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AN EMPIRICAL TEST OF A DECISION SUPPORT SYSTEM IN A GROUP DECISION-MAKING ENVIRONMENT

Arizona State University D.B.A. 1984

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AN EMPIRICAL TEST OF A DECISION SUPPORT SYSTEM IN A GROUP DECISION-MAKING ENVIRONMENT

by

Michael R. Ruble

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Business Administration

Arizona State University

August 1984

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IN A GROUP DECISION-MAKING ENVIRONMENT

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ABSTRACT

Computer-based decision aids are purported to provide many benefits to their users. One of the primary benefits is increased decision effectiveness. One appropriate method for defining decision effectiveness is by measuring decision outcomes. Another important benefit expected to be derived from DSS usage is an increased rate of learning. Operationlization of learning rate can be affected by measuring the change in decision outcomes over time.

This study's purpose was to provide empirical evidence that a DSS could positively impact decision effectiveness in a group decision-making environment. In addition, the effect of DSS usage on the rate of learning was investigated.

The research approach employed was a laboratory study designed to capture the effects of DSS usage on decision outcomes. A total entity business game served as the decision-making environment. Multi-period game results were operationalized as the decision outcomes.

In this study, DSS usage was not found to increase decision effectiveness or learning rate in a group

decision-making environment. It is suggested that task complexity and the quantity and quality of interactions between the DSS and its users could explain the experimental results as sufficiently as any flaw in DSS theory.

DEDICATION

To Mikie A., who does not understand but some day may, to Mary J., who does not understand but does not care and to Moeder, who understands but has no sympathy. They get all my love and many thanks!

ACKNOWLEDGEMENTS

I extend sincere thanks to Dr. J. Hal Reneau for all his assistance and encouragement in his capacity as dissertation chairman. I also extend appreciation to Dr. Andy Philippakis, Dr. Joe Wilkinson, Dr. Sue McKinley and especially Dr. Sheila Adams for allowing me to intrude into her classes for a semester.

Many thanks to my parents for their support and the word processor which made this task much more bearable.

Finally, to Vickie, Mary J. and Mikie A. for letting me know from time to time that there is life outside the dissertation.

TABLE OF CONTENTS

	Page
LIST OF TABLES	xi
LIST OF FIGURES	xii
CHAPTER	
I. PURPOSE AND DESIGN	1
Introduction	1
Problem Statement	3
Significance of the Problem	4
Research Approach	5
Significance of the Study	6
Assumptions and Limitations	7
Organization of the Study	8
II. REVIEW OF RELATED LITERATURE	9
Decision Support Systems	9
Concept	9
Framework	14
Evaluation	16
Learning and DSS	22
Group DSS	24
Group Decision-Making	25
Decision Process	25

CHAPTER Page

Group Cohesiveness 27

Chapter Summary 29

III. RESEARCH METHODOLOGY 31

Model for Research 31

Research Questions 33

Hypotheses 34

Decision Environment 35

Experimental Environment 36

Subjects 36

Group Formation 37

Experimental Groups 38

Control Groups 39

DSS Generator 39

Specific DSS 39

Traditional Information System 40

Technical Intermediary/DSS Builder 40

Measurement of Variables 41

Cohesiveness 41

Decision Outcomes 42

Learning 43

Model for Data Analysis 46

Chapter Summary 47

CHAPTER	Page

IV. DATA ANALYSIS 48

Model Development and Testing 48

Factor Analysis 50

Demographic Analysis 55

Preliminary Tests 57

World Effect 57

Cohesiveness Effect 58

Test of Hypotheses 62

Hypotheses 1 62

Hypothesis 2 67

Chapter Summary 71

V. SUMMARY,CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH 72

Summary 72

Research Approach 73

Results 75

Conclusions of the Study 77

Cohesiveness Covariate 77

Decision Effectiveness 78

Learning 81

Assumptions and Limitations 82

Implications and Direction for Future Research 84

Summary 87

Page

BIBLIOGRAPHY 88

APPENDICES 91

A. Initial Model of the Firm 92

B. Cohesiveness Instrument 97

C. Sample Reports and Listings 100

D. Academic Major by Company 109

E. Summarized Business Game Instructions 112

LIST OF TABLES

Table		Page
1.	DSS Benefits	18
2.	Examples of Measures for DSS Evaluation	20
3.	Decision Outcome Variables	44
4.	Pro Forma Financial Statements and Reports	49
5.	Rotated Factor Loadings	52
6.	Factor-score Coefficient Matrix	54
7.	Demographic Variables by World By Group	56
8.	MANOVA for World Effect	59
9.	ANOVA's of Cohesiveness Variable	61
10.	Regression of Factor Scores on Post-Game Cohesiveness Scores	63
11.	MANOVA for Group Effect - World One	65
12.	MANOVA for Group Effect - World Two	66
13.	ANCOVA for Learning Rate - World One	69
14.	ANCOVA for Learning Rate - World Two	70
15.	DSS Usage by Group	83

LIST OF FIGURES

Figure		Page
1.	Gorry and Scott Morton's Framework	11
2.	Sprague's DSS Framework	17
3.	Simple Model of Decision-Making Groups	26
4.	Model of Small Group Interaction and Task Performance	28
5.	Model for Research	32
6.	Expected Learning Curves	45

CHAPTER I

PURPOSE AND DESIGN

Introduction

In recent years the concept of computer-aided decision making has been formalized under the heading of Decision Support Systems (DSS). Much theoretical groundwork has been done by Sprague (1980), Sprague and Carlson (1982), Keen and Scott Morton (1978) and others. However, little empirical research has been performed to verify the theoretical framework purported to support the DSS concept. To date, a majority of the research in DSS has focused on decision maker perceptions or the decision-making process rather than decision outcomes. While this is valuable research which needs to be done, examination of decision outcomes should be a major concern of DSS research. The objective of this study is to test whether a DSS can positively impact decision effectiveness in a group decision-making environment.

One of the primary beliefs regarding DSS is that the use of an interactive decision aid will increase decision effectiveness (Keen, 1981). From a theoretical standpoint, there is little consensus regarding the definition of effectiveness. However, empirically it is essential to operationalize decision effectiveness in a meaningful manner. One appropriate method for defining decision effectiveness is measurement of decision outcomes.

Another possible benefit of DSS, which has received little attention, is an increased rate of learning by the decision maker. Such a benefit could mitigate the effects of the learning curve in situations in which repetitive decisions are made. The effective operationalization of learning rate is dependent upon the ability to properly define a decision context in which the effect could be measured.

Past empirical work on computer-aided decision-making, such as the Minnesota experiments described by Dickson, Senn and Chervany (1977), has examined the effects of differential information systems on the decision process. DSS can be considered a logical extension of the management information systems (MIS) context in which those earlier studies were performed. Therefore, it appears that a similar research approach would be appropriate for the examination of potential DSS benefits.

The majority of DSS studies have examined DSS effects on individual decision makers. While this is still of interest, the effects on group decision-making are also important. Many decisions in business organizations are not made by one person but rather a group of individuals with a common purpose.

Group decision-making is a complex process affected by all the factors relevant to individual decision-making plus factors unique to groups. The most cited of these group factors are size, composition, cohesiveness and structure. These will be examined later in the context of a model of decision-making groups developed by Collins and Guetzkow (1964).

If DSS benefits can be attained by groups using a specific DSS, it may be possible to increase group decision effectiveness. As a result, businesses and other organizations could accrue increased profits and/or other rewards through the use of decision-making groups.

This research focuses on the use of a DSS in a group decision-making environment. Of interest are the effects of DSS on group decision effectiveness and group learning. Decision outcomes are used to measure the decision effectiveness of a particular group. Learning is measured by the change in decision outcomes over time.

Problem Statement

For DSS to be considered useful in a business environment, it is necessary to demonstrate that DSS aided decision-making results in better decisions. Equal decisions at a lower cost would also be desirable but it is assumed that the high cost of DSS leads to a higher cost in making a particular decision. The issue is incremental decision quality. The primary question can be stated simply. Can a DSS be implemented that will increase the effectiveness and/or rate of learning for group decision-makers?

The purpose of this study is to test whether a specific DSS can impact decision effectiveness in a group decision-making environment. Additionally, it is hoped that such application will result in groups demonstrating an increased rate of learning.

Significance of the Problem

Group decision-making is a complicated and fragile process. An intervention into that process that results in more desirable decision outcomes would be most welcomed in many business entities. A DSS can be viewed as an intervention since it impacts and is impacted upon by a number of group variables.

An improvement of group decision effectiveness through DSS usage could lead to significant changes in the ways that groups interact. Projects such as the SMU Decison Room, as reported by Gray (1981), and the MINDSIGHT research reported by Wagner (1981a) and Kull (1982) are examples of how computer-aided decision making could restructure the group decision-making process. However, before such strides can take place it is necessary to determine the worth of DSS in the group decision-making environment.

Research Approach

The major research question of this study is whether a specific DSS can have a positive impact on decision outcomes in a group decision-making environment. To test this question, the research approach must be able to isolate the potential DSS effects while maintaining a rich decision environment. To achieve these purposes, a laboratory study approach is selected which utilizes a total entity business game as the simulated decision-making environment.

Senior level business students, acting as surrogates for business decision-makers, are formed into groups to play the game over the course of a semester. Half of the groups are provided access to a specific DSS while the other half serve as control groups. Decision outcomes are statistically analyzed to determine if significant differences exist between the groups.

This research approach has been employed successfully in MIS research. Its application to DSS research seems most appropriate since the research objectives are almost identical. Studies such as those of Mock (1969,1973) and the Minnesota experiments reinforce the use of this approach for DSS research.

In their review and critique of MIS research, Ives, Hamilton and Davis (1980) discuss the importance of including process variables, such as decision outcomes, in information systems research. This study follows their recommendations by employing decision outcomes as the dependent variables.

Significance of the Study

The primary objective of this study is to test the effects of DSS usage in a group decision-making environment. The analysis may have important ramifications for both DSS and the group decision-making process.

If it is shown that DSS does have a positive impact upon decision outcomes then a major tenet of DSS will gain experimental support. This link between decision outcomes and DSS usage is critical if DSS are to gain and maintain widespread acceptance. The importance of DSS in the decision-making process only holds true if DSS usage does result in increased decision effectiveness.

Evidence showing that the group decision-making process is positively affected by DSS usage could lead to significant changes in how decision-making groups approach their tasks. Electronic boardrooms, such as that discussed in the MINDSIGHT research, and other computerized facilities for groups could become a reality.

Assumptions and Limitations

The ability of this study's DSS to have a positive impact on decision outcomes is subject to the quality and quantity of interactions between the DSS and the experimental groups. While the groups are encouraged to utilize the DSS, and their usage monitored, there is no requirement that they avail themselves of the DSS. This approach is taken for the sake of realism.

The decision environment employed is a business game. Its ability to depict a rich and real experimental setting and provide appropriate stimuli for decision makers is assumed. While all such games must sacrifice some reality, the game employed provides a realistic experimental setting.

Students are used as surrogates for business decision makers. Much has been written about this limitation in research. However, since control over relevant experimental variables was desired, it was essential to conduct the study in a laboratory setting. As a result, the use of business decision makers was not possible due to the time commitment required by the game. Therefore, the choice was made to use business students in an experimentally realistic setting.

Organization of the Study

The first chapter has provided an overview of the study. The research problem and approach are discussed. In addition, the significance and limitations of the study are described.

The second chapter provides a review of literature relevant to the design of this study. The review consists of two parts. The first addresses sources regarding decision support systems. The second examines the group decision-making process and the variables relevant to its study.

Chapter III discusses the research methodology employed in this study. The model for research is developed, research hypotheses stated and the decision and experimental environments defined. Also, the model for data analysis is described.

Results of the research and data analysis are presented in Chapter IV.

The final chapter provides a summary of the study and conclusions regarding the results. Limitations and implications of the research results are discussed and suggestions for future research are made.

CHAPTER II

REVIEW OF RELATED LITERATURE

This study was founded in two major research areas: (1) decision support systems and (2) group decision-making. This chapter relates the findings of the review of the relevant research findings in the two areas.

Decision Support Systems

Concept

In 1971, Michael Scott Morton put forth the idea of management decision systems, later to be rephrased decision support systems (DSS) by Peter Keen. The concept is simple: computer based data retrieval and analysis systems render support to management in their decision-making processes. Keen and Wagner (1979) have since coined the term "executive mind-support" and define a DSS as follows:

> A decision support system (DSS) is a computer-based system (say, a data base management system or a set of financial models) which is used personally on an

> ongoing basis by managers and their immediate staffs in direct support of managerial activities--that is, decisions. (p. 117)

However, even simple terms have a way of getting twisted. A review of the literature finds many different ideas regarding what a DSS is or does. As Alter points out, "Upon hearing that general ledger systems, financial planning models, programming languages, data bases with query capabilities, etc., are all DSS, it is not clear what is going on and whether the DSS movement actually has anything coherent to say" (Alter, 1981, p. 8).

Scott Morton's concept rests on a framework which combines Simon's dimension of task structuredness with Anthony's classification of managerial activities as shown in Figure 1, known as Gorry and Scott Morton's framework. This initial effort had DSS located at the strategic planning level and in the semi-structured task zone. It was reasoned that only top management would have need for a DSS and the requirement of some structure for computer application would limit DSS to either semi-structured or structured tasks with the latter being more the domain of EDP and MIS.

