). Ethical Aspects of Group Decision Making, in *Group Decision Making*, 5(2), 115-150.

Bell, D. (1982). Regret in Decision Making Under Certainty, *Journal of Risk and Uncertainty*, 2, 105-117.

Belton, V., (1993). Project Planning and Prioritisation in the Social Services – an OR Contribution, *Journal of the Operational Research Society*, 44 (2), 115-124.

Benbasat, I. and Lim, L. H., (1993). The effects of group, task, context, and technology variables on the usefulness of group support systems: A meta-analysis of experimental studies, in *Small Group Research*, 24 (4), 430-462.

Benbasat, I., Lim, F. J. and Rao, V. S., (1995). A Framework for Communication Support in Group Work with special reference to Negotiation Systems, in *Group Decision and Negotiation*, 4, 135-158.

Bikson, T.K., (1997). Groupware at the World Bank, in Ciborra, C. U. (ed), *Groupware and Teamwork - Invisible Aid or Technical Hindrance?* John Wiley and Sons, Chichester, UK, 145-183.

Brembeck, W. and Howell, W., (1976). *Persuasion: a Means of Social Influence*, Prentice-Hall, New Jersey.

Brown, R., (1988). *Group Processes: Dynamics Within and Between Groups*, Basil Blackwell, Oxford.

Bryson, N., (1996). Group Decision-Making And The AHP: Exploring The Consensus-Relevant Information Content, *Computer Operations Research*, 23(1), 27-35.

Bryson, N., (1996). Supporting consensus formation in Group Support using the Qualitative Discriminant Process, *Annals of Operations Research*, 71, 75-91.

Bryson, N., Ngwenyama, O.K., and Mobolurin A.; (1994). A Qualitative Discriminant Process for Scoring and Ranking in Group Support Systems, *Information Processing Management*, 30 (3), 389-405.

Burke, K. and Chidambaram, L., (1995). Developmental Differences between Distributed and Face to Face Groups in Electronically Supported Meeting Environments: An Exploratory Investigation, *Group Decision and Negotiation*, 4, 213-233.

Campbell, D. J., (1988). Task Complexity: A Review and Analysis, *Academy of Management Review*, 13, 40-52.

Clawson, V, Bostrom, R. and Anson, R., (1993). The Role of the Facilitator in computer Supported Meetings, *Small Group Research* (November), 216.

Connolly, T., Jessup, L. M., Valacich, J. S., (1990). Effects of Anonymity and Evaluative Tone on Idea Generation in Computer-Mediated Groups, *Management Science*, 36 (6), 689-703.

Connolly, T., Routhieaux, R. L., and Schneider, S. K., (1993). On the Effectiveness of Group Brainstorming: Test of the Underlying Cognitive Mechanism, *Small Group Research*, 24, 490-503.

Cooper, R.B., Blair, D. and Rao, M., (1992). Communicating MIS Research: A Citation Study of Journal Influence. *Information Processing and Management*, 29(1), 55-67.

Corbin, R. and Marley, A. A. J., (1974). Random Utility Models with Equality, but not Actual, Generalization of Random Utility Models, in *Journal of Mathematical Psychology*, 11, 274-293.

Couger, J. D., (1995). *Creative Problem Solving and Opportunity Finding*, Boyd and Fraser, Danvers, MA.

Daellenbach, H.G., (1996) A comment on Henig and Buchanan (1996). Solving MCDM Problems: Process Concepts, *Journal of Multi-Criteria Decision Analysis*, 5, 15.

de Bono, E. (1993). *Thinking Course, Facts on File*, New York, NY, 1993.

Deming, E., (1986). *Out of Crisis*, John Wiley and Sons, New York

Dennis, A. R., (1993). Information Exchange and Use in Group Decision Making: You Can Lead a Group to Information, but You Can't Make It Think, in *Best Paper Proceedings of the Academy of Management Meeting*, Atlanta, Georgia, 283-287.

Dennis, A. R., Aronson, J. E., Heninger, W. G., and Walker, E. D. (1999). Structuring Time and Task in Electronic Brainstorming, *MIS Quarterly*, 23(1), 95-108.

Dennis, A.R., George, J.F., Jessup, L. M., Nunamaker, J.F., and Vogel, D. R., (1988). IT to Support Electronic Meetings, *MIS Quarterly*, 12(2), 591-624.

Dennis, A.R., Heminger, A., Nunamaker Jr., J.F. and Vogel, D. R. (1990a). Bringing Automated Support to Large Groups: The Burr-Brown Experience, *Information and Management*, 18(3), 111-121.

Dennis, A. R., Nunamaker, J. F., and Vogel, D. R., (1991). A Comparison of Laboratory and Field Research in The Study of Electronic Meeting Systems, *Journal Of Information Systems*, 7(3), 107-135.

Dennis, A. R. and Valacich, J. S. (1993). Computer Brainstorms: More Heads Are better Than One, *Journal of Applied Psychology*, 78 (4) 531-537.

- Dennis, A. R. and Valacich, J. S. (1994). Group, Sub-Group and Nominal Group Brainstorming: New Rules for a New Media?, *Journal of Management*, 723-736.
- Dennis, A. R., Valacich, J. S., Connolly T., and Wynne, B. E., (1996). Process Structuring in Electronic Brainstorming, *Information Systems Research*, 7(2), 268-277.
- Dennis, A. R., Valacich, J. S., and Nunamaker Jr., J. F., (1990). An Experimental Investigation of the Effects of Group Size in an Electronic Meeting Environment, in *IEEE Transactions on Systems, Man and Cybernetics*, 20(5), 1049-1057.
- DeSanctis, G. and Gallupe, R.B., (1987). A Foundation For The Study Of Group Decision Support Systems, *Management Science*, 33, 589-609.
- Diehl M., and Stroebe, W., (1987). Productivity Loss in Brainstorming Groups: Toward the Solution of a Riddle. *Journal of Personality and Social Psychology*, 53 (3), 497-509.
- Dominowski, R. L. and Jenrick, R., (1972). Effects of Hint and Interpolated Activity of Solution of an Insight Problem, *Psychonomic Science*, 26, 335-338.
- Dubin, R., (1969). *Theory Building*, The Free Press, New York.
- Dyer, J. S., (1990). Remarks on the Analytic Hierarchy Process, *Management Science*, 36(3), 249-259.
- Dyer, J. S., (1990a). A Clarification of Remarks on the Analytic Hierarchy Process, *Management Science*, 36(3), 274-275.
- Dyer, R.F., Forman, E.H., (1992). Group Decision Support with the Analytic Hierarchy Process, *Decision Support Systems*, 8 (1), 99-124.

Earley, P. C., (1989). Social Loafing and Collectivism: A comparison of the United States and the People's Republic of China, *Administrative Science Quarterly*, 34, 565-585.

Earley, P. C., (1993). East meets West meets MidEast. Further Explorations of Collectivistic and Individualistic Work Groups, *Academy of Management Journal*, 36, 319-348.

Eden, C. (1992). A Framework for Thinking about Decision Support Systems, *Journal of Operations Research Society*, , 165-175.

Eom, S. E., (1998). The Intellectual Development and Structure of Decision Support Systems (1991-1995) *Omega International Journal of Management Science*, 26 (5), 639-657.

Erez, M., and Somech, A., (1996). Is Group Productivity Loss The Rule or The Exception? Effects of Culture and Group-Based Motivation, *Academy of Management Journal*, 39 (36), 1513-1537.

Expert Choice Inc.(1992). *Expert Choice Version 8: User Manual*. Decision Support Software, Mclean, Virginia.

Fern, E. F., (1982). The Use of Focus Groups for Idea Generation: Effects of Group Size, Acquaintanceship, and Moderator on Response Quantity and Quality, *Journal of Marketing Research*, 19, 1-13.

Festinger, L., (1968). Informal Social Communication, *Group Dynamics: Research and Theory*, 3, 182-191.

Finke, R. A., Ward, T. B., and Smith, S. M., (1992). *Creative Cognition: Theory, Research and Applications*, The MIT Press, Cambridge, MA.

Fishburn, P.C., (1970). *Utility Theory for Decision Making*, Wiley, New York.

Fishburn, P.C., (1983). Transitive Measurable Utility, *Journal of Economic Theory*, 31, 293-317.

Forman, E.H., (1993). Facts and Fiction About The Analytic Hierarchy Process, *Mathematical and Computer Modelling*, 17 (4/5), 19-26.

Forman, E. H., (1997). *Decision Making*, www.expertchoice.com

Forman, E.H and Peniwati, K., (1996). Aggregating Individual Judgments and Priorities with the Analytic Hierarchy Process, in *Proceedings International Symposium on AHP 1996*, Simon Fraser University, Vancouver, 383-391.

