

**THE SELECTION OF CONSTRUCTION PROJECT MANAGER BY USING
ANALYTICAL HIERARCHY PROCESS (AHP)**

LAU HUI SENG

A project report submitted in partial fulfilment
of the requirements for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
Univeriti Teknologi Malaysia

MAY 2006

**Special
Dedicated To
My Heavenly Father,
My Lord and Savior Jesus Christ
And
My beloved friends, parents and family.**

ACKNOWLEDGEMENT

This study would not have been possible without the assistance and support of those who guided me in the course of my graduate work. First, I would like to thank God for His grace and mercy throughout this research. It is by His hands and wisdom in guiding me to finish my work within the study period.

I would like to extend my thanks to my honorable supervisor, Dr Arham Bin Abdullah, for his academic guidance, support, encouragement, and help during the course of my study. I would like to specially thank his patience and tolerance towards me, in which he always trusts me that I am able to do it. His diligence, dedication and working attitudes are good examples for me to follow.

Last but not least, I also appreciate the love, support and encouragement given to me by my family members and friends.

ABSTRACT

The scope of this research deals with the decision making process concerning selection of the finalists for position of project manager. The Analytical Hierarchy Process (AHP) and the Decision Support Software program-Expert Choice was used to assist with the decision. The research focus on the integration of Analytical Hierarchy Process (AHP) and Decision Support Software-Expert Choice into overall decision making process. The first objective of this research is to identify procedure in selection of a project manager. The second objective is to identify the factor and criterions that should be considered in selection process. Finally, a new framework as a Decision Support System (DSS) for evaluating project manager called Project Manager Selection System (PMSS) will be developed based on AHP. The research method used includes the knowledge acquisition technique, data analysis, and model development process. The study will focus on 100 local construction companies to capture the knowledge from the expert on the selection process. It is believe that the proposed framework will provide an even more structured approach and assist in formulating guidelines for construction company in selection of a project manager.

ABSTRAK

Skop kajian ini berkaitan dengan proses membuat keputusan untuk memilih seorang pengurus projek pembinaan. Analytical Hierarchy Process (AHP) dan Decision Support Software program-Expert Choice telah digunakan untuk membantu dalam proses membuat keputusan. Kajian ini memberi fokus kepada gabungan dan penggunaan Analytical Hierarchy Process (AHP) dan Decision Support Software-Expert Choice dalam proses membuat keputusan keseluruhan. Objektif pertama kajian ini adalah untuk menentukan prosedur dalam proses pemilihan seorang pengurus projek pembinaan. Objektif kedua adalah untuk menentukan faktor dan criteria yang perlu dipertimbangkan dalam proses pemilihan. Akhirnya, satu rangka Decision Support System (DSS) untuk pemilihan pengurus projek dengan nama Project Manager Selection System (PMSS) akan dibangunkan berdasarkan AHP. Cara kajian yang telah digunakan termasuk teknik pengumpulan maklumat, analisis data, and proses pembangunan model. Kajian ini fokus kepada 100 syarikat pembinaan tempatan (kontraktor Kelas A) untuk mendapatkan maklumat awalan daripada pakar bidang tentang proses pemilihan. Daripada kajian yang telah dijalankan, terbukti sistem ini dapat menyediakan satu cara yang lebih berstruktur kepada syarikat pembinaan dalam pemilihan pengurus projek pada masa yang akan datang.

TABLE OF CONTENTS

CHAPTER	SUBJECT	PAGE
	TITLE PAGE	i
	DECLARATION PAGE	ii
	DEDICATION PAGE	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xvi
	LIST OF APPENDICES	xvii
CHAPTER 1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Background of Research	2
	1.2.1 Construction Project Manager	3
	1.2.2 Selection Process	3
	1.2.3 Decision Making	4
	1.3 Problem Statement	4
	1.4 Research Aim and Objective	5
	1.5 Scopes of Studies	5
	1.6 Research Methodology	6
	1.7 Expectation	7
	1.8 Hypothesis	7
	1.9 Limitation of studies	8

CHAPTER 2 LITERATURE REVIEW

2.1.	Introduction	9
2.2.	Overview of Construction Project Manager	9
2.2.1.	Responsibilities of Project Manager	11
2.2.2.	Challenges of Project Manager	17
2.2.3.	Overview of Selection Process	20
2.2.3.1.	Interview the Candidates	26
2.2.3.2.	Employee's Selection	30
2.3	Review of Decision Making	
2.3.1	Introduction	32
2.3.2	Decision Making	32
2.3.2.1	Multicriteria Decision Making (MCDM)	33
2.3.2.2	MCDM Analysis	34
2.3.2.3	MCDM Method Adopted for Research	36
2.3.3	Analytic Hierarchy Process	39
2.3.3.1	Background of AHP	40
2.3.3.2	AHP Principles	41
2.3.4	Decision Support System (DSS)	46
2.3.4.1	DSS Concepts	47
2.3.4.2	DSS Adopted for the Research	47
2.4	Summary	49