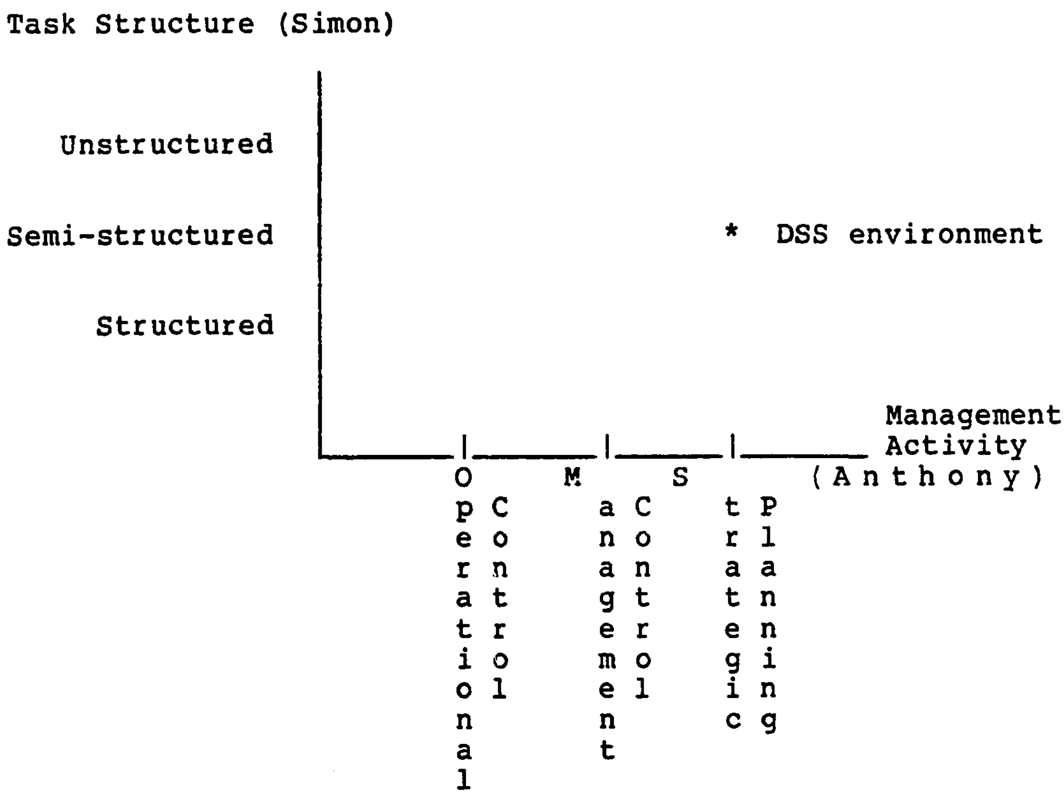

Figure 1. Gorry and Scott Morton's Framework

DSS was moved out of its one dimension into all levels by Sprague (1980) and Akoka (1981). Both pointed to potential applications for DSS which existed at all levels of management and possessed varying degrees of structure. Two of Sprague's (1980) performance requirements for DSS address this point directly:

1. A DSS should provide support for decision making, but with emphasis on semi-structured and unstructured decisions.

2. A DSS should provide decision making support for managers at all levels, assisting in integration between the levels whenever appropriate. (p. 12)

Thus DSS should be able to support decisions at all levels of the organization and with any degree of structure.

A third dimension, task interdependency, was added to the framework by Hackathorn and Keen (1981). The purpose of this dimension is to accommodate interpersonal relations within an organization. The nature of these interactions is said to depend upon the task being faced by the decision-maker. Task interdependency, borrowed from J.D. Thompson, defines tasks into three types:

1. Independent - A task is independent if a person can perform the task without interaction with other persons.

2. Pooled - A task is pooled if two or more people must interact in order to perform their respective tasks.

3. Sequential - A task is sequential if several people can only perform their respective tasks in a certain sequence in which the outputs of one task must be used as the inputs to another task. (p. 23)

Using task interdependency, Hackathorn and Keen separate decision support into three distinct components:

1. Personal Support focuses on a user or class of users in a discrete task or decision that is relatively independent of other tasks.

2. Group Support focuses on a group of individuals, each of whom are engaged in separate, but highly interrelated, tasks.

3. Organizational Support focuses on an organizational task or activity involving a sequence of operations and actors. (p. 24)

To date, the majority of the practical applications and empirical research efforts have been aimed at the independent task area. As a result, this new dimension opens up a whole new field of research in DSS, which has only recently begun to be examined (Gray, 1983).

In summary, DSS are computer-based decision aids designed to support managers in complex tasks. Such systems are intended to support and improve a decision process without replacing the decision-maker. DSS usage attempts to reduce uncertainty within a stochastic environment. Therefore, it relies heavily on external information and produces results of a probabilistic nature.

Framework

A framework for DSS development was put forth by Sprague (1980) and further elaborated on by Sprague and Carlson (1982). This framework consists of three levels of technology, which are employed by individuals and/or groups holding various roles within the DSS framework. The three levels of technology are:

Specific DSS - A system which actually accomplishes the work. The model(s) for a specific application.

DSS Generator - A package of related hardware and software which provides a set of capabilities to quickly and easily build a specific DSS.

DSS Tools - Hardware or software elements which facilitate the development of a specific DSS or a DSS generator. Examples include graphics capabilities, conversational technology, database management systems, applications of higher level languages, and new special purpose lanaguages.

These three levels interact such that a specific DSS could rise out of a DSS generator, a DSS tool or a combination of both. Generally, a DSS generator will be created using DSS tools.

The roles that could exist include the manager or decision maker, the DSS builder, the intermediary, the technical supporter and the toolsmith. The intermediary acts as a buffer between the manager and the model builder to facilitate communication and relieve the manager of possessing a very deep understanding of the technical issues. The technical supporter and toolsmith are in the background handling the necessary technical issues of the DSS generator (technical supporter) or the DSS tools (toolsmith).

The final element of Sprague's framework is the development approach of DSS. The standard step approach to systems design is not appropriate for DSS because of the rapidity of change in the conditions which decision makers face. As a result the functional requirements of the system are continually being altered. Rather, he suggests a one step, iterative design process with short, rapid feedback loops to insure proper development of a DSS. Accompanying the idea of iterative design is the concept of an adaptive system. Such a system is one which is not cast in concrete but instead is molded over time as changing circumstances require. Figure 2 (Sprague and Carlson,1982) portrays the various relationships within the framework and provides examples of some of the elements making up each component.

The framework helps in providing support for the contention of many researchers, supported by a survey (Wagner,1981b), that managers either are not interested or are too busy to personally develop or run models. Rather, they will rely on the intermediary and/or model builder. Thus, any investigation into DSS usage needs to consider this relationship between the manager and the technology.

Evaluation

What are the benefits that DSS provides and what methods are available to evaluate them? DSS benefits tend to be application specific but several attempts have been made to develop general benefits which would apply to all DSS. Keen (1981) lists twelve benefits "frequently cited in DSS case studies" along with his estimation of the ease of measurement and ability to monetarily quantify the benefits. In Keen's estimation, only the cost saving and time saving benefits can be transformed directly into "bottom line" effects. The other benefits may accrue financial gains but no measurement methods exist which can capture, with any degree of validity, their effects. Keen's list of benefits is shown in Table 1.

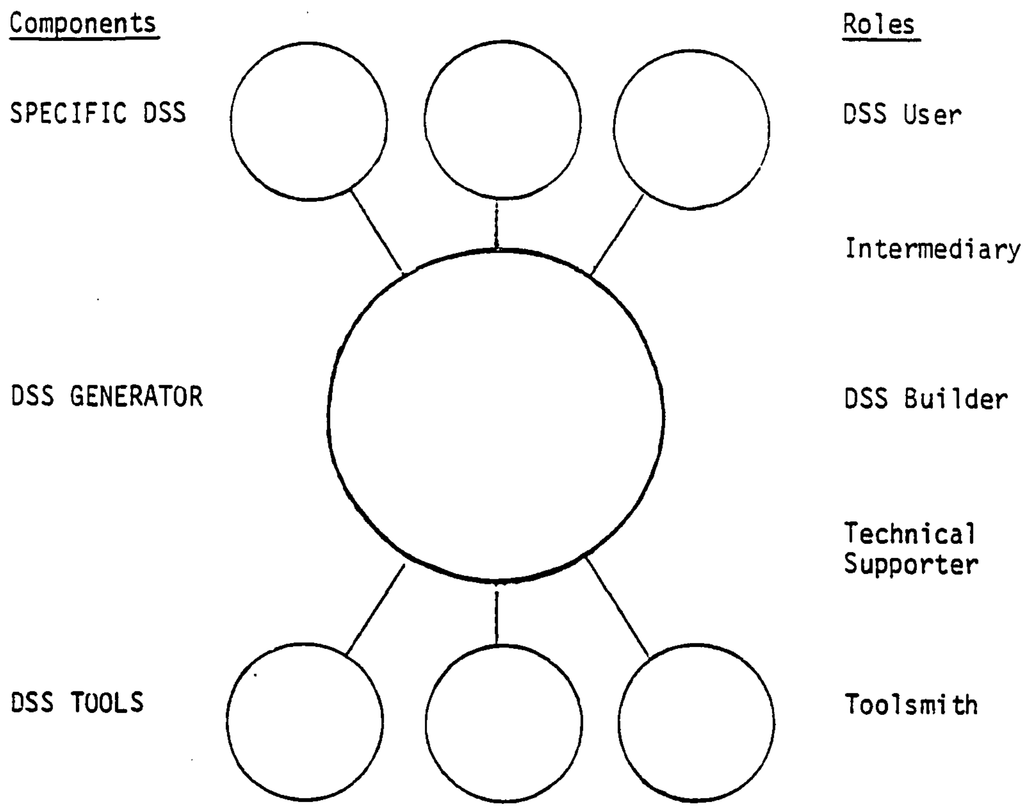

Figure 2. Sprague's DSS Framework. Adapted from Ralph D. Sprague, "A Framework for the Development of Decision Support Systems", MIS Quarterly, December 1980, p. 9.

Table 1. DSS Benefits.

	Easy to measure?	Can benefit be quantified in a "bottom line" figure?
1. Increase in number of alternatives examined.	Yes	No
2. Better understanding of the business.	No	No
3. Fast response to unexpected situations	Yes	No
4. Ability to carry out ad hoc analysis	Yes	No
5. New insights and learning	No	No
6. Improved communication	No	No
7. Control	No	No
8. Cost Savings	Yes	Yes
9. Better decisions	No	No
10. More effective teamwork	No	No
11. Time savings	Yes	Yes
12. Making better use of data resource	Yes	No

From Peter G.W. Keen, "Value Analysis: Justifying Decision Support Systems", MIS Quarterly, March 1981, p. 7.

Sprague and Carlson discuss four types of measures which can be used to evaluate DSS. The four types along with examples are listed in Table 2. While similar to Keen, this approach is more structured since the four areas address all aspects of the decision process, segregated by segment measured. In addition, Sprague and Carlson provide suggested measurement methods for each of the four types of measures.

Most of the literature cites "better decisions" as the major benefit of DSS. Measurement of better decisions needs to focus on the outputs of the decision process. A more desirable decision outcome is necessary evidence that a better decision was made. Measures such as cost and time savings from Table 1 and results of the decision from Table 2 are good examples of appropriate decision quality measures. All the other benefits can be classified as signs that a better decision may have been made, not that it was made.

Once it has been decided what is to be measured, the next step is to develop a method for evaluation of the DSS. Several methods or procedures have been conceptualized as being appropriate for DSS evaluation. Representative of these are those discussed by Keen (1981), Sprague and Carlson (1982) and Akoka (1981).

Table 2. Examples of Measures for DSS Evaluation.

PRODUCTIVITY MEASURES
1. Time to reach a decision
2. Cost of making a decision
3. Results of the decision
4. Cost of implementing the decision

PROCESS MEASURES
1. Number of alternatives examined
2. Number of analyses done
3. Number of participants in the decision-making
4. Time horizon of the decision
5. Amount of data used
6. Time spent in each phase of decision-making
7. Time lines of the decision

PERCEPTION MEASURES
1. Control of the decision-making process
2. Usefulness of the DSS
3. Ease of use
4. Understanding of the problem
5. Ease of "selling" the decision
6. Conviction that the decision is correct

PRODUCT MEASURES
1. Response time
2. Availability
3. Mean time to failure
4. Development costs
5. Operating costs
6. Maintenance costs
7. Education costs
8. Data acquisiton costs

Adapted from Ralph Sprague and Eric Carlson, *Building Effective Decision Support Systems*, 1982, p. 160.

Keen proposes Value Analysis as an alternative to other, more traditional evaluation methods. This method is a modified cost/benefit model which provides for the building of a prototype system. The building of the prototype is justified on the estimated value of the potential benefits over and above a cost threshold. If the prototype is successful then a full system is designed and justified using traditional cost/benefit analysis.

Sprague and Carlson utilize a matrix of methods. The specific measurement depends upon the system to be evaluated. However, no method of combining individual measurements into an overall system evaluation is presented.

Akoka also develops a matrix approach but his matrix is based on the Gorry and Scott Morton DSS framework in Figure 1. The process consists of placing the DSS in the appropriate element of the framework, which then determines the applicable evaluation method(s). The items to be measured and the measurement methods for evaluation are similar to Sprague and Carlson's as shown in Table 2.

While it is desirable to measure the effects of DSS on the decision process, the central focus of evaluation is on the various outputs of the decision process. If the outcome(s) are not improved (higher profits, lower costs, etc.) then the DSS has not provided the essential benefit. In some cases it is difficult to define direct relationships between outputs and the system. In those cases surrogate measures for outputs should be developed.

One concept which is left out of evaluation schemes is improved learning. Learning improvement can be both in terms of a deeper understanding of a problem and a greater learning rate. This DSS evaluation deficiency is examined next.

Learning and DSS

DSS should play a major role in managerial learning. Both Keen and Scott Morton (1978) and Keen and Wagner (1979) explicitly discuss the importance of such a role for DSS. Also learning has been mentioned by Keen (1981) and Sprague and Carlson as a potential benefit to be derived from DSS usage. The learning which may take place could take the form of better understanding or new insights into a particular problem or perhaps the organization as a whole. Evidence of such learning could be faster decisions, cost savings or other previously mentioned DSS benefits.

A major difficulty with applying the concept of learning in DSS is measurement. How is it possible to know if and when learning took place. Lucas and Nielsen (1980) suggest that learning be defined as the rate of increase in performance over time in the context of information systems research. Their study on mode of information presentation and learning rate did not find a significant relationship between learning rate and amount of information at decision makers disposal. However, it cannot be determined from the study whether learning did not occur or the definition of learning employed was in appropriate.