Forman E.H, Gerrits, M., and Rijsberman, F. R., (1994). Group Decision Support System in Coastal Zone Management Policy Analysis, in *Proceedings of the International Symposium on the Analytic Hierarchy Process*, Washington, 519-529.

Forrester, T., (1988). *The Information Technology Revolution*, Basil Blackwell, Oxford.

French, S. (1984). *Multi Criteria Decision Making*,

Friend, J., (1990). Handling Organizational Complexity in Group Decision Support, in *Tackling Strategic Problems – The Role of Group Decision Support*, C. Eden and J. Radford (Eds.), Sage Publications, London.

Gallupe, R. B., Bastianutti, L. M. and Cooper, W. H., (1991). Unblocking Brainstorms, *Journal of Applied Psychology*, 76,137-142.

Gallupe, R. B., Dennis, A. R., Cooper, W.H., Valacich, J. S., Nunamaker, J. F. Jr., and Bastianutti, L., (1992). Group Size and Electronic Brainstorming, *Academy of Management Journal*, 35(2), 350-369.

Gallupe, R.B. and DeSanctis, G. (1988). Computer-Based Support for Group Problem-Finding: An Experimental Investigation, *Management Information Systems Quarterly*, 12, 277-296.

Gallupe, R.B. and McKeen, J .D., (1990). Enhancing Computer Mediated Communication :An Experimental Investigation into the Use of a Group Decision Support system for Face to Face Versus Remote Meetings, *Information and Management*, 18, 1-13.

Gallupe, R.B., (1985). 'The Impact of Task Difficulty on the Use of a Group Decision Support Meeting', unpublished Ph.D. dissertation, University of Minnesota.

Gallupe, R.B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., and Nunamaker Jr., J. F., (1992a). Electronic Brainstorming and Group Size, *Academy of Management Journal*, 35 (2), 330- 369.

George, J.F., Easton, G.K., Nunamaker, Jr., J.F. and Northcraft, G. B., (1990). A Study of Collaborative Work with and without Computer-Based Support, *Information Systems Research*, 1(4), 394-415.

Gersick, C. J. G., (1988). Time and Transition in Work Teams: Toward a New Model of Group Development, *Organizational Behavior and Human Performance*, 24, 93-110.

Gettys, C. F., Pliske, R. M., Manning, C. and Casey, J. T., (1987). An Evaluation of Human Act Generation Performance, *Organizational Behavior and Human Decision Processes*, 39,23-31.

Giddens, A., (1984). *The Constitution of Society: Outline of the Theory of Structure*, University of California Press Berkeley, CA.

Goicoechea, A., Hansen D. and Duckstein, L., (1982). *Multiobjective System Analysis with Engineering and Business Application*, Wiley & Sons, New York.

Golden, B.L. and Wang, Q., (1989). An alternative Measure of Consistency, in Golden, Wasil and Harker (eds), *The Analytic Hierarchy Process – Application and Studies*, Springer-Verlag, New York.

Gorry, G. A., and Scott-Morton, M. S., (1971). A Framework for Management Information Systems, *Sloan Management Review* 13(1), 121-130.

Gray, P. and Olfman, L., (1989). The User Interface in Group Decision Support Systems, *Decision Support Systems*, 5,119-137.

Gray, P., Berry, N. W., Aronofsky, J. S., Helmer, O., Kane, G. R. and Perkins, T.E., (1981). The SMU Decision Room Project, in *Transactions of the First International Conference on Decision Support Systems*, 122-129.

Grohowski, R.B., McGoff, C., Vogel, D. R., Martz, W.B., Nunamaker, J.F., (1990). Implementation of Electronic Meeting Systems at IBM, *MIS Quarterly*, 14(4), 369-415.

GSS-ListServe - newsgroup, (1999). <mailto:GSS-L@LISTSERV.UGA.EDU>

Hackman, J. R. and Kaplan, R. E., (1974). Interventions into Group Process: An Approach to Improving the Effectiveness of Groups, *Decision Sciences*, 5, 459-480.

Haines, B. and Amabile, T., (1988). The Conditions of Creativity, in R. Sternberg (ed.), *The Nature of Creativity: Contemporary Psychological Perspectives*, Cambridge University Press, Cambridge, MA, 11-38.

Haines, L. M., (1998). Interval Judgements in the Analytic Hierarchy Process: A Statistical Perspective, in, Stewart, T. J. and van den Honert, R. C. (eds.) *Trends in Multi-Criteria Decision Making*, Springer-Verlag, Berlin, 87-95.

Hamalainen, R. P., Salo A. and Poysti (1992). Observations about Consensus in Multiple Criteria Environment, *A Technical Report from the Systems Laboratory, University of Helsinki*, 190-198.

Hanson, R. D., (1998). Consensus by Identifying Extremists, *Theory and Decision*, 44, 293-301.

Hare, A. P., (1981). Group Size in *American Behavioral Scientist*, 24 (5), 695-708.

Harker, P. T. and Vargas, L. J., (1987). The Theory of Ratio Scale Estimation: Saaty's Analytic Hierarchy Process, *Management Science*, 33(11),1383-1403.

Harker, P. T. and Vargas, L. J., (1990). Reply to: Remarks on the Analytic Hierarchy Process, *Management Science*, 36(3), 269-323.

Harkins, S. G., (1987). Social Loafing and Social Facilitation, *Journal of Experimental and Social Psychology*, 23, 1-18.

- Hart, S. L., (1985). Toward Quality Criteria for Collective Judgments , *Organizational Behavior and Human Decision Science Processes*, 6, 209-228.
- Henig, M. I. and Buchanan, J. T., (1996). Solving MCDM Problems: Process Concepts, *Journal of Multi-Criteria Decision Analysis*, 5, 3-12.
- Hiltz, S. and Turoff, M. (1981). The Evolution of User Behavior in a Computerized Conferencing System, *Communications of the ACM*, 24 (11), 739.
- Hirokawa, R. and Gouran, D., (1989). Facilitation of Group Communication: A Critique of Prior Research and an Agenda for Future Research, *Management Communication Quarterly*, 3 (1), 71-92.
- Ho, T.H. and Raman, K.S., (1991). The Effect of GDSS and Elected Leadership on Small Group Meetings, *Journal of Management Information Systems*, 8(2), 109-133.
- Hoffman, L. and Maier, N., (1959). The Use of Group Decision to Resolve a Problem of Fairness, *Personnel Psychology*, 12, 545-559.
- Holloman, C. R., and Hendrick, H. W., (1977). Adequacy of Group Decisions as a Function of the Decision Making Process, *Academy. Management Journal*, 15, 175-184.
- Howard, R. A., (1992). 'In Praise of the Old Time Religion', in Ward Edwards' (ed.) *Utility Theories: Measurements and Applications*, Kluwer Academic Publishers, Boston, MA, 27-56.
- Huber, G. P., (1982). Group Decision Support Systems as Aids in the Use of Structured Group Management Techniques, in *DSS-82 Transactions*, 211-225.

Huber, G. P., (1984). Issues in the Design of Group Decision Support Systems, in *MIS Quarterly*, September: 195-204.

Hwang, M., (1998). Did Task Type Matter in the Use of Decision Room GSS? A Critical Review and a Meta- analysis, *Omega International Journal of Management Science*, 26(1), 1-15.

Iz, P. H. & Gardiner L. R., (1993). *Analysis of Multiple Criteria Decision Support Systems for Cooperative Groups*, *Group Decision and Negotiation*, 2, pp.61-79.

Jablin, F. and Sussman, L., (1978). An exploration of Communication and Productivity in Real Brainstorming Groups, *Human Communications Research*, 4 (4), 327.

Jackson, M.C., (1995). Beyond the Fads: Systems Thinking for Managers, *Systems Research*, 12 (1), 25-43.

Jacob, V. S. and Pirkul, H., (1992). A Framework For Supporting Distributed Group Decision-Making, *Decision Support Systems* 8,17-28.

Janis, I. L., (1972). *Victims of Groupthink: A Psychological Study of Foreign Policy Decisions and Fiascoes*, Houghton-Mifflin, Boston.

Janis, I. L. and Mann, L. (1979). *Decision Making A Psychological Analysis of Conflict, Choice and Commitment*, Free Press, New York.

Jarke, M., Jelassi, M.T., and Shakun, M. F., (1987). MEDIATOR: Towards a Negotiation Support System, *European Journal of Operations Research* 31, 317-334.