CHAPTER 3 RESEARCH METHODOLOGY

3.1	Introduction	50
3.2	Research Methodology	50
3.3	Methodology Adopted for the Research	51
3.3.1	Literature Review	52
3.3.2	Defining the Topic	52
3.3.3	Identifying Sources of Information	53

3.3.4	Keeping Records	53
3.3.5	Reading and note taking	54
3.3.6	Knowledge Acquisition	54
3.3.7	Questionnaire Survey	55
3.3.8	Interviews	55
3.3.9	Protocol Analysis	56
3.3.10	Prototype Development	56
3.3.11	Evaluation	57

CHAPTER 4 KNOWLEDGE ACQUISITION FOR MODEL DEVELOPMENT

4.1	Introduction	59
4.2	Questionnaire Survey	59
4.2.1	Questionnaire Design	60
4.2.2	Survey Sample	60
4.2.3	Results	60
4.2.4	Discussion	72
4.3	Interview	73
4.3.1	Results	73
4.3.2	Discussion	74
4.4	Summary	83

CHAPTER 5 DEVELOPMENT AND OPERATION OF THE PROTOTYPE SYSTEM

5.1	Introduction	84
5.2	Functional Architectural of the Prototype System	84
5.3	Development of the AHP Model	85
5.3.1	Problem Definition	85
5.3.2	Rapid Prototyping	86
5.3.3	Developing the AHP Hierarchy	86

5.3.4	The Pairwise Comparison	87
5.3.5	Synthesis of the AHP Model	90
5.3.6	Sensitivity Analysis	90
5.3.7	Developing the Information Document	91
5.4	Operation of the Prototype System	93
5.4.1	Users Requirements	94
5.4.2	System Requirements	94
5.4.3	Starting the Prototype System	94
5.4.4	Assigned Judgment in Pairwise Comparison	95
5.4.5	Synthesize to get Results	99
5.5	Summary	104

CHAPTER 6 EVALUATION OF THE PROTOTYPE SYSTEM

6.1	Introduction	105
6.2	Evaluation Aim and Objectives	105
6.3	Evaluation Methodology	106
6.3.1	Evaluation Approach	106
6.3.2	Questionnaire Design	107
6.4	Evaluation Results	108
6.5	Discussion	110
6.5.1	Suggestion for Improvement	111
6.5.2	Benefit of the Prototype	112
6.5.3	Limitation of the Prototype	112
6.5.4	Appropriateness of the Evaluation Approach	113
6.6	Summary	113

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1	Introduction	114
-----	--------------	-----

7.2	Summary	114
7.3	Benefits	118
7.4	Limitations	118
7.5	Conclusion	119
7.6	Recommendation for further research	121
7.7	Closing Remarks	122
REFERENCES		123
APPENDICES		125
A		126
B		136
C		142

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.1	Random Index <i>RI</i>	46
4.2	Procedure in Selection Process	71
6.1	The responses to evaluation questions	108
6.2	Comments from evaluators for prototype system	109

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
3.1	Research Methodology	51
4.1	Group of Respondents	62
4.2	Respondent's Pre-qualification Selection Experience	62
4.3	Category of work involve by respondents	63
4.4	Types of Project Engaged by respondent's company	63
4.5	Method to determine decision criteria and rules	64
4.6	Information submitted by candidates in pre-qualification selection	65
4.7	Peoples responsible for candidate's qualification evaluation	65
4.8	Decision Criteria Evaluation Techniques	66
4.9	Decision Support System (DSS)	67
4.10	Analytic Hierarchy Process (AHP)	67
4.11	Application of methodology Decision Support System (DSS) for selection process	68
4.12	Types of methodology decision support tools applied	69
4.13	Important of Decision Support System (DSS)	69
5.1	The functional architecture of the Project Manager Selection System (PMSS)	85