In a study focusing on decision maker learning, Chorba and New (1980) utilized the amount of information selected as a measurement of learning. Their premise was based on Ackoff's (1967) assertion that knowledgeable managers use less data in the decision-making process. Their results demonstrated that decision makers, given the opportunity to select their own information system, learned at a faster rate than decision makers that received externally prescribed reports.

Others (Day, 1966; Remus, 1981 and Mock, Estrin and Vasarhelyi, 1972) have suggested that reduction of variance from optimum performance over time is evidence that learning took place. This approach is appropriate in decision environments in which optimum performance standards can be determined.

Due to the nature of the decision environment, an adaption of the Lucas and Nielsen definition, using nominal changes in decision outcomes, was considered most appropriate to measure learning for this study.

Group DSS

The effects of DSS in group decision-making have only recently received attention. At this time the focus is on the process rather than the outputs. Gray (1983) reports on preliminary results from a project at Southern Methodist University using a computerized "decision room" to study the process of group decision-making. So far only exploratory testing of the room and its effect on subjects has been performed.

Another study, reported by Kull (1982), used top executives to run a simulated board meeting. The purpose was to explore the possible effects of a specific DSS, MINDSIGHT, on the decision process of the executives. The results were in the form of anecdotal reports from the executives as to their likes and dislikes of the system. Most felt the system had potential but the simulation problem lacked realism.

Huber (1982) outlines potential DSS research exploring the effects of Group DSS, like MINDSIGHT, on various group decision-making techniques. Again the focus is the process and not the product.

Research in DSS in a group decision-making environment appears to be a relatively unexplored field. This study proposes to explore a portion of this field with an emphasis on decision outcomes.

Group Decision-Making

Decision Process

In today's business environment of complex organizations and specialization, an individual may be faced with insurmountable decision tasks. To overcome these situations, a group of individuals can be formed to investigate the problem and make the decision. However, this approach is not without its disadvantages.

Groups introduce added complexities by the mere fact that they are a collection of individuals. Social interaction within a group is an important element in determining the effectiveness of the group. Patton and Giffin (1978) state that individuals not only bring their abilities to the group but their social and personal needs as well. These needs are the primary reason for the interpersonal behavior within the group.

A simple model of decision-making groups developed by Collins and Guetzkow (1964), (Figure 3) portrays the dynamics of the group process. Of special interest are the "obstacles" or variables of the problem and their interaction to stimulate group behaviors. In turn, these behaviors affect group productivity. According to Collins and Guetzkow, group productivity consists of individual productivity and "assembly-effect bonuses", which is the group synergy.

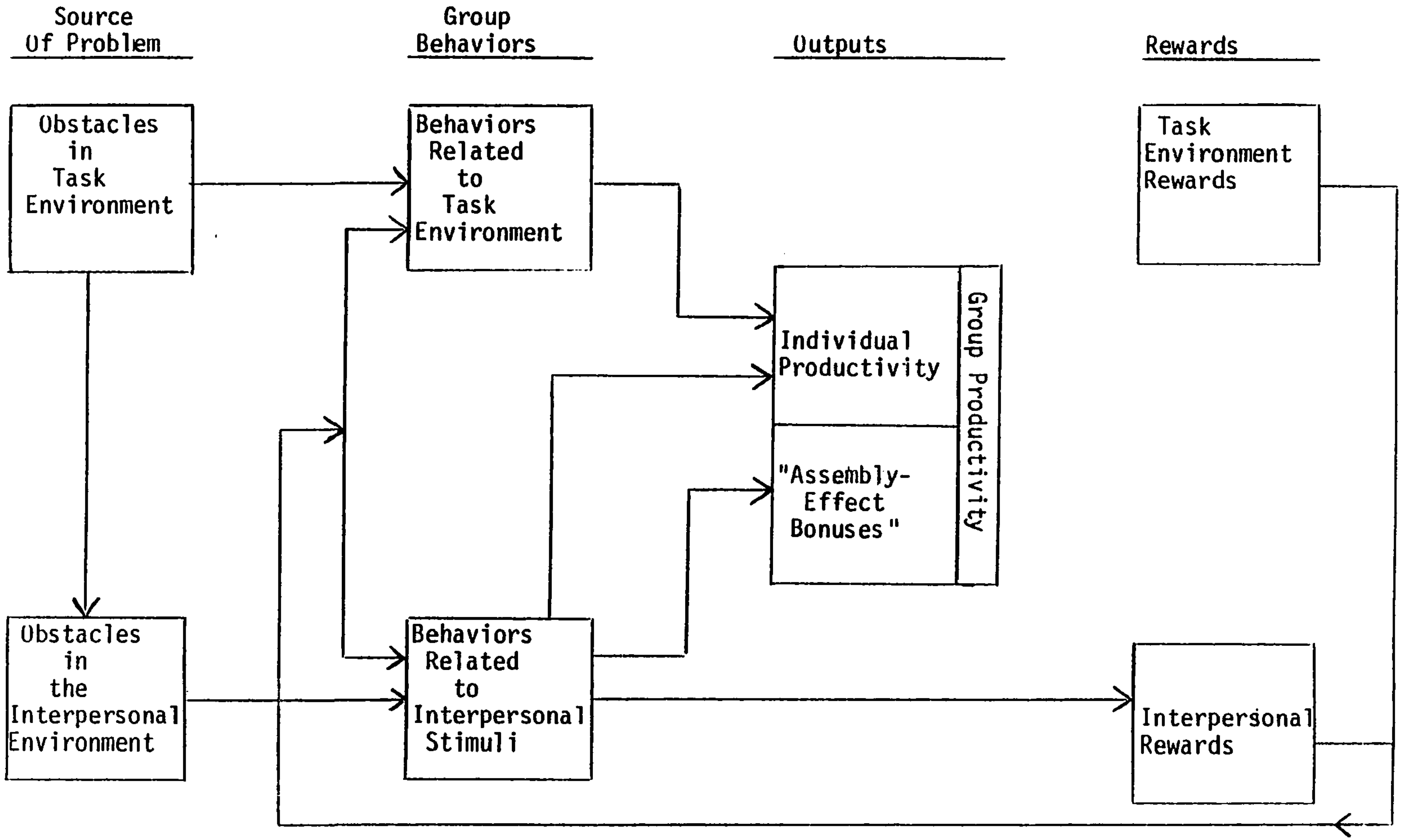

Figure 3. Simple Model of Decision-Making Groups. Adapted from B.E. Collings and H. Guetzkow, A Social Psychology of Group Processes for Decision-Making, 1964.

Group Cohesiveness

A more detailed identification of the "obstacles" or group variables was performed by Flamholtz (1976). His model (Figure 4) presents the variables and their relationships as described by previous research. It is believed that a specific DSS should impact many of these variables which in turn will impact performance.

Since the primary goal of this study was to explore the relationship between decision outcomes and DSS usage, it was desirous to eliminate or mitigate the possible effects of the group variables. The experimental methods were selected with this objective in mind. However, since no technique could control for group cohesiveness, it was measured and its effect evaluated.

Group cohesiveness can be defined as the degree to which group members have positive feelings toward each other and their desire to maintain membership in the group. Thus high cohesiveness is evidenced by a high degree of positive feeling among group members and a high desire to remain in the group.

Bjerstedt(1961) found that groups with high cohesiveness attained higher levels of performance. Similar results have been reported by Goodacre(1951,1953) and Berkowitz(1956). Davis(1969) feels the relationship between performance and cohesiveness is circular in nature.

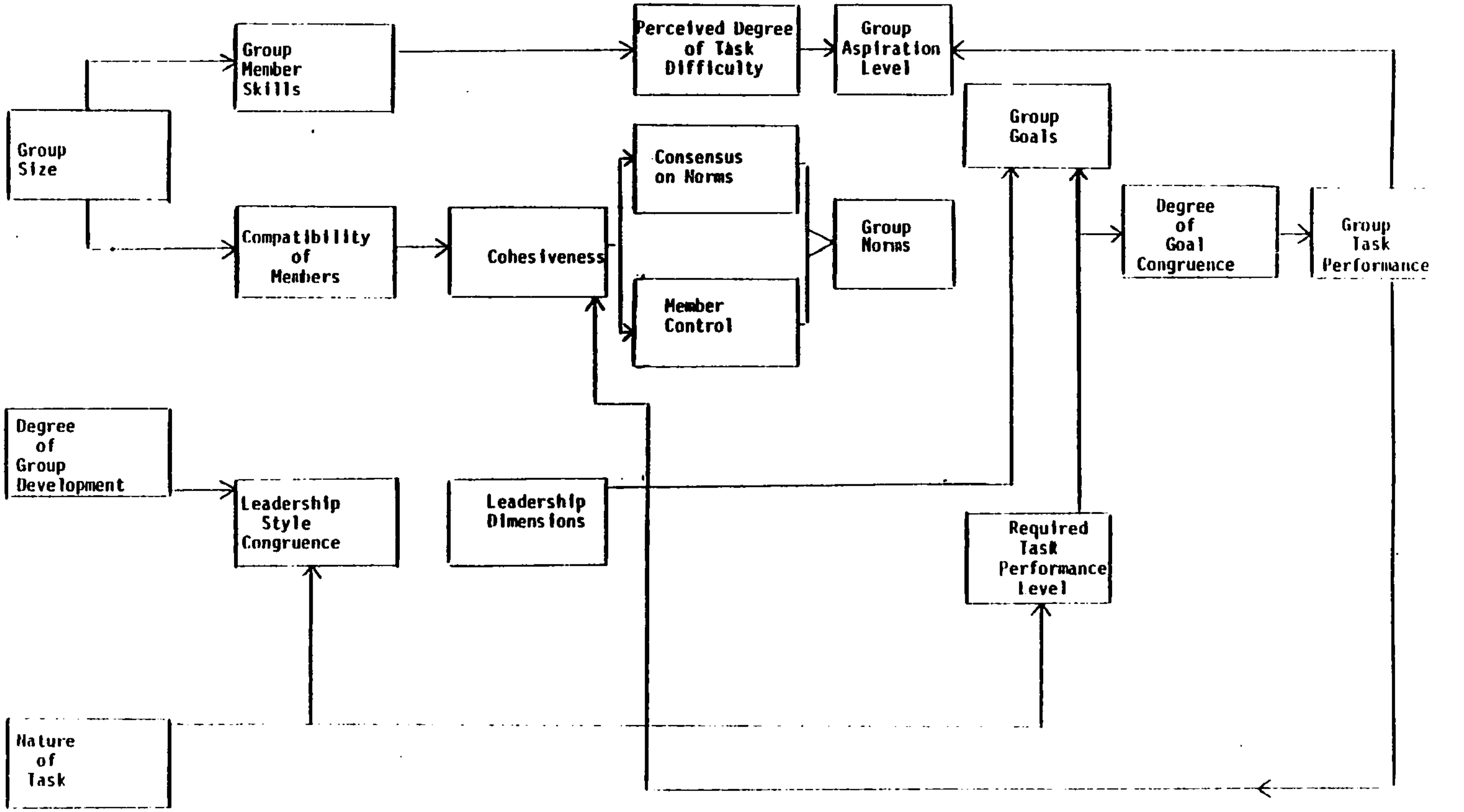

Figure 4. Model of Small Group Interaction and Task Performance. Adapted from Eric Flamholtz, "Toward a Formal Model of Group Dynamics in Task Performance Relevant to Accounting", Journal of Business Finance & Accounting, Vol. 3, No. 4, p. 6.

His position is that initial cohesiveness affects performance which in turn affects cohesiveness and so on through time. As a result, it is difficult to identify the cause and effect relationship between cohesiveness and performance.

In this study, group cohesiveness is seen as an intervening variable which could affect performance and therefore the interpretability of results. As a result, cohesiveness will be measured both at the beginning and the end of the study to aid in the assessment of the effect of this variable.

Chapter Summary

The literature review concentrated on 1) the evolution of DSS, its conceptual framework and evaluation methods and 2) the process of group decision-making and identification of relevant group variables. No investigation into the evaluation of a DSS in a group decision-making environment was found during the literature search.

DSS is an evolving concept within the broader field of information systems. Its main thrust is the aiding of semi-structured problems through computer technology. However, a great deal of controversy remains concerning the appropriate method or methods for evaluation. As a result, no methodology or measures have been agreed upon as being most appropriate.

DSS usage in a group decision-making environment has received little attention by DSS researchers. The research that has been done is exploratory in nature and has lacked sound experimental designs.

Group decision-making is a complex process with enormous importance for business organizations. It was shown that many variables impact and are impacted upon by group performance. Of the variables identified, only group cohesiveness was examined as a part of this study since its potential effect was not subject to experimental control.

CHAPTER III

RESEARCH METHODOLOGY

The impact of a specific DSS on group decision outcomes is examined utilizing a laboratory study. A total entity business game is employed as the decision environment. Subjects are formed into groups to play the game in a multi-period setting. Decision outcomes serve as the dependent variables of interest. The questions examined are: 1) Does the use of a specific DSS have a positive impact on group decision quality as represented by more desirable decision outcomes? and 2) Does DSS usage have an impact upon the rate of learning?

Model for Research

The major research question of this study is whether the use of a specific decision support system by decision makers positively impacts decision outcomes. Figure 5 presents a simplified model of the decision process. As shown, the DSS role is to aid rather than to replace the decision maker.