Jarvenpaa, S. L., Rao, V. S., and Huber, G. P., (1988). Computer Support for Meetings of Groups Working on Unstructured Problems: A Field Experiment, in *MIS Quarterly*, 12(2), 645-666.

Jennings, D. and Wattam, S. (1994). *Decision Making An Integrated Approach*, Pitman Publishing, Long Acre London

Jessup, L. M., Connolly, T., and Galegher, J., (1990). The Effects of Anonymity on GSS Group Process with an Idea Generating Task, *MIS Quarterly*, (September), 313-321.

Jessup, L.M. and Valacich, J.S., (1993). Future Directions and Challenges in the Evolution of Group Support Systems, in Jessup and Valacich (Eds.) *Group Support Systems: New Perspectives*, MacMillan Publishing Co., New York.

Johansen, R., (1991). Teams For Tomorrow, in *Proceedings of the Hawaii International Conference on Systems Sciences*, IEEE Computer Society Press, 521-534.

Karau, S. J., and Williams K. D., (1993). Social Loafing: a Meta-Analytic Review and Theoretical Integration, *Journal of Personality and Social Psychology*, 65, 681-706.

Katz, D., and Kahn, R. L., (1966). *The Social Psychology of Organisations*, John Wiley and Sons Inc., New York.

Keen, P. G. W., (1986). *Justifying Decision Support Systems*, Prentice-Hall International Inc., New Jersey.

Keen, P. G. W., and Scott Morton, M. S. (1978). *Decision Support Systems: An Organizational Perspective*, Addison-Wesley Publishing Co., Reading.

Keen, P.G. W. and Raiffa, H. (1993). *Multicriteria Decision Making*, John Wiley and Sons.

Keeney, R. L., (1992). On the Foundations of Prescriptive Decision Analysis, in Edwards W. (ed) *Utility Theories: Measurements and Applications*, Kluwer Academic Publishers, Boston, MA, 57-72.

Keeney, R.L and Raiffa, H. (1976). *Decision with Multiple Objectives: Preferences and Value Tradeoffs*, Wiley, New York.

Keller, L. R., (1992). Properties of Utility Theories and Related Empirical Phenomena, in Edwards W. (ed) *Utility Theories: Measurements and Applications*, Kluwer Academic Publishers, Boston, MA, 3-26.

Kelly, J.R. (1988). Entrainment in Individual and group Performance, in McGrath, J. E. (ed.) *The Social Psychology of Time: New Perspectives*, Sage, Newbury Park, CA.

Kelly, J.R., Futoran, G. C. and McGrath, J. E. (1990). Capacity and Capability: Seven Studies of Entrainment and Task Performance Rates, *Small Group Research*, 21, 283-314.

Kelly, J.R. and Karau, S. J., (1993). Entrainment of Creativity for Small Groups, *Small Group Research*, 24, 179-198.

Kelly, J.R and McGrath, J. E. (1985). Effects of Time Limits and Task Types on Task Performance and Interaction of Four-Person Groups, *Journal of Personality and Social Psychology*, 49,395-407.

Kerr, N.L (1982). Social Transition Schemes: Model, Method, and Applications, In Brandstatter, H., Davis J.H. and Stocker-Kreichgauer, G., *Group Decision Making*, Academic Press, New York, 59-79.

Kerr, S., (1979). *Organizational Behavior*, Grid Publishing Inc, Ohio.

Kraemer, K., and King, J., (1986). Computer-Based Systems for Group Decision Support: Status of Use and Problems in Development in *Procedures of the Conference on Computer-Supported Cooperative Work*, 4, 353-375.

Lai, Y-J. and Hwang C-L. (1994). *Fuzzy Multiple Objective Decision Making Methods and Applications*, Springer, Berlin.

Lamm, H. and Trommsdorff, G., (1973). Group Versus Individual Performance on Tasks Requiring Ideational Proficiency (Brainstorming): A Review, *European Journal of Social Psychology*, 361-387.

Lasden, M., (1986). Facing Down Groupthink, *Computer Decisions*, 18 (10), 52-56.

Laudon, K. C., and Laudon J. P., (1996). *Management Information Systems: Organization and Technology*, (Fourth Ed.), Prentice Hall International.

Lee, A. S., (1989). Scientific Methodology for MIS Cases. *MIS Quarterly*, 13(1), 33-50.

Lewis, F. (1982). Facilitator: A Microcomputer Decision Support Systems for Small Groups, unpublished Doctoral Dissertation, University of Louisville.

Lim, L. H. and Benbasat, I., (1993). A Theoretical Perspective of Negotiation Support Systems, *Journal of Management Information Systems*, 9(3), 27-44.

Locke, E. A. and Latham, G. P., (1990). *A Theory of Goal Setting and Task Performance*, Prentice-Hall, Englewood Cliffs, New Jersey.

Lockett, G., Naude, P., Islei, G., (1998). Influence in Group Decision Making, in, Stewart, T. J. and van den Honert, R. C. (eds.) *Trends in Multi-Criteria Decision Making*, Springer-Verlag, Berlin, 87-95.

Lootsma, F.A., (1993). Scale Insensitivity in the Multiplicative AHP and SMART, *Multi-Criteria Decision Analogies*, 2, 87-110.

Lootsma, F.A., (1996). Comments on Roy, B. and Vanderpooten, D., The European School of MCDA: Emergence, Basic features and Current Works, *Journal of MultiCriteria Decision Analysis*, 5(1), 37-38.

Lootsma F.A. and Schuijt H., (1996) The Multiplicative AHP, SMART and ELECTRE in a Common Context, Report 95-200, Technical University of Delft.

Loy, S. L., (1991). The Interaction Effects Between General Thinking Skills an Interactive Graphics-Based DSS to Support Problem Structuring, *Decision Sciences*, 22, 846-868.

Luce, R. D., and Raiffa. (1957). *Games and Decisions*, John Wiley and Sons, Inc., New York.

Luft, J. (1984). *Group Processes: An Introduction to Group Dynamics*, third Ed. Mayfield Publishing Co., California.

MacCrimmon, K. R., Wagner, C., (1994). Stimulating Ideas through Creativity Software, *Management Science*, 40 (11), 112-122.

Maier, N. R. F., (1961). Quality and Acceptance of Problem Solutions by Members of Homogenous and Heterogeneous Groups., in *J. Abnormal and Social Psychology*, 62, 401-407.

Maier, N.R.F., (1970). *Problem Solving and Creativity*, Brooks Cole, California.

March, J. G., and Simon, H. A., (1958). *Organizations*, New York: John Wiley.

Markus, M.L (1997). The qualitative difference in information systems research and practice In Info Systems and Qualitative Research Proceedings of the IFIP TC8 WG 8.2 International Conference on Information Systems and Qualitative Research, Lee, A., Liebenau, DeGross, J.I (eds.), Philadelphia, Pennsylvania: 11-26.

Massetti B., (1996). An Empirical Examination of the Value of Creativity Support Systems on Idea Generation, *MIS Quarterly* (March): 83-97.

McGoff, C. and Ambrose, L., (1991). Empirical Information From the Field: A Practitioner's View of Using GDSS in Business, *Proceedings of the Twenty-Fourth Annual Hawaai Conference on System Sciences*, 3, IEEE Society, Press, Los Alamitos, CA.

McGrath, J. E., (1984). *Groups: Interaction and Performance*, Prentice Hall, Englewood Cliffs, New Jersey.

McGrath, J. E., Kelly, J. R. and Machatka, D.E., (1984). The Social Psychology of Time: Entrainment of Behavior in Social and Organizational Settings, in S Oskamp (Ed.), *Applied Social Psychology Annual*, 5, Sage, Beverly Hills, CA, 21-44.

McLaughlin-Hymes, C., and Olson, G. M., (1992). Unblocking Brainstorming Through the Use of a Simple Group Editor, *Cognitive Science and Machine Intelligence Laboratory*, 99-106.