For this study, the simplified model is expanded to include a computer support position called technical

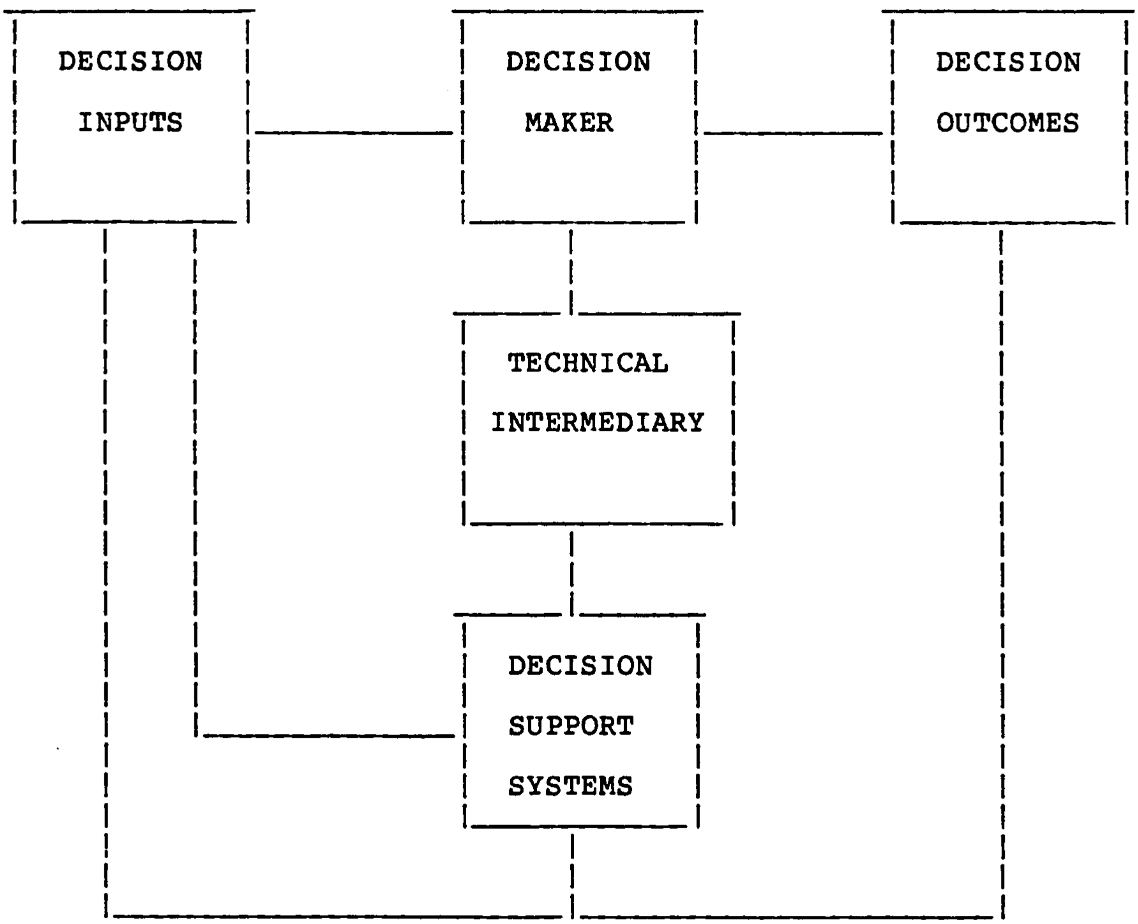

Figure 5. Model for Research.

intermediary. This is done to more accurately depict reality. Such a position is discussed by Sprague (1980) and supported by survey results of Wagner(1981b), which found that a separation does exist between the operator of a DSS and the user of the output from the DSS.

The focus of the study is on the interaction between the decision makers and the DSS and the interaction's impact on decision outcomes. Other possible interactions and linkages within the model are not examined in this study. Additionally, group cohesiveness and its interaction with decision outcomes is examined.

Research Questions

The relationship between decision outcomes and DSS usage is operationalized through the development of research questions and related hypotheses.

The two major research questions explored are:

1. Does DSS usage have a positive impact upon decision outcomes in a group decision making environment?
2. Does DSS usage have an impact upon the rate of learning in a group decision making environment?

Hypotheses

A major tenet of DSS usage is that the decision outcomes attained by DSS users should be more desirable than those attained by non-DSS users. This would especially be true in a semi-structured or complex environment as shown in the Gorry and Scott Morton framework portrayed in Figure 1 and further expanded upon by Sprague.

As discussed by Keen (1981), a DSS should provide new insights and learning not provided by traditional information systems. Therefore the DSS groups should exhibit a quicker awareness of the environment as evidenced by incremental decision outcome gains greater than those of the control groups.

The following specific hypotheses are based upon the research questions and follow from the expected benefits of DSS usage:

> H1: Groups using a specific DSS will attain decision outcomes superior to those attained by the groups using the traditional information system.

Acceptance of this hypothesis implies that a specific DSS impacts group performance as the DSS framework suggests. If this hypothesis is not confirmed, it becomes necessary to more closely examine the appropriateness of the DSS concept in a group decision-making environment.

H2: Groups using a specific DSS will demonstrate a faster rate of learning than the groups using the traditional information system.

Evidence in support of this hypothesis would indicate that DSS usage does have a favorable impact on the rate of learning. No supporting evidence would lead to the conclusion that those DSS benefits concerning rate of learning may not be attainable in a complex decision environment.

Decision Environment

The Business Policy Game by Cotter (1973) is the decision-making environment. It is considered representative of total entity business games, containing all the essential elements within the marketing, production and finance functional areas as discussed by Keys (1980). Using his classification scheme, this game would be considered complex due to the number of decisions made each simulated quarter. Complexity is considered necessary for the specific DSS to be advantageous over non-computerized analyses. This is consistent with Keen's and others' contention that DSS is most appropriate in a semi-structured environment. In addition, the game focuses on strategic planning, an area in which a complex, semi-structured environment is likely to be found. A summarization of instructions to game participants is provided at Appendix E.

A total of twelve teams participate in the experiment in two six-team "worlds". Each world operates independently, while the six teams within each world are in competition against each other. In each world the teams start at equal positions in all respects.

Each period the teams make approximately 35 decisions across the functional areas of marketing, production and finance. To be successful requires that adequate strategic decisions be made.

Sixteen simulated quarters are run over the course of the Fall 1983 academic semester. Student subjects are not informed of the termination of the game until after the decisions for the sixteenth quarter has been made. However, the decisions made during the final few quarters are examined for any "end of game " strategies. If such strategies are noted, the period(s) effected may be dropped from the final analysis.

Experimental Environment

Subjects

Sixty-two students in two sections of an undergraduate business policy course participate in the study. The students serve as surrogates for top-level managers as the amount of time required by the game is prohibitive for the inclusion of more experienced decision makers. Since playing the game constitutes approximately 20 percent of the student's grade for the course, it is felt student motivation is sufficient for commitment to the game to occur.

All subjects have completed the core of the business curriculum and possess senior standing. It is anticipated that, except for any academic major differences, the subjects are be approximatly equal as to the intellectual abilities and/or knowledge required of the game.

Group Formation

Within each section, subjects are formed into six groups on a free choice basis. However, they are advised to diversify the backgrounds of their group members as to undergraduate major and/or special interests or abilities. As a result, it is felt the groups are approximately equal in distribution of undergraduate major, grade point and other pertinent characteristics. That is, it is expected there is homogeneity across groups while individual groups are heterogenous in nature. To confirm this, academic major, special interests or abilities and grade point are obtained and evaluated.

One class section is assigned to the experimental condition while the other is assigned to the control on a random basis. Three groups from each section are then assigned on a random basis to one of the two six team worlds as shown below:

	World One	World Two
Section 1	Experimental 1 Experimental 2 Experimental 3	Experimental 4 Experimental 5 Experimental 6
Section 2	Control 4 Control 5 Control 6	Control 1 Control 2 Control 3

Experimental Groups

The subjects assigned to the experimental groups receive the traditional information system and the output of the specific DSS. They have access to the intermediary/builder to request runs and/or make modifications to the DSS.

The groups are able to make modifications of the original model, build supplemental models and use the model interrogation features of IFPS such as WHAT IF, IMPACT and SENSITIVITY. However, no direct access to a computer is necessary or permitted. All such duties are handled by the intermediary/builder.

A joint training session approximately one-half hour in length is given to the experimental groups on the abilities of IFPS. In addition, supplemental information and/or explanations that appear necessary both before and during the course of the experiment are provided.

Control Groups

The subjects assigned to the control groups receive only the traditional information system. Access to the intermediary/builder is restricted to limited consulting regarding the traditional information system.

DSS Generator

As described by Sprague (1980), a DSS generator is the computer environment in which a specific DSS is built. In this study the Interactive Financial Planning System (IFPS) serves as the host of the specific DSS.

IFPS was chosen as the DSS generator since it is a widely used and often researched financial planning language. Its capabilities, applications and other attributes have been discussed by Braun (1980), Keen and Wagner (1979), Wagner (1981b) and others.

Specific DSS

The specific DSS includes an initial model of the industry represented in the game (Appendix A). The model was developed by the technical intermediary from the information and data provided in the game manual. In addition, the specific DSS will contain any modifications of the initial model suggested by the groups as the game is being played. These enhancements are only available to experimental groups which develop or suggest them. Therefore, it is possible that six separate specific DSS's will be developed over the course of the study. It is anticipated the six will be quite similar.

Traditional Information System

The output of the game, which includes financial statements, economic indicators and selected financial ratios, served as the traditional information system in the game environment. This is differentiated from a management information system (MIS) since a MIS generally does not include information regarding the external environment as does the game output. Both experimental and control groups receive this information during the playing of the game.

Technical Intermediary/DSS Builder

A technical intermediary serves as a liaison between the DSS builder and the manager/user to facilitate the building of the model and its use by the manager. The intermediary is familiar with the technology but has a managerial background.

The DSS builder assembles the models within the DSS generator. He is technologically oriented with little or no managerial background. If he does possess a significant amount of managerial knowledge and/or skill then he could act as both the builder and the intermediary.

In a survey of IFPS users by Wagner (1981), it was reported that upper and middle management request 61% of all DSS applications, build only 19% and run the model in only 23% of all applications. Thus, it appears the role of the intermediary is a real one.

In this study, the experimenter serves as the intermediary and builder. When an experimental group makes requests of the intermediary, he will modify and/or run the application. The output of the model is provided to the groups as input to their decision-making process.

In addition, the experimenter acts as a consultant to the control groups. He answers specific questions regarding the play of the game or interpretation of output. The purpose of this role is to assure that any potential influence by the experimenter on the experiment is minimized.

Measurement of Variables

Cohesiveness

Group cohesiveness is measured using an instrument developed by Gross as discussed in Schutz(1966). The instrument(Appendix B) consists of seven questions, each answered on a 5 point scale. The questions chosen by Gross were selected from measures of cohesiveness from other studies which formed a unidimensional cumulative scale when used together.

The cohesiveness measures are used to assist in determining whether group cohesiveness has a significant impact on performance measures. It is anticipated the groups will be approximately equal in initial group cohesiveness while ending group cohesivness will be positively correlated with performance. Accordingly, the instrument is administered at the beginning and the end of the study.

Decision Outcomes

Decision outcomes are measured using a multi-criteria method adapted from Biggs (1978). He suggests a relational scoring system in which point values are assigned based on team standings at the end of a given simulation period. The method uses five variables (dollar sales, income before taxes, return on assets, return on sales and stock price) to rate team performance. While this approach does take into account the magnitude of differences between teams, it does not consider that many of the variables will be highly correlated with each other. As a result, the method may be measuring the same attribute of performance five times instead of five separate attributes.

To overcome the limitation of Bigg's method, a factor analysis is performed using the decision outcomes from the study for the variables listed in Table 3. The purpose of the analysis is to extract independent factors for measuring decision outcomes. Based upon the results of a factor analysis using data from a previous play of the game, it is anticipated that three factors would be extracted.

Factor loadings are used to construct factor scores. These scores are used as the composite measures of decision outcomes.

Learning

It is anticipated that both groups will experience learning, especially in the early periods. However, the experimental group should learn at a faster rate. To capture this effect, learning is defined as the change in composite decision outcome measures from one simulated quarter to the next.

The approximate shape expected for the learning curves of the groups is given in Figure 6. The change in decision outcome measures should be greater in earlier periods for both groups as learning takes place. However, the DSS groups should demonstrate a higher level of learning in the

Table 3. Decision Outcome Variables

Net Income	Sales/Assets
Sales in Dollars	Net Income/Assets
Sales - Percent of Market	Net Income/Sales
Total Equity	Net Income/Equity
Plant and Equipment	Cash Flow/Net Worth
Stock Price	Interest Coverage
Earnings per Share	Bonds/Equity
Total Assets	

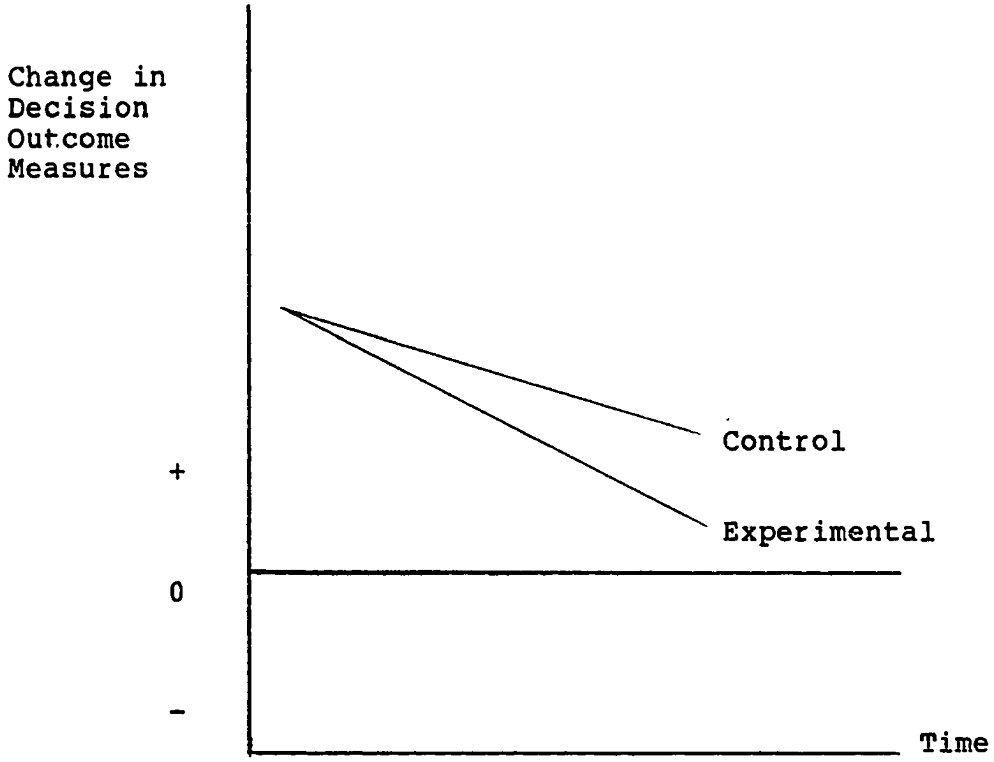

Figure 6. Expected Learning Curves

earlier periods. Faster learning by the experimental group will be evidenced by a steeper sloped learning curve.