McLeod, P. L. and Liker, J. K., (1992). Electronic Meeting Systems: Evidence from a Low Structure Environment, *Information Systems Research* 3(3), 195-233

- Melone, N. P., (1990). A Theoretical Assessment of the User- Satisfaction Construct in Information Systems Research, *Management Science*, 36 (1), 76-91.
- Midgaard, K. and Underdal, A. (1977). Multiparty Conferences, in *Negotiations: Social-Psychology Perspectives*, D. Druckman (Ed.), Sage, Beverly Hills, CA, 329-346.
- Mintzberg, H., Raissinghani, D. and Theoret, A., (1976). The Structure of “Unstructured” Decision Processes, *Administrative Science Quarterly*, June, 246-275.
- Mitchell, T. R. (1982). *People in Organizations – an Introduction to Organizational Behavior*, McGraw-Hill Book Co, New York.
- Mladenova, G. and Millwood, R., (1998). About Making Choices, www.ultralab.anglia.ac.uk .
- Nagasundaram, M. and Dennis, A. R., (1993). When a Group is not a Group: The Cognitive Foundation of Group Idea Generation, *Small Group Research*, 24,463-489.
- Nemiroff, P. M., and King, D. C., (1975). Group Decision-Making Performance as Influenced by Consensus and Self-Orientation, *Human Relations*, 28,1-21.
- Ngwenyama, O. K. and Lee, A. S., (1997). Communication Richness in Electronic Mail: Critical Social Theory and The Contextuality of Meaning, in *MIS Quarterly*, 21(2), 145-167.
- Ngwenyama, O.K., Bryson, N. and Mobolurin, A., (1996). Supporting Facilitation in Group Support Systems: Techniques for Analyzing Consensus Relevant Data, *Decision Support Systems*, 16, 155-168.

Nunamaker J.F, Jr., (1989). Experience with and Future Challenges in GDSS: *Decision Support Systems*, 5 (1), 3.

Nunamaker, J. F. Jr., Briggs, R. O., Mittleman, D. D., (1999). Electronic Meeting Systems: Twelve Years of Lessons Learned, www.ventana.corp.

Nunamaker J.F, Jr., Dennis, A. R., Valacich, J. S., Vogel, D. R., (1991). Information Technology for Negotiating Groups: Generating Options for Mutual Gain, *Management Science*, 37(10), 1325-1346.

Nunamaker, J. F. Jr., Dennis, A. R., Valacich, J. S., Vogel, D. R., George, J.F., (1991). Electronic meeting systems to support group work in *Communications of the ACM*, 34(7), 40-61.

Nunamaker, J. F. Jr., Vogel, D. R., Heminger, A., Martz, B., Grohowski, R., McGoff, C., (1989). Experiences at IBM with Group Support Systems: A Field Study, *Decision Support Systems* 5,183-196.

O, Brien, B. (1995). *Information Management Systems - Briefings and Critical Thinking*, Pitman Publishing, Long Acre, London.

Osborn, A. F., (1957). *Applied Imagination* (rev. ed), Scribner, New York.

Ouchi, W. G. and Price, R. L., (1983). *Perspectives on Behavior in Organizations*, McGraw-Hill, New York.

Peniwati, K., (1996). The Analytic Hierarchy Process: The Possibility Theorem for Group Decision Making in *Proceedings International Symposium on AHP 1996*, Simon Fraser University, Vancouver 145-151.

Peniwati, K., (1996a). Evaluation of Group Decision Making Methods, in dissertation excerpt, www.expertchoice.com/support/ahpcompare/chapter6/.

Pervan, G. P., (1998). A Review of Research in Group Support Systems: Leaders, Approaches and Directions, *Decision Support Systems* 23, 149-159.

Pervan G. P. and Atkinson, D. J., (1995). GDSS Research: An Overview and Historical Analysis, *Group Decision and Negotiation*, 4(6), 475-484.

Petkov, D., (1994). One Way to Propagate Management Policies in a Decentralised Decision Making Environments, in Trappel R. (ed.), *Cybernetics and Systems '94*, World Scientific Publ. Singapore, 1191-1198.

Phillips, L. (1996). A comment on Henig and Buchanan (1996). Solving MCDM Problems: Process Concepts, *Journal of Multi-Criteria Decision Analysis*, 5, 17.

Pinsonneault, A., and Kraemer, K. L., (1989). The Impact of Technological Support on Groups: An Assessment of the Empirical Research, *Decision Support Systems* 5, 197-216.

Pitz, G. F., Sachs, J. N. and Heerboth, J., (1980). Procedures for Eliciting Choices in the Analysis of Individual Decisions, *Organizational Behavior and Human Performance*, 26, 396-408.

Pollard, J.H. (1977). *A Handbook of Numerical and Statistical Techniques*, Cambridge University Press.

Poole, M. S. and DeSanctis, G. L., (1989). Use of Group Support Systems as an Appropriation Process, in *Proceedings of the Twenty-Second Annual Hawaii International Conference on Systems Sciences*, 4, 149-157.

- Post, B.Q., (1993). A Business Case Framework for Group Support Technology, *Journal of Management Information Systems*, 9(3), 7-26.
- Poyhonen, M and Hamalainen, R.P. (1997). *On the Convergence of Multiattribute Weighting Methods*, Technical Report A66, Systems Analysis Laboratory, Helsinki University of Technology, Helsinki.
- Pumsook, N. and Jenney, B. W., (1997). A Literature Survey of Decision Support, Systems, ...,599-611.
- Radford, K. J.,(1981). *Modern Managerial Decision Making*, Reston Publ. Reston.
- Robey, D., (1996). Research Commentary: Diversity in Information Systems Research: Threat, Promise and Responsibility, *Information Systems Research*, 7 (4), 400-408.
- Roy, B., (1977). Partial preference analysis and decision-aid: The fuzzy outranking relation concept, in Bell D.E., Keeney R. L. and Raiffa, H. (eds.), *Conflicting Objectives in Decisions*, John Wiley and Sons, 40-75.
- Roy, B. and Vanderpooten, D., (1996). The European Version of MCDA: A Historical, in Slowinski, R. (ed.) Semi Plenary papers by EURO Working Groups, 14th European Conference on Operational research, Jerusalem, 39-66.
- Saaty, R. (1996a). The Analytic Hierarchy Process and Utility Theory: Ratio Scales, in *Proceedings of the Fourth International Symposium the Analytic Hierarchy Process, Vancouver*, 22-27.
- Saaty, T. L., (1980). *The Analytic Hierarchy Process*, McGraw-Hill , New York.

Saaty, T. L., (1984). Hierarchies and Priorities, in Saaty, T. L. and Alexander, J. (eds) *Thinking with Models*, Praeger Publ.Oxford, 148-155.

Saaty, T. L., (1990). *Multicriteria Decision Making: The Analytic Hierarchy Process, Second Edition*, RWS Publications, Pittsburgh.

Saaty, T. L., (1990a). An Exposition of the Analytic Hierarchy Process in Reply to the Paper 'Remarks on the Analytic Hierarchy Process', *Management Science*, 36 (3), 259-268.

Saaty, T. L., (1991). Why the Analytic Hierarchy Process is a Valid Theory, *Proceedings of the Second Int. Symposium on the Analytic Hierarchy Process*, University of Pittsburgh, Pittsburgh.

Saaty, T. L., (1991a). A Natural Way to Make Momentous Decisions, *Journal of Scientific and Industrial Research*, 51, 561-571.

Saaty, T.L. (1991b). Inner and Outer Dependence in the Analytic Hierarchy Process: The Supermatrix and the Superhierarchy, *Proceedings of the Second Int. Symposium on the AHP*, University of Pittsburgh, Pittsburgh, 5-28.

Saaty, T. L., (1991c). What is Relative Measurement? The Ratio Scale Phantom, *Proceedings of the Second Int. Symposium on the AHP*, University of Pittsburgh, Pittsburgh, 1-15.

Saaty T. L. (1992). *MultiCriteria Decision Making – The Analytic Hierarchy Process*, 2nd.ed, RWS Publications.

Saaty T. L. (1994a). How to Make a Decision: The Analytic Hierarchy Process, *Interfaces*, 24(6), 19-46.

Saaty T. L., (1994b). *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, RWS Publications, Pittsburgh

Saaty, T. L., (1994c). A Ratio Scale and the Compatibility Scales: On the Possibility of Arrows's Impossibility Theorem, in *Proceedings of the Third International Symposium the Analytic Hierarchy Process, Washington, DC*, 33-39.

Saaty, T. L., (1996). *Decision Making With Dependence And Feedback: The Analytic Network Process*, RWS Publications, Pittsburg.

Saaty, T. L., (1997). That is Not the Analytic Hierarchy Process: What the AHP Is and What It Is Not, *Journal of Multicriteria Decision Analysis*, 6(4), 324-335

Saaty T. L. and Alexander J. (1989). *Conflict Resolution: The Analytic Hierarchy Process*, Praeger Publ. Co. Oxford

Saaty T. L. and Kearns, K.P. (1991). *Analytical Planning. The organisation of systems*, 2nd ed., RWS Publications, Pittsburgh.

Saaty, T L. and Vargas, L.G. (1991). *Prediction, Projection and Forecasting*, Kluwer Academic Publishers, Massachusetts.

Saaty, T. L. and Vargas, L.G, (1991). *The Logic of Priorities*, RWS Publications, Pittsburgh

Saaty, T L, and Vargas, L.G., (1994). The Legitimacy of Rank Reversal, *OMEGA*, 12(5), 513-516.