Model for Data Analysis

As previously discussed, a factor analysis of selected performance variables is performed. Factors are extracted using the VARIMAX rotation method to obtain orthogonal factors. Factor scores are calculated by multiplying the individual variables by their associated element in the factor scoring matrix. The factor scores are the dependent variables used for testing hypotheses.

A 2 x 2 multivariate analysis of covariance (MANCOVA) with group cohesiveness as the covariate is to be used to test hypothesis 1. However initial tests are performed to determine if there is a significant world effect and if the cohesiveness covariate is significant. If the world effect is significant then a single factor MANCOVA or MANOVA will be conducted on each world separately in testing hypothesis 1. MANOVA will be the method employed if the covariate is not significant.

In all multivariate tests of hypotheses , the results obtained by Wilk's lambda criterion are reported. Follow-up univariate ANOVA's are performed to investigate significant MANOVA effects.

Hypothesis 2 uses the change in factor scores as dependent variables. Analysis of covariance (ANCOVA) is employed to determine if the learning curve slopes are equal for the experimental and control groups. A significant difference will support hypothesis 2.

Chapter Summary

The research questions described in this chapter concern the impact on performance of the usage of a DSS in a group decision-making environment. These questions were subsequently operationalized as two hypotheses.

A model for research was described in which a business game is employed as the decision-making environment. Operational definitions for the research model were listed and explained. Dependent variables were developed from game output utilizing factor analysis. A model for data analysis was introduced which employs multivariate analysis techniques and analysis of covariance for testing hypotheses.

CHAPTER IV

DATA ANALYSIS

This chapter presents the development of the model of the firm, development of the dependent variables and subsequent data analysis. The research hypotheses are tested as discussed in Chapter III. Additional analyses are performed on certain demographic variables, an expected covariate and a potential world effect are investigated.

Model Development and Testing

The DSS utilized by the experimental groups consists of an initial computer model of the firm (Appendix A) constructed by the experimenter in the capacity of technical intermediary. The IFPS language is employed to build the model. The purpose of the initial model is to provide a starting point from which the unique DSS would evolve for each group.

The model, which employs the traditional accounting model as its basis, can be used to produce the proforma financial statements and reports listed in Table 4. Samples of these statements and reports can be found in Appendix C. Also, each experimental group can request

Table 4. Pro Forma Financial Statements and Reports

Balance Sheet

Income Statement

Cash Flow Statement

Sales Analysis

Production Analysis

Ratio Analysis

additional reports as desired from the technical intermediary.

The initial model is tested for logical and arithmetical accuracy by running it with data from a previous semester's game output. The results obtained from this procedure are compared with the actual output from the game. Any discrepancies are investigated and corrected until the model is considered to be fully valid.

In addition, during the course of the game the previous quarter's results are used to further test the model. All reports are generated to verify that the relationships in the model continue to reflect the relationships in the game. This is necessary as some relationships do vary during the game depending upon factors such as plant location and inventory level.

As a result of the initial and on-going testing of the model, it is believed the model is valid and correct for all experimental groups throughout the course of the game.

Factor Analysis

To construct the measures of decision outcomes, a factor analysis is performed on the results of the sixteen quarters of the game. The data consists of the decision outcomes for each of the twelve groups over the sixteen quarters on the fifteen variables previously listed in Table 3. This gives an overall total of 2,880 separate observations for performing the factor analysis. Since many of the decision outcome variables are highly correlated, factor analysis is used as a data reduction technique in building independent measures of decision outcomes.

The principal components method of factor analysis is employed for the initial factor solution. This method was chosen since it results in orthogonal factors being extracted (Morrison, 1976, p. 267). Since no apriori assumptions regarding the relationships between the variables are made, no prior estimates of communalities are made in the extraction of the principal components.

Using a minimum eigenvalue of 1.00 as a criterion, two factors are retained in the initial factor analysis. The final solution is reached with a VARIMAX rotation to attain a simple structure yet retain orthogonal factors as discussed by Kim (1975). The factor loadings on the resulting two factors after rotation are given in Table 5.

The resulting factors can be seen to represent two separate dimensions of a business enterprise. Variables loading highest on Factor 1 are associated with the income statement while those loading highest on Factor 2 relate more closely to the balance sheet. One variable, market share, while loading highest on the balance sheet factor does not appear to fit well with either factor. On further

Table 5. Rotated Factor Loadings

Variable	Factor 1	Factor 2
Net Income / Assets	.98277	.05544
Net Income / Equity	.97554	.03270
Cash Flow / Net Worth	.97496	-.00455
Net Income	.91651	.34550
Earnings per Share	.90187	.11773
Net Income / Sales	.88795	.05806
Sales / Assets	.83998	-.14510
Interest Coverage	.80669	.33872
Sales	.78139	.53540
Stock Price	.77885	.01274
Total Equity	.04842	.97609
Total Assets	.18453	.94728
Plant & Equipment	.02371	.85634
Equity / Bonds	-.06287	.73827
Market Share	.11028	.48541

/ means "divided by"

analysis, it appears to represent yet another dimension or factor. However, as its associated eigenvalue is below the 1.00 cut-off at .9339 , this third factor is not retained for further analysis.

The next step in constructing the decision outcome measures is to calculate factor scores for each of the observations for each of the factors. Factor scores are standardized composite scales or indices. The process consists of first computing the factor-score coefficient matrix, which is a standardization of the final factor loading. Then the individual factor scores for each observation are calculated by multiplying the factor-score coefficient matrix by the vector of standardized variables (Kim, 1975, pp. 487-489). The factor-score coefficient matrix which results from this factor analysis is given in Table 6.

The factor-score method of determining decision outcome measures was chosen because it provides standardized composite indices of the variables included in the analysis. Thus a composite scale is obtained which does not contain scaling differences present in the original variables. The factor scores constructed yield 192 observations on each of the factors. It is these observations which serve as the dependent variables for testing the research hypotheses.

Table 6. Factor-score Coefficient Matrix

Variable	Factor 1	Factor 2
Net Income / Assets	.12933	-.03151
Net Income / Equity	.12944	-.03733
Cash Flow / Net Worth	.13112	-.04741
Net Income	.10669	.05033
Earnings per Share	.11552	-.01077
Net Income / Sales	.11647	-.02630
Sales / Assets	.11966	-.07916
Interest Coverage	.09227	.05370
Sales	.07956	.10826
Stock Price	.10397	-.03343
Total Equity	-.03973	.26255
Total Assets	-.02009	.24828
Plant & Equipment	-.03738	.23123
Equity / Bonds	-.04341	.20329
Market Share	-.00818	.12648

/ means "divided by"

Demographic Analysis

Before testing the research hypotheses, it is necessary to evaluate the effectiveness of team and group assignments. The method for assignment to individual teams should result in homogeneity between teams on academic achievement, experience and academic background. The variables used in this analysis are academic grade point, age and academic major. Grade point and age, along with team size, for each team by world by experimental group is given in Table 7. A listing of academic majors by team is provided in Appendix D.

As seen in Table 7, there does appear to be some variability for both GPA and age between individual teams. However, when aggregated by experimental group, both across and within worlds, the difference is slight. Given the smallness of the differences and the nature of this demographic analysis, statistical tests of significance are not considered necessary. It is concluded that the experimental groups are homogeneous in academic achievement and experience. The other variable addressed in Table 7, group size, is equal at five per group except for two groups of six, both in the control group. This difference in size should not significantly affect experimental results.

Table 7. Demographic Variables by World by Group

World One

Experimental				Control			
Team Number	Size	GPA	Age	Team Number	Size	GPA	Age
1	5	3.21	23.8	4	6	3.13	22.3
2	5	2.86	22.8	5	5	2.67	22.2
3	5	2.85	21.4	6	5	3.14	25.2
Average		2.97	22.7			2.99	23.2

World Two

Experimental				Control			
Team Number	Size	GPA	Age	Team Number	Size	GPA	Age
4	5	2.92	23.2	1	5	3.13	23.2
5	5	2.85	21.4	2	6	2.89	21.7
6	5	2.88	23.2	3	5	2.38	22.3
Average		2.88	22.6			2.81	22.4

Experimental Average	2.93	22.7	Control Average	2.90	22.8

A review of the listing of academic major by team in Appendix D reveals that no team consists of members with the same academic major. While it is impossible to have every major or field represented on each team, the variety of majors within each team is sufficient to provide each team with a broad business knowledge base. As a result, it is concluded that the teams are heterogeneous within and homogeneous across on academic background.

Preliminary Tests

Before testing the research hypotheses, it is necessary to determine whether the decision outcome variable results are consistent between the two experimental worlds. If the worlds differ it is necessary to analyze each world separately.

In addition, the significance of the cohesiveness variable between groups and its relationship to the decision outcome variables must be determined. If the cohesiveness variable is significant then MANCOVA will be used to test the research hypotheses otherwise MANOVA is the appropriate statistical technique.

World Effect

In order to test the world effect, the decision outcome scores for Factor 1 and Factor 2 are utilized. A single-factor between world MANOVA is performed. The individual company scores are collapsed into the single world factor. The MANOVA (Table 8) indicates a significant overall world effect, $F(2,189)=14.27$, $p< 0.0001$. Also, the individual ANOVA's (Table 8) for each factor are significant with Factor 1 at $F(1,190)=4.33$, $p< .05$ and Factor 2 at $F(1,190)=23.22$, $p< 0.0001$. Since the world effect is significant, it is necessary to analyze each world separately.

Cohesiveness Effect

The initial analysis of the cohesiveness variable is to test whether it is significant between groups. This is accomplished with three single factor ANOVA's employing the individual participant's post-game cohesiveness score, obtained using the Cohesiveness Scale in Appendix B, as the dependent variable.

The single factors used in the analysis are group (experimental versus control), company and world. The primary analysis is the group factor with the company factor being a sub-analysis of the group factor. The analysis by world is presented for comparison with the previous analysis by world of the decision outcomes (Table 8).

Table 8 MANOVA for World Effect

Source of Variation	df	F	p<
MANOVA			
World	2,189	14.27	0.0001
ANOVA by Factor			
Factor 1 - Income Statement			
World	1,190	4.33	0.0387
Factor 2 - Balance Sheet			
World	1,190	23.22	0.0001

World Means by Factor

World	Factor 1	Factor 2
1	.1489	-.3292
2	-.1489	.3292

The ANOVA results (Table 9) indicate that only the company factor is significant, $F(11,50)=2.40, p< .05$. The group factor is not significant. This indicates that the cohesiveness variable is not an appropriate covariate for this analysis. However, before a final decision is made the nature of the relationship between cohesiveness and the decision outcome variables should be explored.

The world factor is not significant, $F(1,60) = 2.90$, $p< .0935$. This differs from the results obtained with the decision output variables for a world effect and provides further evidence that cohesiveness is not an explanatory variable for this analysis. As can be seen by the ranking of the cohesiveness score means by company (Table 9), no pattern of cohesiveness developed either within world or within groups.

The relationship between cohesiveness and the decision outcome variables is examined by regressing the factor score means on the post-game cohesiveness scores. This is done as two separate regressions with each factor serving as the dependent variable in its own analysis. The purpose of these analyses is to determine if the relationship between cohesiveness and the decision outcome variables is significant and the nature of the relationship, that is, whether cohesiveness is positively or negatively related to the decision outcome variables.

Table 9. ANOVA's of Cohesiveness Variable

Source of Variation	df	F	p<
Individual ANOVA's			
Group	1,60	.06	.8003
Company	11,50	2.40	.0179
World	1,60	2.90	.0935

Company Means by World and Group

	World 1			World 2			
	Co. No.	Mean	Rank	Co. No.	Mean	Rank	Group Means
Experimental Group	1	28.80	7	4	29.60	5	
	2	30.80	2	5	29.20	6	28.53
	3	24.40	12	6	28.40	8	
Control Group	4	26.17	11	1	29.80	4	
	5	27.20	10	2	28.00	9	28.75
	6	30.60	3	3	31.40	1	
World Means		27.94			29.36		

The regressions (Table 10) demonstrate no significant relationship between either decision outcome variable and cohesiveness. Both F values have p values of greater than .3. Also, as evidenced by the slopes of the regressions, the relationship with Factor 1 (slope = -.0315) is negative while it was positive with Factor 2 (slope = .1240).

As a result of the above regressions and the other cohesiveness analysis discussed previously, it appears cohesiveness is not an explanatory variable in this study. Therefore, it is not included as a covariate in the subsequent test of hypotheses.

Test of Hypotheses

Hypothesis 1

Hypothesis 1 is tested using a single factor MANOVA with group as the factor and the decision outcome factor scores as the dependent variables. It is necessary to test each world separately due to the significant world effect previously discussed.

World One

The MANOVA results for World One are given in Table 11. The overall effect is not significant, $F(2,93) = 0.02$, $p < 0.9758$. Thus Hypothesis 1 is not supported for World

Table 10. Regression of Factor Scores on Post-Game Cohesiveness Scores.

Factor 1

Source of Variation		df	F	p<
Cohesiveness		1,10	.31	.591
Intercept	.9043			
Slope	-.0315			

Factor 2

Source of Variation		df	F	p<
Cohesiveness		1,10	1.07	.325
Intercept	-3.5584			
Slope	.1240			

One. There is no difference in decision outcome factor scores between groups in World One.

Since the two factors could offset each other in the overall test of significance, individual factor ANOVA's were performed even though no significant overall result was obtained . Their results (Table 11) confirm the overall result with $F(1,94)= 0.00$, $p< 0.9995$ for Factor 1 and $F(1,94)=0.04$, $p< 0.8421$ for Factor 2. Thus, neither group outperformed the other on either decision outcome factor. This is further corroborated by an examination of the group means by factor provided in Table 11.