Salo A. and Hamalainen, R. P., (1997). On the Measurement of Preferences in the Analytic Hierarchy Process, *Journal of Multicriteria Decision Analysis*, 6, 309-319.

- Salo, A., and Hamalainen, R.P., (1996). On the Measurement of Preferences in the Analytic Hierarchy Process Research Report A47, *Systems Analysis Laboratory*, University of Technology, Helsinki.
- Sambamurthy, V., Poole, M. S., (1993). The Effects of Variations in Capabilities of GDSS Designs on Management of Cognitive Conflict in Groups, *Information System Research*, 3 (3), 224-251.
- Samson, D. (1988) *Managerial Decision Analysis*, Irwin, Homewood, Illinois.
- Schoemaker, P. J. H. and Russo, J. E., (1991). Strategies for Making Decisions: A Pyramid of Choice Procedures, A Technical Report of the *Graduate School of Business The University of Chicago*, July 17, 1-19.
- Shakun, M.F., (1992). Defining a Right Problem in Group Decision and Negotiation: Feeling and Evolutionary Generating Procedures, *Group Decision and Negotiation*, 1, 27-40.
- Shaw, M. E., (1973). Scaling Group Tasks: A Method for Dimensional Analysis, *JSAS Catalog of Selected Documents in Psychology*, 3(8), 5-25.
- Shaw, M. E., (1981). *Group Dynamics: The Psychology of Small Group Behavior*. (Third Ed), McGraw-Hill, New York.
- Siegel, J., Dubrovsky, V., Kiesler, S. and McGuire, T.W. (1986). Group Processes in Computer-mediated Communication, *Organizational Behavior and Human Decision Processes*, 37, 157-187.
- Simon, H., (1960). *The New Science of Management Decision*, Harper and Row, New York.

Simon H., (1962). The Architecture of Complexity, *Proc. Am. Philos. Society*, 106, 467-486.

Simon, H., (1977). *The New Science of Management Decision*, Rev. ed., Prentice Hall, New Jersey.

Simon, H., Dantzig, G., Hogarth, R., Plott, C., Raiffa, H., Schelling, T., Shepsle K, Thaler, R., Tversky, A., Winter, S., (1987). Decision Making and Problem Solving, *Interfaces*, 17(5), 11-31.

Srinivasan, V. R. and Jarvenpaa, S. L., (1991). Computer Support of Groups: Theory Based Models for GDSS Research, *Management Science*, 37 (10),

Stam, A. and Silva, A. P. D., (1997). Stochastic Judgments in the AHP: the Measurement of Rank Reversal Probabilities, in *Decisive Sciences*, 28 (3), 655-688.

Steeb, R. and Johnston, S. C., (1981). A Computer Based Interactive System for Group Decision Making, in *IEEE Transactions on Systems, Man and Cybernetics*, 11 (8), 544-552.

Steiner, I. D., (1972). *Group Process Productivity*, Academic Press, New York.

Stevens, C. A., Finlay, P. N., (1996). A Research Framework for Group Support Systems, *Group Decision and Negotiation*, 5, 521-543.

Stewart, T.J., (1992). A Critical Survey on the Status of Multiple Criteria Decision Making Theory and Practice, *OMEGA*, 20 (5/6): 569-586.

Stewart, T.J., (1996) A Comment on Henig and Buchanan (1996). Solving MCDM Problems: Process Concepts, *Journal of Multi-Criteria Decision Analysis*, 5, 17

Tan, B. C .Y., Teo, Hock-Hai, Wei, K-K., (1995). Promoting Consensus in Small Groups, *Information and Management*, 28, 251-259

The American Heritage Dictionary and Roget's Electronic Thesaurus, 1987, Houghton Mifflin Company.

Timmermans, D., and Vlek, C., (1996). Effects on Decision Quality of Supporting Multi-attribute Evaluation in Groups, *Organizational Behavior and Human Decision Processes*, 68(2): 158-170.

Todd, P., and Benbasat, I., (1987). Process Tracing Methods in Decision Support Systems Research: Exploring the Black Box, *MIS Quarterly*, 11(4), 493-512.

Turban, E. and Aronson, J. E., (1998). *Decision Support Systems and Intelligence Systems* (fifth Ed.) Prentice Hall, New Jersey.

Turban, E., and Meredith, A. (1994). *Fundamentals of Management Science*, (sixth Ed.), Irwin, Burr-Ridge, IL.

Turoff, M. (1999). in discussions on the GSS-ListServe newsgroup, <mailto:GSS-L@LISTSERV.UGA.EDU>

Turoff, M. and Hiltz, S. R., (1982). Computer Support for Groups versus Individual Decisions, *IEEE Transactions on Communications*, COM-30, (1), 82-90.

Vachnadze, R.G. and Markozashvili, N.I. (1987). Some Applications of the Analytic Hierarchy Process (in the Soviet Union), *Mathematical Modeling*, 9 (3), 185-191.

- Valacich, J. S., Dennis, A. R. and Connolly, T., (1994). Idea Generation in Computer-based Groups: A New Ending to an Old Story, *Organizational Behavior and Human Decision Processes*, 57,448-467.
- Valacich, J. S., Dennis, A. R., and Nunamaker, J. F., (1990). Anonymity and Group Size Effects in an Electronic Meeting System Environment, in *Small Group Research*, 3(10), 112-122.
- Valacich, J. S., Jessup, L. M., Dennis, A. R. and Nunamaker, J.F., (1992). A Conceptual Framework of Anonymity in Group Support Systems, in *Group Decision and Negotiation*, 1, 219-241.
- Vargas, L. G., (1994). Comparison of Three Multi-Criteria Decision Making Theories: The Analytic Hierarchy Process, Multi-attribute Utility Theory and Outranking Methods, in *Proceedings of the International Symposium on the Analytic Hierarchy Process, Washington*, 19-32.
- Vogel, D., Nunamaker, J., Applegate, L. and Konsynski, B., (1987). Group Decision Support Systems: Determinants of Success, in *Proceedings of the 7th International Conference on Decision Support Systems*, June: 243-255.
- Vogel, D.; Nunamaker, J.; Martz, B., Grohowski, R., and McGoff, C. (1990). Electronic Meeting System Experience at IBM. *Journal of MIS*, 6(3), Winter, 25-43.
- Vogel, D.R., Vreede, G.J. De, (1999). The Organizational Application of GSS: A Comparison Across Time and National Boundaries, in Vreede, G.J. de, Ackermann, F. (eds) *Proceedings of the 10th EuroGDSS Workshop*, Copenhagen, June, 141-143
- Volkema, R .J. (1983). Problem Formulation in Planning and Design, *Management Science*, 29, 639-652.

- von Neumann, J and Morgenstern, O. (1947). *Theory of Games and Linear Programming*, Second Ed., Wiley , New York
- Vreede, G.J. De, and Van Wijk, W., (1997). A Field Study into the Organizational Application of Group Support Systems, in: Niederman, F. (ed.) *Proceedings of the ACM SIGCPR Conference*, San Francisco, April, 151-159.
- Vroom, V., (1969). The Consequences of Social Interaction in Group Problem-Solving, *Organizational Behavior and Group Performance*, 4, 77.
- Watson, R., (1987). A Study of group Decision System Use in Three and Four-person Groups for a Preference Allocation Decision, Unpublished Doctoral Research, University of Minnesota.
- Watson, R.T., DeSanctis, G., Poole, M. S., (1988). Using a GDSS to Facilitate Group Consensus: Some Intended and Unintended Consequences, *MIS Quarterly*, 12(3), 463-478.
- Winkler, R. L., (1990). Decision Modeling and Rational Choice: AHP and Utility Theory, *Management Science*, 36(3), 247-248.
- Xiang W.Y. and Ming, W.X., (1991). Feedback Structure Model and its Application, in *Proceedings of the 2nd International Symposium on the AHP*, Pittsburgh, 96-109.
- Yin, R. K., (1984). Case Study Research, Design and Methods, *Applied Social Research Methods Series, Volume 5*, California, Sage Publications.
- Zahedi, F., (1986). The Analytic Hierarchy Process – A Survey of the Method and its Applications, *Interfaces*, 16 (4), 96-108.
- Zeleny, M., (1982). *Multiple Criteria Decision Making*, McGraw-Hill.

Zigurs, I., (1993). Methodological and Measurement Issues in Group Support Systems Research, in Jessup, L. M. and Valacich, J. S. (Eds.) *Group Support Systems: New Perspectives*, McMillan Publishing Co. New York, 112-122.