World Two

In World Two, the overall result (Table 12) is significant, $F(2,93)=18.50$, $p< 0.0001$. There is a significant difference between groups on the decision outcome factor scores in World Two. However, further analysis is required to determine whether this significant result supports hypothesis 1.

Individual ANOVA's are performed to examine each factor individually. From the ANOVA results (Table 12), it is seen that only Factor 2 is significant, $F(1,94)=36.03$, $p< 0.0001$. However, examination of the related Factor means (Table 12) shows that the control group outperformed the experimental group on Factor 2. This result is in the

Table 11. MANOVA for Group Effect - World One

Source of Variation	df	F	p<
MANOVA			
Group	2,93	0.02	0.9758
ANOVA by Factor			
Factor 1 - Income Statement			
Group	1,94	0.00	0.9995
Factor 2 - Balance Sheet			
Group	1,94	0.04	0.8421

Group Means by Factor

Group	Factor 1	Factor 2
Experimental	0.1490	-0.3192
Control	0.1489	-0.3391

Table 12. MANOVA for Group Effect - World Two

Source of Variation	df	F	p<
MANOVA			
Group	2,93	18.50	0.0001
ANOVA by Factor			
Factor 1 - Income Statement			
Group	1,94	1.90	0.1716
Factor 2 - Balance Sheet			
Group	1.94	36.03	0.0001

Group Means by Factor

Group	Factor 1	Factor 2
Experimental	-0.0152	-0.3239
Control	-0.2827	0.9822

opposite direction of the prediction for Hypothesis 1. Therefore, Hypothesis 1 is not supported by the results of this test.

Further examination of Factor 1 does provide evidence, while not significant, $F(1,94)=1.90$, $p< 0.1716$, that the experimental group outperformed the control group on the income statement factor. Thus, unlike World One, in World Two the two decision outcome factors are in the opposite direction of each other. The effect of Factor 1 slightly offsets the effect of Factor 2 in the overall test but not enough to negate its significance.

Hypothesis 2

Hypothesis 2, the equality of regression slopes over time, is tested using analysis of covariance (ANCOVA). A single factor ANCOVA is performed with group as the factor and quarter of the game as the covariate. While the test of both the factor and the covariate are reported (Tables 13 and 14), it is the quarter by group interaction which tests the homogeneity of regression slopes between groups.

As with Hypothesis 1, it is necessary to analyze each world separately because of the significant world effect. Also, in order to perform the ANCOVA, it is necessary to evaluate each factor individually as shown in Tables 13 and 14.

World One

The ANCOVA results (Table 13) for World One reveals no significant difference between regression slopes for either factor. The Quarter * Group interactions are $F(1,26)=0.12$, $p < 0.7273$ for Factor 1 and $F(1,26)=0.27$, $p<0.6086$ for Factor 2. Therefore, it is concluded that the learning rate is the same for both groups in World One on both factors.

Additionally, the slopes for both groups on both factors is not significantly different from zero as evidenced by the T test results in Table 13. Thus, it appears that learning, as measured by the changes in the two decision outcome factors, did not take place in either group.

World Two

In World Two, the ANCOVA results (Table 14) are consistent with those of World One. No significant differences on the Quarter * Group interaction are reported for either factor. With $F(1,26)=0.03$, $p < 0.8584$ for Factor 1 and $F(1,26)= 1.06$, $p < 0.3136$ for Factor 2, neither result was even close to significant. As with World One, Factor 2 does show the most difference between groups with the only F ratio greater than one in either world on the Quarter * Group interaction. However, with no significant results, it

Table 13. ANCOVA for Learning Rate - World One

Factor 1

Source of Variation	df	F	p<
Quarter	1,26	0.98	0.3315
Group	1,26	0.02	0.8791
Quarter * Group	1,26	0.12	0.7273

	Estimate	T for HO=0	p<
Intercept	-0.0969	-0.15	0.8793
Slopes:			
Experimental	0.0601	0.88	0.3944
Control	0.0285	0.49	0.6312

Factor 2

Source of Variation	df	F	p<
Quarter	1,26	2.20	0.1503
Group	1,26	0.47	0.4978
Quarter * Group	1,26	0.27	0.6086

	Estimate	T for HO=0	p<
Intercept	0.0143	0.23	0.8226
Slopes:			
Experimental	0.0089	1.28	0.2239
Control	0.0043	0.78	0.4521

Table 14. ANCOVA for Learning Rate - World Two

Factor 1

Source of Variation	df	F	p<
Quarter	1,26	1.24	0.2761
Group	1,26	0.00	0.9777
Quarter * Group	1,26	0.03	0.8584

	Estimate	T for HO=0	p<
Intercept	-0.3527	-0.57	0.5745
Slopes:			
Experimental	0.0410	0.61	0.5554
Control	0.0568	1.01	0.3293

Factor 2

Source of Variation	df	F	p<
Quarter	1,26	0.11	0.7373
Group	1,26	6.56	0.0166
Quarter * Group	1,26	1.06	0.3136

	Estimate	T for HO=0	p<
Intercept	0.2575	2.65	0.0136
Slopes:			
Experimental	0.0094	1.88	0.0827
Control	-0.0047	-0.37	0.7177

is concluded that the learning rate is the same for both groups in World Two on both factors. The slopes for both groups on both factors are not significantly different from zero as evidenced by the T tests in Table 14.

Chapter Summary

This chapter described the development of the model of the firm, the development of the dependent variables and subsequent data analysis. The research hypothesis were tested as described in Chapter III on a by world basis. Additional analyses were performed on certain demographic variables, the cohesiveness covariate and the world effect.

The results of the test of hypotheses provided no support for the assertions that the DSS group would experience higher decision outcomes or that the DSS groups would exhibit a faster learning rate.

CHAPTER V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This chapter presents the summary and conclusions of this study. The implications of this study for DSS usage are noted. Suggestions for future research are also presented.

Summary

Proponents of DSS conceptualize many benefits to be derived from DSS usage. One of the primary benefits is increased decision effectiveness. While no agreed upon measures of effectiveness have been developed, an excellent case can be made for focusing on decision outcomes as appropriate measures of effectiveness.

To date, a majority of the research in DSS has focused on decision maker perceptions or the decision-making process rather than decision outcomes. While this is valuable research which needs to be done, examination of decision outcomes should be a major concern of DSS research.

Most DSS research has centered on the individual as the decision-making entity. Just as important in today's business environment is the decision-making group. However, little attention has been paid to groups in either MIS or DSS research.

This study's purpose was to provide empirical evidence that a DSS could positively impact decision effectiveness in a group decision-making environment. If this assertion is supported then the use of DSS as decision aids may be warranted.

In addition, the effect of DSS usage on the rate of learning was investigated. Supportive evidence of an increase learning rate by DSS users would be an important finding for purposes of justifying DSS development.

Research Approach

The research approach employed was a laboratory study designed to capture the effects of DSS usage on decision outcomes. A total entity business game served as the decision-making environment.

Student subjects were formed into twelve groups of five or six individuals. Six of the groups were assigned to the experimental condition and six to the control condition. The experimental and control groups were then split equally between two independent experimental settings or worlds.

Thus each world consisted of three experimental groups and three control groups competing against each other.

As an integral part of a business policy class, the subjects played the game over the course of the Fall 1983 academic semester. During the course of the game both experimental and control groups received traditional game output or decision outcome results. However, only the experimental groups had access, through a technical intermediary, to a specific DSS.

The specific DSS consisted initially of a financial planning model of the firm as described in the game manual. This model was then used by the six experimental groups to independently evaluate possible decision strategies over the course of the game. The DSS generator selected for this study was the IFPS langauge since it has the capabilites to handle such financial modeling tasks with ease.

Game results were operationalized as the decision outcomes. These decision outcomes were used as the dependent variables in the statistical analysis of results. In addition, a possible covariate and several demographic variables were measured and analyzed as a part of the study.

Multivariate analysis of variance and analysis of covariance were the statistical techniques employed in testing the research hypotheses. These tests were preceded by a factor analysis of selected variables to obtain independent factors or measures of decision outcomes for use as the dependent variables.

Results

As a result of the factor analysis, fifteen decision outcome variables were reduced to two independent factors. Those variables associated with the income statement loaded highest on the first factor while the balance sheet variables loaded highest on the second factor. These results were consistent with the concept that the two financial statements measure separate dimensions of a firm's financial performance.

It was anticipated there would be homogeneity between groups and heterogeneity within groups on selected demographic variables. Analyses of grade point average, age and academic major confirmed this assumption and revealed no significant differences which could confound the testing of research hypotheses.

In preliminary testing, it was found that the two independent worlds were significantly different on both decision outcome factors. As a result, the research hypotheses were tested within each world. Such a difference was not anticipated but was possible due to the independent status of the two worlds.

In this study, group cohesiveness was measured since theory suggests that group performance affects and is affected by group cohesiveness. However, statistical tests found the cohesiveness variable to be not significant between groups. In addition, no significant relationship existed between cohesiveness and the decision outcome factors. As a result, group cohesiveness was not included as a covariate in the testing of research hypotheses.

The test of increased decision effectiveness was performed using a single factor MANOVA. No significant difference was found between the experimental and control groups on either factor in World One. In World Two, a significant difference was found on the balance sheet factor. However, the results showed that the control groups outperformed the DSS groups on that factor. Thus the increased decision effectiveness hypothesis was not supported by the empirical evidence.

The increased rate of learning hypothesis was tested using analysis of covariance. The test was of equality of regression slopes between the experimental and control groups on learning. In both worlds the learning slopes were found to be equal between groups and not significantly different from zero. The evidence of this test does not support the hypothesis of an increased learning rate for DSS users.

Conclusions of the Study

Cohesiveness Covariate

While previous research has shown group cohesiveness to be related to group performance, no such relationship was found in this study. This result could be attributed to several factors. First, the instrument used to measure cohesiveness could have been inadequate in discerning true differences in cohesiveness. Secondly, the groups may not have been sufficiently committed to the task. As a result, the intragroup attitudes may not have been representative of attitudes within groups facing real life situations. Finally, it may be that in this decision environment cohesiveness does not have an impact on performance nor is it impacted by performance.

The instrument used to measure cohesiveness has been shown to be valid in other studies. Its application in this study was considered appropriate given the nature of the task and the type of groups involved. In addition, the groups were observed by the experimenter over the course of the study. One purpose of these observations was to cross-validate the cohesiveness instrument. As a result of these observations and the validity of the instrument, it is thought that the procedure employed in the measuring of cohesiveness was proper and valid.

It was assumed that commitment to task would be sufficient given the reward structure provided. Observation of and discussion with the groups during the study confirms this assumption. Except for some possible fatigue effects which appeared to occur very late in the game, the group commitment to task appeared very high. This conclusion is based on both observation of the decision process and review of the decisions resulting from the process.

No significant difference between groups was found on the cohesiveness variable. Since the groups' cohesiveness scores were almost equal, it would be impossible to discern any effects of cohesiveness on decision outcomes. Therefore, it is concluded that in this study cohesiveness was not a factor in determining decision outcomes.

Decision Effectiveness

DSS usage was not shown to result in a higher level of decision effectiveness. However, to conclude that DSS usage could not be beneficial in a group decision-making environment would be to reject the theoretical framework which has developed within DSS research. Instead, it is necessary to question the ability of studies such as this to capture the effects of DSS usage.

The focus on decision outcomes as measures of DSS benefits is essential. While the process is important, the true value of a DSS will come from the outcomes of the decisions that are supported. The decision outcome variables chosen for inclusion in this study were traditional accounting measures. These are and will continue to be important, although not the only, outcome measures by which decisions can be judged. Therefore, both the focus on decision outcomes and the type of outcome variables examined in this study were appropriate for DSS research.

The laboratory study is an important tool in this type of research. It allows the experimenter to control a significant number of extraneous factors which could contaminate experimental results in a field setting. In addition, a well-constructed laboratory study can achieve experimental realism while a field study is likely to suffer from mundane realism.

Past MIS and DSS research has relied on laboratory studies utilizing simplistic decision problems which allowed for clear cut interpretation of results. In this study, a more complex environment was employed. The purpose was to provide a more realistic experimental setting and present subjects a semi-structured problem to solve. A resultant danger is that the environment is so complex that it is extremely difficult for the subjects to identify the relevant relationships among the variables even with the aid of a DSS. The input-process-output analysis becomes clouded such that a trial and error process of decision making could occur.

How complex is too complex? That question cannot be answered without further research. The decision environment faced in this experiment was complex: each simulated quarter required each team to make over thirty decisions. These decisions reflected either a team's strategy or their response to the environment of the game. Review of decisions made and observations of the teams during the study leads to the conclusion that task complexity had an impact upon decision outcomes. However, the amount of impact is unknown.

Another possible reason why DSS users did not out perform the control groups was the quality and quantity of interactions between the groups and the DSS. A full discussion of this limitation of the study will be presented later in this chapter.

At this point, it can only be concluded that improved decision effectiveness did not occur in this study and that there are possible explanations other than an incorrect theory supporting the DSS framework.

Learning

DSS usage did not result in a faster rate of learning. These results are not consistent with DSS theory. As before, alternative explanations for such results may exist. Both task complexity and interactions between the DSS and its users could explain the results of this study.

If the task was overly complex, learning would occur very slowly in both groups. The ability of the DSS to provide a learning advantage would be diminished until the relevant relationships were identified. Thus the DSS may have been useful but the length of the study was insufficient to allow DSS benefits to become noticeable in decision outcomes.

The nature of the interactions between the experimental groups and the DSS could have a significant impact on the learning rate. If the DSS was not utilized effectively then the control groups could exhibit a learning effect equal to or greater than that of the experimental groups. This point will be addressed in the next section of this chapter.

The inability of this study to detect an improved learning rate for DSS users is not necessarily due to an incorrect theory. Plausible alternative explanations exist which could not be refuted.

Assumptions and Limitations

The quality and quantity of interactions between the experimental groups and the provided DSS, through the technical intermediary, were an integral component of this study. For the DSS to provide benefits, it was necessary for the DSS users to take advantage of the tool at their disposal.