Conversations

Zondi, S. (1998) - SRC President , the University of Natal, Pietermaritzburg.

Shangase, S. (1998) - SRC Treasure, the University of Natal, Pietermaritzburg.

Appendices

APPENDIX A: Task Hand Out for the Idea Generation Laboratory Experiment

This section shows the Task Handout, which was given to both treatment groups for the idea generation task structuring exercise, which was run under laboratory conditions. It is noted that although the group was given a hand out, this served to supplement the problem explanation provided by the facilitator. The handouts given to both groups were identical in all respects except on how the problem question was structured.

The text immediately below was handed out to the subjects as is. Part a) shows the case for the single-question treatment, whereas Part b) shows what modifications were made for the multiple-question treatment group.

a) Team Expert Choice Brainstorming Session 1:-Task Handout To Single-Question Treatment

Problem: Generate ideas on the design of an information system to assist with the promotion of enthusiasm for customer service (at Fields Cookies, Pty Ltd.) and where necessary, with the compliance with this important company goal: financial and administrative functions.

1. **Principle Underlying The Business Problem, explored through an IT solution.**

There is a universal truth that states:

“People generally tend not do those things they do not like doing; plus they will do those that they like doing extremely well.”

More formally:

There is a continuous spectrum between levels of commitment or enthusiasm and compliance within individuals. In order get things done, people are motivated by one of the two factors:

- They have an intrinsic commitment to or enthusiasm for the tasks they perform. This commitment and enthusiasm drives individuals to perform optimally without much external intervention or interference.
- On the other hand, when individuals are required to perform a task for which commitment or enthusiasm is lacking, then compliance measures must be set in place in order to ensure that the task will be performed.

2. The nature of the IT task on which Creativity will be studied

Fields Cookies Pty Ltd. is a medium sized chain of Biscuit Stores, which employs, as a matter of company policy, managers whose commitment levels are very high on Customer Service Issues. They have found that frequently their managers have limited commitment or enthusiasm towards other critical business issues. This is particularly true for issues concerning matters financial and administrative. To close this gap, the company has decided to implement a business system that will support their managers in what they do best, but also to ensure that they perform the tasks they do not necessarily like doing. In other words the company wants systems are in place to make their managers comply with financial and administrative functions.

In sum, the company wants to:

Design a system that supports the company's desire to maximise the balance between the compliance-commitment dichotomy of its store managers given the following company objectives and constraints.

3. The Company Policy Objective is to

(a) To employ managers whose strengths and job focus are in maximising Customer Service. For example friendly staff, high response times, cheerful decor etc. Hence, managers are employed on the basis that their over-riding quality strength lies in their ability to provide excellent customer service. These people have high levels of commitment and natural enthusiasm for customer service, above all else.

(b) As for other management functions (e.g. financial administration.) it is calculated that the accomplishment of these functions will be as a result of compliance measures that the company puts into place.

4. The Constraints faced by the Company:

Because the chain store is a relatively medium sized business, it is not cash-flooded, it cannot afford the best educated and most experienced managers. People of such high calibre are expensive to hire and generally, only the conglomerates can afford them. Therefore, hiring additional managers whose commitment to financial administration is high is not a viable solution for Fields Cookies.

5. The System Requirements

The company seeks to install a computer system that supports all the functions that the business faces in its operations to sustain itself. The company wants to have compliance measures for the financial-administrative tasks of the stores, and support measures for the areas in which their managers are strong.

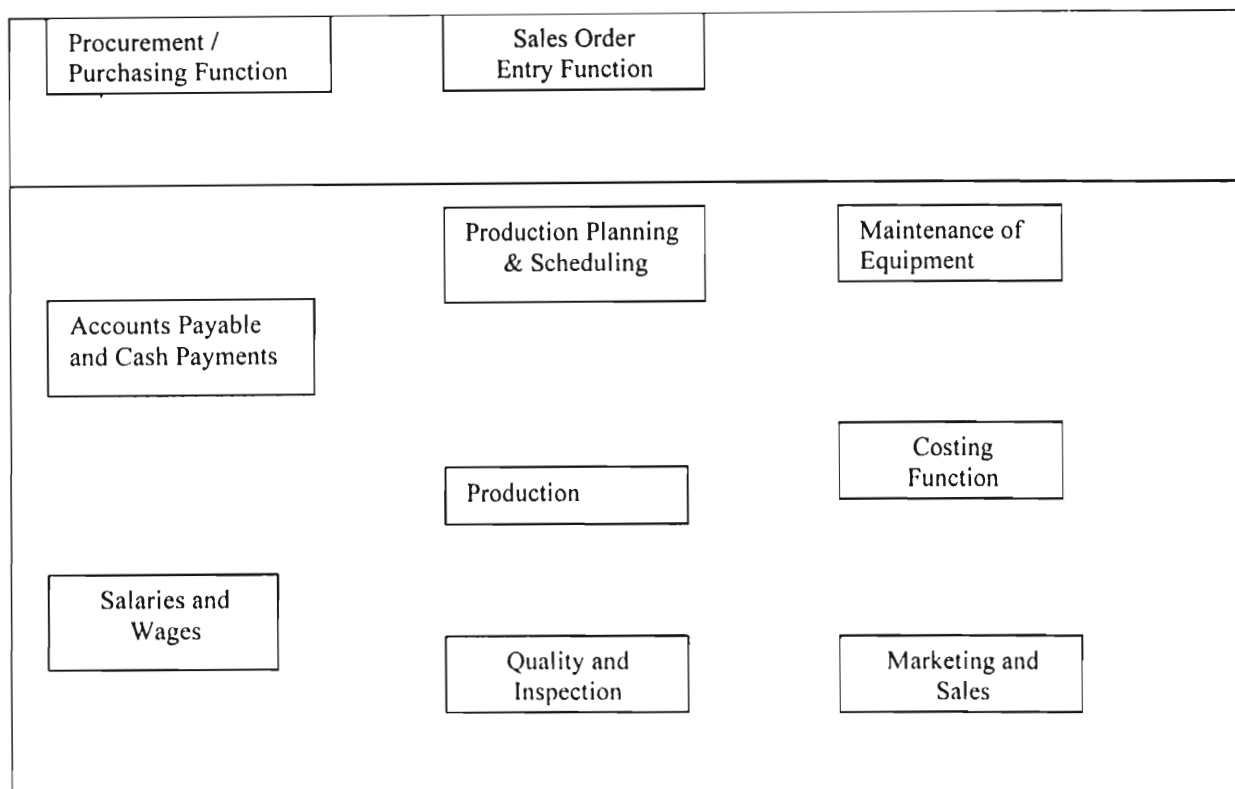
You have been given the task of identifying and suggesting the major detailed system components required by Fields Cookies (Pty) Ltd, having familiarized yourself with the issues organization faces.

6. The Formulation of the Task:

“What characteristics and components should the Fields Cookies (Pty) Ltd. business system have to support and enhance managers’ commitment to customer service plus support and enforce compliance to sound business practice in the administrative-financial aspects of running the business?”

You are required to brainstorm around this question with the objective of defining the “*must have components*” of the system under the circumstances.

Note: Underneath is a Diagram Summarizing the Business Processes at Fields Cookies (Pty) Ltd.



(b) Team Expert Choice Brainstorming Session 2: Task Handout to Multiple-Question Treatment

(As already stated the handout for this treatment group was identical to the above, except for the formulation of the task question. This group was instructed to deal serially with the two questions within allocated time slices)

6. The Formulation of the Task

1. *“What characteristics/components should the system have to support and enhance managers’ commitment to customer service?”*

II. What characteristics/components should the system have to support and enforce compliance to proper sound business practices in the administration - financial aspects of running the business?

You are required to brainstorm around these questions with objective of defining the “*must have components*” of the system under the circumstances. Brainstorm each question separately, i.e. once you have finished with the first question, only then can you tackle the second question.

Note: Underneath is a Diagram Summarizing the Business Processes at Fields Cookies (Pty) Ltd.

APPENDIX B: Post-Session Questionnaire to the Idea Generation Task

This appendix shows a specimen of the post-session questionnaire handed out to both groups, which participants filled out upon completion of the task. Subjects were asked to complete the questionnaire by circling the figure next to the expression that closely identified their feelings.

DATE: 5/24/98

RE: **GROUP:**

Please answer the following questions to complete the session.

1. How satisfied were you with the effectiveness of the process (the TeamEC Environment) used to generate ideas?

- (1) Completely satisfied.
- (2) Moderately satisfied.
- (3) Neither satisfied nor dissatisfied.
- (4) Moderately dissatisfied.
- (5) Completely dissatisfied.