Table 15 contains information regarding DSS usage as well as each group's ranking on DSS usage and the two decision outcome factors. The ranks are by world excluding the control groups.

As presented in Table 15, there was a sizable variance in DSS usage between groups. While the quantity of interactions tells little of their quality, the two could be related. The comparison of usage ranks with factor ranks does provide some evidence that there is a relationship between DSS usage and decision outcomes. The heaviest DSS user, Team One of World One, ranked first on both factors both within its own world and across all experimental groups. However this result cannot be extended to other experimental groups. The inconsistency of DSS usage across experimental groups could have had an effect on the experimental results.

Table 15. DSS Usage by Group

World One

Team Number	Number of Times Used	Technical Intermediary Hours	In World Rankings: DSS Usage	In World Rankings: Factor 1	In World Rankings: Factor 2
1	10	17	1	1	1
2	5	6.5	3	2	3
3	6	12	2	3	2

World Two

Team Number	Number of Times Used	Technical Intermediary Hours	In World Rankings: DSS Usage	In World Rankings: Factor 1	In World Rankings: Factor 2
4	3	3	2	1	2
5	8	12	1	2	3
6	2	2.5	3	3	1

It was assumed that the business game would provide a rich decision environment for the study. Ex post analysis of the game and its effect on the experiment is inconclusive. While the game ran very smoothly with few technical problems, its complexity may have contributed to the lack of support for the research hypotheses. Observation of the teams over the course of the experiment leads to the conclusion that game complexity may have had an impact on decision outcomes and the ability of the DSS to be of value to the experimental groups.

The ability of any abstraction of reality to fully depict that reality is limited. In the case of a business game, it is impossible to accurately capture all facets of the business situation being simulated. While the game employed did provide a realistic experimental environment, it is recognized that the game's inability to totally duplicate reality is a limitation of the study.

This study utilized students as surrogates for business decision makers. While this limits the generalizeability of results to student populations, it does not diminish the importance of the research. The students were presented with a decision task for which their backgrounds and abilites made them well-suited. Therefore, this limitation is not considered to seriously impair the usefulness of the study.

Implications and Direction for Future Research

Based on this study, future research could be undertaken in three areas: 1) further exploration of the relationship between DSS usage and decision outcomes 2) study of the effect of task complexity on DSS usefulness and 3) investigation into the nature of the interactions between DSS and DSS users and the resultant effects on DSS usefulness. This research should continue to focus on decision outcomes as the relevant dependent variables.

This study should be replicated to corroborate its results. In addition, similar studies employing different decision environments and other types of subjects are desirable to permit generalization of DSS research to a larger population.

Task complexity may have had an effect on decision outcomes in this study. Research is necessary to establish the impact that complexity has on the ability of DSS to provide benefits to DSS users. Such research should seek to identify decision environments in which DSS are useful, as well as environments where they are not. It is possible that a continuum of environments could be identified. This continuum could be used to determine whether a DSS should be developed for a given decision environment. This could help avoid inappropriate DSS applications before a significant investment of time and money was made.

The ability of a DSS to increase decision effectiveness can be limited by the quality and quantity of interactions between the DSS and its users. In this study, a wide variance of DSS usage was experienced. While it is believed that this is a an accurate representation of reality, future studies could require various levels of DSS usage.

An investigation of the interaction between the DSS and its users should be conducted. The major focus of such research would be on those factors which encourage DSS usage. An initial step would be a survey of current DSS users to discover the nature of their interactions with DSS and their likes and dislikes regarding the process. This would be followed by laboratory or field studies to collect empirical evidence supporting or refuting the survey.

In this study, decision outcomes were limited to traditional financial statement variables on an aggregate basis. Future research could examine other decision outcomes in tests of DSS usage effects. While financial statement variables are important , other decision outcome variables such as net present value and many managerial accounting variables could be useful in DSS research. A related avenue for research could be to use the financial statement variables individually rather than in the aggregate. DSS effects on any single variable or variables may be lost through the aggregation process.

Summary

This chapter presented a summary of the results of this study. DSS usage was not found to increase decision effectiveness or learning rate in a group decision-making environment. Conclusions regarding the results were stated and discussed.

Assumptions and limitations were presented, along with directions for future research. Research regarding DSS and decision effectiveness could explore the impact of task complexity as well as the interactions between the decision maker and the DSS. Additional studies of this type utilizing different decision environments and different types of subjects are necessary to provide a broader interpretation of results.

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APPENDICES

Appendix A

Initial Model of the Firm

Initial Model of the Firm

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MODEL GAME1
10 *
20 *  MODEL OF FIRM
30 *
40 * REVENUE
50 *
60 HPRICE = 10.00
70 PRICE2 = 10.00
80 PRICE3 = 10.00
90 PRICE4 = 10.00
100 HSALES = 170
110 HP = HSALES/USALES * 100
120 SALES2 = 44
130 P2 = SALES2/USALES * 100
140 SALES3 = 44
150 P3 = SALES3/USALES * 100
160 SALES4 = 79
170 P4 = SALES4/USALES * 100
180 USALES = HSALES + SALES2 + SALES3 + SALES4
190 TSALES = THSALES + TSALES2 + TSALES3 + TSALES4
200 THSALES = HSALES * HPRICE
210 PTH = THSALES/TSALES * 100
220 TSALES2 = SALES2 * PRICE2
230 PT2 = TSALES2/TSALES * 100
240 TSALES3 = SALES3 * PRICE3
250 PT3 = TSALES3/TSALES * 100
260 TSALES4 = SALES4 * PRICE4
270 PT4 = TSALES4/TSALES * 100
280 *
290 * PRODUCTION
300 *
310 BINVT = 489
320 BINVTUNITS = 106
330 UPROD =(LINES * HOURS * (100 * 13) + LINES2 * HOURS2 *
             (100 * 13))/1000
340 LABOR = LABOR RATE * UPROD
350 MATERIALS = MATERIAL COST * UPROD
360 MAINTENANCE = (LINES + LINES2) * (HOURS + HOURS2) *
                   (25 * 13) / 1000
370 REPLACEMENT = ( 12.5 * LINES + 12.5 * LINES2)
380 DEPRECIATION = (BUILDING COST * .01)/1000
390 *
400 *  PER UNIT PRODUCTION INFORMATION
410 LABOR RATE = 2.80
420 MATERIAL COST = 1.20
430 MAINT PER UNIT = MAINTENANCE/UPROD
440 REP PER UNIT = REPLACEMENT/UPROD
450 DEP PER UNIT = DEPRECIATION/UPROD
```

```
460 COST PER UNIT = SUM(L410 THRU L450)
470 *
480 *  AREA INFORMATION
490 *
500 AVERUCOST = AVAIL GOODS/(BINVTUNITS + UPROD)
510 HCGS = HSALES * AVERUCOST
520 CGS2 = SALES2 * AVERUCOST
530 CGS3 = SALES3 * AVERUCOST
540 CGS4 = SALES4 * AVERUCOST
550 SELLINGH = MEN1 * 7 + HSALES * .50
560 SELLING2 = MEN2 * 7 + SALES2 * 1.1
570 SELLING3 = MEN3 * 7 + SALES3 * 1.1
580 SELLING4 = MEN4 * 7 + SALES4 * .80
590 VARPROFIT HOME = THSALES - HCGS - SELLINGH
600 VARPROFIT2 = TSALES2 - CGS2 - SELLING2
610 VARPROFIT3 = TSALES3 - CGS3 - SELLING3
620 VARPROFIT4 = TSALES4 - CGS4 - SELLING4
630 VPPH = VARPROFIT HOME/THSALES * 100
640 VPP2 = VARPROFIT2/TSALES2 * 100
650 VPP3 = VARPROFIT3/TSALES3 * 100
660 VPP4 = VARPROFIT4/TSALES4 * 100
670 VPUH = VARPROFIT HOME/HSALES
680 VPU2 = VARPROFIT2/SALES2
690 VPU3 = VARPROFIT3/SALES3
700 VPU4 = VARPROFIT4/SALES4
710 *
720 LINES = 6
730 LINES2 = 0
740 HOURS = 40
750 HOURS2 = 0
760 BUILDING COST = 4000000
770 PRODCOST = LABOR + MATERIALS + MAINTENANCE +
                 DEPRECIATION + REPLACEMENT
780 UPRODCOST = PRODCOST/UPROD
790 EINVTUNITS = (BINVTUNITS + UPROD) - USALES
800 EINVT = EINVTUNITS * UPRODCOST
810 AVAIL GOODS = BINVT + PRODCOST
820 GOODS SOLD = AVAIL GOODS - EINVT
830 *
840 GROSS PROFIT = TSALES - GOODS SOLD
850 *
860 ADVERTISING = 146
870 MEN1 = 18
880 MEN2 = 5
890 MEN3 = 5
900 MEN4 = 7
910 SALESMEN = MEN1 + MEN2 + MEN3 + MEN4
920 SAL SALARY = 3
930 SALES SALARIES = SAL SALARY * SALESMEN
940 COMMISSIONS = USALES * .20
950 GENSELLING = 150 + (4 * SALESMEN) + (USALES * .20)
```

```
960 TRANSPORT = HSALES * .10 + (SALES2 + SALES3) * .70 +
                    SALES4 * .40
970 OTHER SELLING = TRAINING * 5
980 TRAINING = 0
990 TOT SALESEXP = L860 + SUM(L930 THRU L970)
1000 *
1010 PROFIT ON SALES = GROSS PROFIT - TOT SALESEXP
1020 *
1030 RES AND DEV = 140
1040 STORAGE = BINVTUNITS * .1
1050 BOND INTEREST = .04 * 2000/4
1060 BANK DISCOUNT = BANK LOAN * INTRATE
1070 BANK LOAN = 2000
1080 INTRATE = .035/4
1090 EXEC COMP = 150
1100 OTHER EXPENSE = 0
1110 *
1120 TOTAL OTHER =  SUM(L1030 THRU L1060) +
                     SUM(L1090 THRU L1100)
1130 *
1140 PROFIT BEFORE TAX = PROFIT ON SALES - TOTAL OTHER
1150 *
1160 INCOME TAXES = PROFIT BEFORE TAX * .5
1170 *
1180 NET INCOME = PROFIT BEFORE TAX - INCOME TAXES
1190 *
1200 DIVIDENDS = 0
1210 RETAINED EARNINGS = BEG RE + NET INCOME - DIVIDENDS
1220 BEG RE = 1674
1230 *
1240 *
1250 *   CASH FLOW
1260 *
1270 BEG CASH = 3347
1280 END CASH = BEG CASH + RECEIPTS - TOT DISBURSE
1290 *    RECEIPTS
1300 ARCOLLECT = BEG AR + (TSALES * .5)
1310 BEG AR = 1086
1320 NEW LOAN = 2000
1330 NEW STOCK = 0
1340 NEW BONDS = 0
1350 RECEIPTS = ARCOLLECT + SUM(L1320 THRU L1340)
1360 *
1370 *   DISBURSEMENTS
1380 OPERATIONS = PROD COST - DEPRECIATION
1390 SALES EXP = TOT SALESEXP
1400 GENERAL EXPENSES = TOTAL OTHER
1410 PLANT INVEST = 0
1420 EQUIP INVEST = 0
1430 TAXES = 0
1440 DIVIDENDS = 0
```