2. Would you recommend this process to generate ideas?

- (1) Yes.
- (2) No.

3. Do you believe you expressed all the ideas that occurred to you?

- (1) Yes
- (2) No

If not, briefly explain why?

.....

.....

.....

4. Did you express your ideas immediately after you thought of them or did you have to wait?

- (1) Yes.
- (2) No.

If you had to wait, what was causing the wait?

.....

.....

.....

5. Did you feel comfortable about expressing your ideas?
 - (1) Very Comfortable.
 - (2) Moderately comfortable.
 - (3) Neither satisfied nor dissatisfied.
 - (4) Moderately Uncomfortable.
 - (5) Very Uncomfortable.

6. Did you ever worry about other participants knowing that you are the owner of the ideas you generated?
 - (1) Yes, all the time.
 - (2) Yes, sometimes.
 - (3) No, not at all.

7. After seeing the ideas of others, were you excited to think differently about some things?
 - (1) Yes.
 - (2) No.

8. After seeing the ideas of others, were you excited to think about more ideas which you had not thought of previously.
 - (1) Yes.
 - (2) No.

9. Did you feel there was sufficient time to tackle the problem?
 - (1) Yes.
 - (2) No

Below are the tabulated results of the questionnaire for both treatment groups. No hypothesis had been stated, the expectation was that the effect of the GSS would be equivalent.

Table B.1 Results From the post-session questionnaire for the single-question treatment group.

Questionnaire Results: All Encompassing Problem

Issue	Participants (Ratings)						Average
Participants	1	2	3	4	5	6	
1 Satisfaction	3	4	3	4	5	4	3.83
2 Process Recommendable?	1	2	2	2	2	2	1.83
3 Production Blocking	2	2	1	2	2	2	1.83
4 Immediately	2	1	2	2	2	2	1.83
5 Evaluation Apprehension	3	4	2	3	4	4	3.33
6 Evaluation Apprehension-Anonymity	3	3	2	2	3	3	2.67
7 Think different	1	2	1	2	2	1	1.50
8 Think More	2	1	1	2	2	2	1.67
9 Time Enough	2	2	1	1	2	2	1.67
	19	21	15	20	24	22	20.17

Table B.2 Results From the post-session questionnaire for the multiple-question treatment group.

Questionnaire Results: The Decomposed Problem.

Issue	Participants (Ratings)						Average
Participants	1	2	3	4	5	6	
1 Satisfaction	4	4	4	5	5	2	4.00
2 Process Recommendable?	2	2	2	2	2	2	2.00
3 Production Blocking	2	2	1	1	2	2	1.67
4 Immediately	2	2	2	1	2	1	1.67
5 Evaluation Apprehension	4	1	3	3	4	4	3.17
6 Evaluation Apprehension-Anonymity	3	2	2	2	3	2	2.33
7 Think different	2	1	1	2	2	1	1.50
8 Think More	2	2	2	2	2	1	1.83
9 Time Enough	2	1	1	1	2	1	1.33
	23	17	18	19	24	16	19.5

APPENDIX C: STATISTICAL ANALYSIS OF IDEA GENERATION TASK

The tables below show the detail calculations for the t-statistic, for the hypothesis testing discussed in chapter five. They also show the results of the test for the homogeneity of variances of the two samples (Alder and Roessler, 1977:314; Pollard, 1977).

Table C.1. Illustrating the calculation of the t-statistic for hypothesis testing on the role of task structure over the number of unique ideas (on the left hand side) and total quality (on the right hand side)

	Group 1 Group 2						Group 1 Group 2					
	Number of Unique Ideas						Total Quality					
	X	Y	X-X	(X-X) ²	Y-Y	(Y-Y) ²	X	Y	X-X	(X-X) ²	Y-Y	(Y-Y) ²
Member 1	5	9	-0.333	0.111	0.333	0.1111	18	30	-2.667	7.111	-0.667	0.444
Member 2	7	7	1.667	2.778	-1.667	2.7778	26	22	5.333	28.444	-8.667	75.111
Member 3	11	7	5.667	32.111	-1.667	2.7778	47	25	26.333	693.444	-5.667	32.111
Member 4	3	7	-2.333	5.444	-1.667	2.7778	8	27	-12.667	160.444	-3.667	13.444
Member 5	2	13	-3.333	11.111	4.333	18.7778	9	45	-11.667	136.111	14.333	205.444
Member 6	4	9	-1.333	1.778	0.333	0.1111	16	35	-4.667	21.778	4.333	18.778
	10						10					
Group Total	32	52.00	0.000	53.333	0.000	27.333	124	184	0.000	1047.333	0.000	345.333
Mean	5.333	8.667					20.667	30.667				
Standard deviatio	3.268	2.338					14.473	8.311				
Variance	10.667	6.487					209.467	69.067				
For t												
Numerator	-10.54093		-10.54093				-31.62278		-31.62278			
Denominator	0.44721	12.04990	5.38888				0.44721	50.06795	22.39107			
t			-1.95605						-1.41229			
t-statistic			1.18120						1.18120			
F-stat	1.951						3.033					
F (5,5)	5.05						5.05					
(Pollard, 1977)	1.951 < 5.0 Therefore difference in variances is not significant						3.033 < 5.0 Therefore difference in variances is not significant					

Table C. 2 Illustrating the calculation of the t-statistic for hypothesis testing on the role of task structure over the mean quality of ideas (on the left hand side) and the number of good ideas (on the right hand side)

	Group 1 Group 2						Group 1 Group 2					
	Mean Quality						Number of Good of Ideas					
	X	Y	X-X	(X-X)2	Y-Y	(Y-Y)2	X	Y	X-X	(X-X)2	Y-Y	(Y-Y)2
Member 1	3.6000	3.3333	-0.192	0.037	-0.209	0.044	4	7	-0.500	0.250	-0.500	0.250
Member 2	3.7143	3.1429	-0.078	0.006	-0.400	0.160	6	5	1.500	2.250	-2.500	6.250
Member 3	4.2727	3.5714	0.480	0.231	0.029	0.001	10	7	5.500	30.250	-0.500	0.250
Member 4	2.6667	3.8571	-1.126	1.267	0.315	0.099	2	7	-2.500	6.250	-0.500	0.250
Member 5	4.5000	3.4615	0.708	0.501	-0.081	0.007	2	11	-2.500	6.250	3.500	12.250
Member 6	4.0000	3.8889	0.208	0.043	0.346	0.120	3	8	-1.500	2.250	0.500	0.250
	10.0000						10					
Group Total	22.7537	21.2552	0.000	2.085	0.000	0.430	27	45	0.000	47.500	0.000	19.500
Mean	3.7923	3.5425					4.500	7.500				
Standard deviation	0.6457	0.2932					3.082	1.975				
Variance	0.4170	0.0860					9.600	3.900				
For t												
Numerator	0.78977		0.78977				-9.48683		-9.48683			
Denominator	0.44721	2.12757	0.95148				0.44721	10.98180	4.91121			
t			0.83006						-1.93167			
t-statistic			1.18120						1.18120			
F-stat	4.860						2.436					
F (5,6)	5.05						5.05					
(Pollard, 1977)	4.850 < 5.0 Therefore difference in variances is not significant						2.436 < 5.0 Therefore difference in variances is not significant					

APPENDIX D: SOME DATA ON THE INDICATORS USED TO SUPPORT CONSENSUS BUILDING

In the support for consensus many consensus data indicators, as defined by Ngwenyama et al. (1996) were generated and analyzed The indicator values shown here relate to the original criteria, which elicited intense discussion relative to the defined intensities. Below is a summary of the process building up to consensus.

Table D.1 Group Strong Agreement Quotient (GSAQ) identifying the percentage of pairs of group members who have a reasonably strong level of agreement

	S W(1), W(GM)	S W(2), W(GM)	S W(3), W(GM)	S W(4), W(GM)	S W(5), W(GM)	S W(6), W(GM)	S W(7), W(GM)	S W(8), W(GM)	GSAQ
CONSTITUTIONAL	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.63
POLITICAL	0.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.50
RELIGIOUS	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.25
CULTURAL	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.25
FACULTY	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.50
ENTERTAINMENT	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.50
DEVELOPM	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.50
DIVERSITY	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Membership Size	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.63
Amount Requested	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.38
Amount Rewarded	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.25
Expense Management	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.88
Perceptions	0.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.38
Income History	0.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00	0.38

The Individual Strong Agreement Quotient (ISAQ) illustrated in Table D.2 used to identify those members who, for the defined criteria, were prime candidates around which to build consensus. Such members were encouraged to lead discussion.

Table D.2 The Individual Strong Agreement Quotient (ISAQ)

ISAQ	constitution	membership size	amount requested	amount rewarded	expenditure management	perceptions	income history
SRC01	0.50	0.50	0.63	0.50	0.75	0.00	0.13
SRC02	0.50	0.50	0.00	0.50	0.38	0.38	0.13
SRC03	0.50	0.50	0.50	0.50	0.38	0.38	0.25
SRC04	0.50	0.50	0.25	0.50	0.50	0.38	0.13
SRC05	0.13	0.13	0.00	0.13	0.38	0.25	0.00
SRC06	0.13	0.13	0.50	0.13	0.50	0.25	0.13
SRC07	0.00	0.50	0.50	0.13	0.00	0.38	0.25
SRC08	0.50	0.00	0.38	0.38	0.63	0.25	0.25

Individual Strong Disagreement Quotient (ISDQ)

The usefulness of this indicator is in assisting highlight the individual of interest in building consensus and promoting a compromise position. It is looked at in conjunction with data in Table D.1 .

Table D.3 The Individual Strong Disagreement Quotient (ISDQ)

ISDQ	constitution	membership size	amount requested	amount rewarded	expenditure management	perceptions	income history
SRC01	-0.38	-0.38	-0.25	-0.38	-0.13	-0.88	-0.75
SRC02	-0.38	-0.38	-0.75	-0.25	-0.38	-0.50	-0.75
SRC03	-0.38	-0.13	-0.38	-0.38	-0.38	-0.50	-0.63
SRC04	-0.25	-0.13	-0.25	-0.38	-0.38	-0.50	-0.75
SRC05	-0.63	-0.50	-0.88	-0.75	-0.50	-0.63	-0.88
SRC06	-0.75	-0.50	-0.25	-0.50	-0.13	-0.63	-0.75
SRC07	-0.75	-0.25	-0.13	-0.63	-0.75	-0.38	-0.50
SRC08	-0.38	-0.88	-0.50	-0.50	-0.25	-0.63	-0.63

A Summary Relating to the Important Criteria and the Intensities of the Criterion Constitutional Objective:

Expenditure management (GSAQ at 0.88) was almost unanimously rated as the most important criterion with respect to the allocation of funds (the goal). Further, the node's sub-criteria (intensities) were fairly straightforward and were agreed. The group was convinced and did not engage in further discussion in this regard. With a GSAQ of 0.88, the usefulness of the consensus relevant data was reassuring at this stage

Constitutional Objective (GSAQ at 63%) was the criterion up next for discussion. In practice, although there was not sufficient consensus, all the group had to do was convince one extra person and consensus would be sufficient. More significantly, however is examining the power of the members comprising the GSAQ at 63%, for in practice that is the reason why issue was passed without “acrimonious discussion.” Four of the five members i.e. members 1, 2, 3, 4, are the President, his deputy, the only woman in the group and the Secretary General. All four members command a lot of respect for their position, experience and/or independence of mind. That member 8 showed high levels of agreement with these four members was a numbers-bonus. All four members did not need encouragement to speak in this regard.

Nonetheless, The extent of agreement between these five members was more easily decipherable from their similarity functions, seen in Table 10, below.

SRC02 and SRC03 at $S(w^2, w^3) = 0.78$ shared the strongest level of agreement, followed by SRC01 and SRC08 at $S(w^1, w^8) = 0.68$ with the next strongest level of agreement, followed by SRC03 and SRC04 at $S(w^3, w^4) = 0.66$ followed by SRC02 and SRC04 at $S(w^2, w^4) = 0.60$.

a) **Development Promoting** (GSAQ at 50%): The value of engaging in activities that are designed to the development of students was rated as the most important intensity (see Figure 5.2 above). Following the discussion on the importance of entertainment members 3,5, and 6 volunteered to change their ratings in principle in order to arrive at 100% consensus. The issue was closed without much discussion.

b) **Diversity Promoting** (GSAQ at 13%): This was discussed in the main body of this study.

d) **Politics Promoting** (GSAQ at 50%). Members were relatively satisfied with the rating of this intensity, viewed against the other intensities. The facilitator individually polled Members 1,5, 6 and 7; their ratings were the obstacle to sufficient consensus. The President (Member 1) indicated he was happy in principle with the group rating, he had no “substantive objections” in light of the fact that this rated higher than “cultural, religious and faculty considerations”. The other three

members were asked to change their ratings. They agreed to do this in principle provided the ratings of “cultural, religious and faculty” were not subsequently adjusted upward.

e) **Culture Promoting** (GSAQ at 38%) At this stage members merely wanted to look at this issue relative to the religious intensity only. Members were polled individually to indicate any disagreement with the group preference rating and there were no objections. Consensus was reached. **Religion Promoting** (GSAQ at 38%) rated second last, above faculty and was discussed simultaneously with the intensity referencing the promotion of cultural issues. Thus the group rating prevailed.

f) **Faculty Councils** (GSAQ at 50%): The intensity referencing the importance faculty councils was rated as the least important. The academic development officer was asked to lead the discussion. she agreed with the group rating. She summarized the issue as follows. *“The issue with faculty councils as you all know is, we think these should be funded by the faculties they serve. SRC funds are limited as it is. Faculty councils play a very specific role, the SRC concerns itself with general student issues.”* The SRC had pondered this issue at length, it appeared. There was no substantive disagreement reflected by the Individual Strong Disagreement Indicator (ISDI) values and their individual preference vectors: Members 1,2,6,7,and 8 rated it as the least important, while Members 3 and 4 rated it as the second last important. The group rating was accepted.

APPENDIX E. A POST SESSION QUESTIONNAIRE FOR THE FIELD STUDY

Subjects were asked to rate the following in order to gauge for satisfaction with the process and the effects of the technology, the decision approach (the Analytic Hierarchy Process)and the facilitator on group ownership of the solution. These were assigned a judgment on a scale from 1 to 7. They were required to circle the relevant answer.

1. How satisfied were you with the process used to assist in making your decisions? Would you recommend it?

- (1) Extremely satisfied
- (2) Very satisfied
- (3) Satisfied
- (4) Neither satisfied nor dissatisfied
- (5) Dissatisfied
- (6) Very dissatisfied
- (7) Extremely Dissatisfied

2. How difficult was it understand the process?

- (1) Extremely easy
- (2) Very easy
- (3) Easy
- (4) Neither easy nor difficult
- (5) Difficult
- (6) Very difficult
- (7) Extremely Difficult

3. Did you ever feel the facilitator made issue decisions for the group?

- (1) Never
- (2) Almost never
- (3) Less than sometimes
- (4) Sometimes
- (5) A good many times
- (6) Almost all the time
- (7) All of the Time

4. Did you ever feel the (AHP) method used made issue decisions for the group?

- (1) Never
- (2) Almost never
- (3) Less than sometimes
- (4) Sometimes
- (5) A good many times
- (6) Almost all the time
- (7) All of the Time

5. Did you ever feel the TEAM EC software made issue decisions for the group?

- (1) Never
- (2) Almost never
- (3) Less than sometimes
- (4) Sometimes
- (5) A good many times
- (6) Almost all the time
- (7) All of the Time

6. Would you recommend this process for future complex decisions your organization may have to make?

- (1) All of the Time
- (2) Almost all the time
- (3) A good many times
- (4) Sometimes
- (5) Less than sometimes
- (6) Almost never
- (7) Never

7. With what level of certainty can you say the solution generated by the group is the group's own solution?

- (1) 76 -- 100 percent
- (2) 61 -- 75 percent
- (3) 46 -- 60 percent
- (4) 31 -- 45 percent
- (5) 16 -- 30 percent
- (6) 1-15 percent
- (7) 0 percent

8. How do you think the process has affected the capacity of your group to work together again?

- (1) Extremely well
- (2) Very well
- (3) Well
- (4) Neither well nor badly
- (5) Badly

- (6) Very badly
- (7) Extremely badly

TableE.1 Summary of the responses of the post-session questionnaire to the field study on supporting consensus building.

	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7	Member 8	AVERAGE	
Question 1	7	7	7	7	7	7	7	7	7.00	1.00
Question 2	7	7	5	5	6	6	6	4	5.75	0.82
Question 3	7	7	7	7	5	6	5	5	6.13	0.88
Question 4	7	7	7	7	7	7	7	7	7.00	1.00
Question 5	7	7	7	7	7	7	7	7	7.00	1.00
Question 6	7	7	7	7	7	7	7	7	7.00	1.00
Question 7	7	7	7	6	6	6	7	6	6.50	0.93
Question 8	7	7	7	7	7	7	7	7	7.00	1.00