```
1450 LOAN REPAID = 2000
1460 BONDS REPAID = 0
1470 TOT DISBURSE = SUM(L1380 THRU L1460)
1480 NETFLOW = RECEIPTS - TOT DISBURSE
1490 *  BALANCE SHEET
1500 *
1510 *     ASSETS
1520 *
1530 CASH BAL = END CASH
1540 ACCTS RE[illegible] = TSALES * .5
1550 INVENTORY = EINVT
1560 NET PLANT = 3020 - DEPRECIATION
1570 EQUIPMENT = 3000
1580 TOTAL ASSETS = SUM(L1530 THRU L1570)
1590 CURRENT ASSETS = SUM(L1530 THRU L1550)
1600 *
1610 *     LIABILITIES & EQUITY
1620 TAXES PAYABLE = 268 + INCOME TAXES - TAXES
1630 BANK LOAN = 2000 + NEW LOAN - LOAN REPAID
1640 BONDS = 2000 + NEW BONDS - BONDS REPAID
1650 TOTAL LIAB = SUM(L1620 THRU L1640)
1660 CURRENT LIAB = SUM(L1620 THRU L1630)
1670 *
1680 CAP STOCK = 5000
1690 RET EARN = RETAINED EARNINGS
1700 TOT EQUITY = CAP STOCK + RET EARN
1710 LIAB AND EQUITY = TOTAL LIAB + TOT EQUITY
1720 *
1730 *
1740 TOT SGA = TOT SALESEXP + TOTAL OTHER
END OF MODEL
```

Appendix B

Cohesiveness Instrument

Cohesiveness Instrument

1. How many of your group members fit what you feel to be the idea of a good group member?

   a. All of them.
   b. Most of them.
   c. Some of them.
   d. Few of them.
   e. None of them.

2. To what degree do you feel that you are included by the group in the group's activities?

   a. I am included in all the group's activities.
   b. I am included in almost all the group's activites.
   c. I am included in some of the activities, but not in some others.
   d. I don't feel that the group includes me in very many of its activities.
   e. I don't feel that the group includes me in any of its activities.

3. How attractive do you find the activities in which you participate as a member of your group?

   a. Like all of them very much.
   b. Like almost all of them.
   c. Like some of them, but not others.
   d. Like very few of them.
   e. Like none of them.

4. If most of the members of your group decided to dissolve the group by leaving, would you like an opportunity to dissuade them?

   a. Would like very much to persuade them to stay.
   b. Would like to persuade them to stay.
   c. Would make no difference to me if they stayed or left.
   d. Would not like to try to persuade them to stay.
   e. Would definitely not like to try to persuade them to stay.

5. If you were asked to participate in another project like this one, would you like to be with the same people who are in your present group?

   a. Would want very much to be with the same people.
   b. Would rather be with the same people than with most others.
   c. Makes no difference to me.
   d. Would rather be with another group more than present group.
   e. Would want very much to be with another group.

6. How well do you like the group you are in?

   a. Like it very much.
   b. Like it pretty well.
   c. It's all right.
   d. Don't like it too much.
   e. Dislike it very much.

7. How often do you think your group should meet?

   a. Much more often than at present.
   b. More often than at present.
   c. No more often than present.
   d. Less often than at present.
   e. Much less often than at present.

Appendix C

Sample Reports and Listings

COMPANY 1
INCOME STATEMENT

	Y6Q2	Y6Q3	Y6Q4
SALES	3,053	4,575	4,575
COST OF SALES	1,578	2,416	2,359
GROSS PROFIT	1,475	2,159	2,216
SELLING EXPENSES			
ADVERTISING	210	242	242
SALES SALARIES	112	124	124
COMMISSIONS	69	105	105
GENERAL SELLING	352	402	402
TRANSPORTATION	90	103	103
OTHER SELLING	20	30	30
TOTAL	853	1,006	1,006
GENERAL EXPENSES			
RESEARCH AND DEVELOPMENT	182	192	192
STORAGE	20	21	15
BOND INTEREST	36	36	36
BANK DISCOUNT	8	0	-8
EXECUTIVE COMPENSATION	150	150	150
OTHER EXPENSE	110	0	0
TOTAL	506	399	385
TOTAL SELLING AND GENERAL	1,359	1,405	1,391
PROFIT BEFORE TAX	116	754	825
INCOME TAXES	58	376	412
NET INCOME	58	378	413

COMPANY 1
BALANCE SHEET

	Y6Q2	Y6Q3	Y6Q4
ASSETS			
CASH	483	-256	-221
ACCOUNTS RECEIVABLE	1,527	2,288	2,288
INVENTORY	1,129	777	482
CURRENT ASSETS	3,138	2,808	2,549
NET PLANT	5,224	5,158	5,092
EQUIPMENT	4,000	4,000	4,000
TOTAL ASSETS	12,362	11,966	11,641
LIABILITIES & EQUITY			
TAXES PAYABLE	362	738	1,150
BANK LOAN	1,000	0	-1,000
CURRENT LIABILITIES	1,362	738	150
BONDS OUTSTANDING	3,500	3,500	3,500
TOTAL LIABILITIES	4,862	4,238	3,650
CAPITAL STOCK	5,000	5,000	5,000
RETAINED EARNINGS	2,501	2,729	2,992
TOTAL EQUITY	7,501	7,729	7,992
TOTAL	12,363	11,967	11,642

COMPANY 1
CASH FLOW

	Y6Q2	Y6Q3	Y6Q4
RECEIPTS			
RECEIVABLES	3,363	3,814	4,575
BANK LOAN	1,000	0	0
STOCK ISSUED	0	0	0
BONDS ISSUED	0	0	0
TOTAL	4,363	3,814	4,575
DISBURSEMENTS			
PRODUCTION	1,611	1,998	1,998
SALES EXPENSES	853	1,006	1,006
GENERAL EXPENSES	506	399	385
PLANT INVESTMENT	520	0	0
EQUIPMENT INVESTMENT	500	0	0
TAXES PAID	0	0	0
DIVIDENDS	150	150	150
LOAN REPAID	0	1,000	1,000
BONDS REDEEMED	500	0	0
TOTAL	4,641	4,554	4,540
NET CASH FLOW	-278	-739	36
BEGINNING CASH	761	483	-256
ENDING CASH	483	-256	-221

COMPANY 1
PRODUCTION ANALYSIS

	Y6Q2	Y6Q3	Y6Q4
PRODUCTION COSTS			
TOTAL			
LABOR	905	1,206	1,206
MATERIALS	454	588	588
MAINTENANCE	78	104	104
REPLACEMENT	75	100	100
DEPRECIATION	66	66	66
OTHER	100	0	0
TOTAL	1,677	2,064	2,064
PER UNIT			
LABOR	2.79	2.87	2.87
MATERIALS	1.40	1.40	1.40
MAINTENANCE	.24	.25	.25
REPLACEMENT	.23	.24	.24
DEPRECIATION	.20	.16	.16
OTHER	.31	.00	.00
TOTAL	5.18	4.92	4.92

```
REPORT INCOME

10 FORMAT....................999,999 999,999 999,999
20 * *DATE*
30 UNDERLINE
40 *
50 CENTER COMPANY &CONUM&
60 CENTER INCOME STATEMENT
70 UNDERLINE
80 *
90 COLUMN TITLES Y6Q2,Y6Q3,Y6Q4
100 /SALES/TSALES
110 /COST OF SALES/GOODS SOLD
120 UNDERLINE
130 GROSS PROFIT
140 UNDERLINE
150 *
160 *SELLING EXPENSES
170 ADVERTISING
180 SALES SALARIES
190 COMMISSIONS
200 /GENERAL SELLING/GENSELLING
210 /TRANSPORTATION/TRANSPORT
220 OTHER SELLING
230 UNDERLINE
240 /TOTAL/TOT SALESEXP
250 UNDERLINE
260 *
270 *GENERAL EXPENSES
280 /RESEARCH AND DEVELOPMENT/RES AND DEV
290 STORAGE
300 BOND INTEREST
310 BANK DISCOUNT
320 /EXECUTIVE COMPENSATION/EXEC COMP
330 OTHER EXPENSE
340 UNDERLINE
350 /TOTAL/TOTAL OTHER
360 UNDERLINE
370 /TOTAL SELLING AND GENERAL/TOT SGA
380 UNDERLINE
390 *
400 PROFIT BEFORE TAX
410 INCOME TAXES
420 UNDERLINE
430 NET INCOME
440 UNDERLINE=
END OF REPORT
```

```
REPORT BALANCE

10 FORMAT....................999,999 999,999 999,999
20 * *DATE*
30 UNDERLINE
40 SPACE 2
50 CENTER COMPANY &CONUM&
60 CENTER BALANCE SHEET
70 UNDERLINE
80 *
90 COLUMN TITLES Y6Q2,Y6Q3,Y6Q4
100 *
110 *    ASSETS
120 /CASH/CASH BAL
130 /ACCOUNTS RECEIVABLE/ACCTS REC
140 INVENTORY
150 UNDERLINE
160 CURRENT ASSETS
170 UNDERLINE
180 NET PLANT
190 EQUIPMENT
200 UNDERLINE
210 TOTAL ASSETS
220 UNDERLINE=
230 *
240 *    LIABILITIES & EQUITY
250 TAXES PAYABLE
260 BANK LOAN
270 UNDERLINE
280 /CURRENT LIABILITIES/CURRENT LIAB
290 UNDERLINE
300 /BONDS OUTSTANDING/BONDS
310 UNDERLINE
320 /TOTAL LIABILITIES/TOTAL LIAB
330 UNDERLINE
340 *
350 /CAPITAL STOCK/CAP STOCK
360 /RETAINED EARNINGS/RET EARN
370 UNDERLINE
380 /TOTAL EQUITY/TOT EQUITY
390 UNDERLINE
400 /TOTAL/LIAB AND EQUITY
410 UNDERLINE=
END OF REPORT
```

REPORT FLOW

```
10 FORMAT....................999,999 999,999 999,999
20 *  *DATE*
30 UNDERLINE
40 SPACE 2
50 CENTER COMPANY &CONUM&
60 CENTER CASH FLOW
70 UNDERLINE
80 *
90 COLUMN TITLES Y6Q2,Y6Q3,Y6Q4
100 *  RECEIPTS
110 /RECEIVABLES/ARCOLLECT
120 /BANK LOAN/NEW LOAN
130 /STOCK ISSUED/NEW STOCK
140 /BONDS ISSUED/NEW BONDS
150 UNDERLINE
160 /TOTAL/RECEIPTS
170 UNDERLINE
180 *
190 *  DISBURSEMENTS
200 /PRODUCTION/OPERATIONS
210 /SALES EXPENSES/SALES EXP
220 GENERAL EXPENSES
230 /PLANT INVESTMENT/PLANT INVEST
240 /EQUIPMENT INVESTMENT/EQUIP INVEST
250 /TAXES PAID/TAXES
260 DIVIDENDS
270 LOAN REPAID
280 /BONDS REDEEMED/BONDS REPAID
290 UNDERLINE
300 /TOTAL/TOT DISBURSE
310 UNDERLINE
320 *
330 /NET CASH FLOW/NETFLOW
340 /BEGINNING CASH/BEG CASH
350 UNDERLINE
360 /ENDING CASH/END CASH
370 UNDERLINE=
END OF REPORT
```

```
REPORT PRODUCT

10 FORMAT....................999,999 999,999 999,999 999,999
20 *  *DATE*
30 SPACE 2
40 CENTER COMPANY &CONUM&
50 CENTER PRODUCTION ANALYSIS
60 UNDERLINE
70 *
80 COLUMN TITLES Y6Q2,Y6Q3,Y6Q4
90 *
100 * PRODUCTION COSTS
110 * TOTAL
120 LABOR
130 MATERIALS
140 MAINTENANCE
150 REPLACEMENT
160 DEPRECIATION
165 /OTHER/OTHER PROD
170 /   TOTAL/PRODCOST
180 *
190 FORMAT....................999.99 999.99 999.99 999.99
200 * PER UNIT
210/LABOR/LABOR PER UNIT
220 /MATERIALS/MATERIAL COST
230 /MAINTENANCE/MAINT PER UNIT
240 /REPLACEMENT/REP PER UNIT
250 /DEPRECIATION/DEP PER UNIT
255/OTHER/OTHER PER UNIT
260 /   TOTAL/COST PER UNIT
END OF REPORT
```

Appendix D

Academic Major by Company

Academic Major by Company

Control Groups-9:40 Class

World 2 Company 1
- General Business
- Accounting
- Master of Quantitative Systems
- Marketing
- Finance

World 2 Company 2
- Accounting
- Marketing
- General Business
- General Business
- Accounting
- Computer Information Systems

World 2 Company 3
- General Business
- Computer Information Systems
- General Business
- Marketing
- Management

World 1 Company 4
- Management
- Computer Information Systems
- Management
- Production
- Accounting
- Marketing

World 1 Company 5
- Accounting
- Management
- Marketing
- Computer Information Systems
- Computer Information Systems

World 1 Company 6
- Computer Information Systems
- Marketing
- Personnel
- Marketing
- Accounting

Experimental Groups - 11:40 Class

World 1 Company 1
- Computer Information Systems
- Accounting
- Finance
- Computer Information Systems
- Marketing

World 1 Company 2
- Marketing
- Computer Information Systems
- Marketing
- Finance
- Accounting

World 1 Company 3
- Computer Information Systems
- Advertising
- Advertising
- Marketing
- Computer Information Systems

World 2 Company 4
- Personnel
- Personnel
- Advertising
- Accounting
- Finance

World 2 Company 5
- General Business
- General Business
- Computer Information Systems
- Finance
- Marketing

World 2 Company 6
- Marketing
- Production
- General Business
- Real Estate
- Accounting

Appendix E

Summarized Business Game Instructions

Summarized Business Game Instructions

The Business Policy Game has been designed as a general management simulation problem to provide a complex decision-making exercise. It requires decisions in the functional areas of marketing, production and finance.

Participants are required to make quarterly decisions regarding the operation of their manufacturing firm as they compete with the management of other manufacturing firms in their industry. It is not intended that the hypothetical operations the players of the game undertake will duplicate any actual business situation. Rather, the game model was designed to include general relationships that might exist in any competitive industry. The model does not purport to include all of the relationships that exist, only those that contribute significantly to the degree of realism required to play the game.

It will be necessary for players to undertake economic forecasting, sales forecasting and profit planning. Cash and capital budgets will be required. Production planning and scheduling must be done. Cost analysis, development of pricing policies and planning and implementing of marketing programs will be necessary. In addition, participants must prepare and analyze financial reports, cash flow statements, cost and sales analyses and information reports regarding their competitors and the economic situation.

Quarterly Decisions

Each simulated quarter the following decisions are required:

In each of four marketing areas:

- Price
- Advertising
- Salesmen to be placed in training

Research and Development:

- Process
- Product

Production of New Model

Employee Compensation:

- Sales Salaries
- Sales Commissions
- Executive Salaries
- Executive Bonus

Production Scheduling:

- Weeks per Quarter
- Hours Per Week
- Possible Second Shift
- Plant, Shift or Line Shutdown

Capital Investment:

- Construction of Plant
- Addition to Existing Plant
- Add lines to Existing Plant

Financing:

- Bank Loans
- Issue or Redeem Bonds
- Pay Dividends
- Issue Stock

Standards for Success

A company's operations will be judged according to how well management performs in competition with the management teams of the other companies in the industry. Some of the performance measures employed in the evaluation process are:

Profitability:

- Cumulative Rate of Return
- Income / Assets
- Income / Sales
- Income / Equity

Efficiency Ratios

- Sales / Assets
- Cost of Goods Sold / Inventory
- Sales / Plant and Equipment

Financial Ratios:

- Bonds / Equity
- Current Ratio
- Quick Ratio
- Interest Coverage
- Net Current Assets

In addition to the above listed measures, more traditional financial analyis measures such as net income, total equity and stock price are utilized in the measurement of a company's performance relative to the other firms in the industry.

BIOGRAPHICAL SKETCH

Michael Ray Ruble was born in Bremerton, Washington, on October 7, 1947. He received his elementary and secondary education in the Central Kitsap Public Schools. In 1965, he entered Central Washington University, graduating in 1970 with a Bachelor of Arts degree in Business, specializing in Accounting. From 1970 to 1975, he was a staff accountant in the Seattle office of Deloitte, Haskins & Sells, Certified Public Accountants. From 1975 to 1978, he held controllership positions at two small privately-owned companies. In September, 1975, he entered Pacific Lutheran University, receiving his Master of Business Administration degree in December 1979. From 1978 to 1980, he was an assistant professor of Accounting at Central Washington University. Since August, 1980, he has held a graduate assistantship in the College of Business Administration, Arizona State University, while studying for the degree of Doctor of Business Administration. He is a Certified Public Accountant in the State of Washington and is a member of the American Accounting Association and the American Institute of Certified Public Accountants. He is married to Vickie and the father of Mary Jo and Michael Adriaan.