5.2	Hierarchic Structure for the Project Manager Selection Model	88
5.3	Equal rating (1) in pairwise comparison between Jobs Experience and Academic Achievement	89
5.4	Rating of 3 in pairwise comparison between Job Experience and Medical Evaluation	89
5.5	The Information Document developed in the AHP Model	92
5.6	The Information Document developed in the AHP Model	93
5.7	Project Manager Selection Model	95
5.8	The Verbal Comparison Window	98
5.9	Derived Priorities of the alternatives with respect to Job Experience	98
5.10	Model View showing the Synthesized Results with respect to the Goal	99
5.11	Synthesis Window	100
5.12	Dynamic Sensitivity Graph	101
5.13	Performance Sensitivity Graph	101
5.14	Gradient Sensitivity Graph	102
5.15	Head-To-Head Sensitivity Graph	103
5.16	Two Dimensional Sensitivity Graphs	104
6.1	System's Performance	110
6.2	System's Applicability	111
6.3	General Rating	111

LIST OF SYMBOLS

AHP	-	Analytic Hierarchy Process
AI	-	Artificial Intelligent
AS_{ij}	-	Assigned Score
B_i	-	The n_{i-1} by n_i matrix with row consisting of estimated Eigenvectors
CI	-	Consistency Index
CIDB	-	Construction Industry Directory
CPM	-	Critical Path Methods
CR	-	Consistency Ratio
$C(I, K)$	-	The vector of composite weights of elements at level K with respect to the element on level 1
C_{ij}	-	Raw Score Each Criterion
DSS	-	Decision Support Software
EC	-	Expert Choice
GP	-	Goal programming
IR	-	Inconsistency ratio
KA	-	Knowledge Acquisition
MCDM	-	Multi-criteria Decision Making
MODM	-	Multi-Objective Decision Making
MS	-	Microsoft programs
n	-	Matrix Size
n_i	-	The number of element at level i
OSHA	-	Occupational Safety and Health Act
PC	-	Personal Computer

PDM	-	Precedence Diagramming Method
PMSS	-	Project Manager Selection System
R_j	-	Ranking Number
WPM	-	Weighted Product Model
WSM	-	Weighted Sum Model
λ_{\max}	-	Eigenvalue Max
%	-	Percent

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Questionnaire Survey Form	123
B	Interview Survey Form	132
C	Evaluation Interview Survey Form	137

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Project manager has an overall responsibility for such planning, organizing, and controlling. They are involved in the project from when the contract document is picked up to when all construction works has been completed and all changes or conflict has been resolved. They are responsible for ensuring that the planning phase of a project involves a complete task description, a thorough resource needs analysis, a practical time schedule, and a sound definition of requirements. Besides, they also involved in estimating, submittal preparation, coordination, project scheduling, correspondence and detail design. The contractor is a 'for profit' company and they typically prefer to have as many jobs as possible. This philosophy requires the project managers to continuously bid on new project while running the current project. This is one of the largest challenges or problem for the project manager to running the multiple jobs.

Project manager plays dynamic roles in a construction company. The company needs to hire qualified, responsible and high efficiency individual to deal with the job. Thus, a search committee for the position of project manager was formulated to meet the need. A job description was developed and advertised in daily news, professional journals and others publication. A number of qualified professionals will applied for

the position. So, it is a need for the search committee to select the most qualified candidates for the final phases of the interview and selection process. Before reviewing the material submitted by each candidate, a decision hierarchy was created that was based on the requirement of position. This requirement research used large scale survey approach or questionnaire survey to capture preliminary knowledge especially in identified the criteria which affect the selection process of a project manager. The depth survey approach, interviews and protocol analysis were used to validate and to gain a better understanding on the knowledge capture from previous approach. After reviewing all the material submitted by each applicant, a decision support software program was used to assist the search committee in the selection of the most qualified candidates for the position of project manager.

1.2 BACKGROUND OF RESEARCH

The scope of this research focused in decision making process concerning the selection process of construction project manager. Some of the applications that relates to this research include the Selection Process of Division Director (Charles McIntyre, Merlin Kirschenman, and Scott Seltveit, 1999); Selection of Demolition Techniques (Arham. B. Abdullah, 2003); Process of Contractor Selection (Jenning and Holt, 1998; Okaroh and Torrance, 1999; Fong and Choi, 2000); and Decision Support System (DSS) in Allocation of Resources in Rehabilitation Projects (Igal M. Shohet, M.ASCE, and Eldad Perelstein, 2004). In this related researches, the Analytical Hierarchy Process (AHP) and the Decision Support Software (DSS) program- Expert Choice was integrated into the overall decision making process. In selection process of division director (Charles McIntyre, Merlin Kirschenman, and Scott Seltveit, 1999), the integration is applied in selection of director at Construction Management and Engineering Division (CME), North Dakota State University. In selection of demolition techniques (Arham. B. Abdullah, 2003), the integration is applied to assist demolition engineers to select the most appropriate demolition technique. However, in process of contractor selection (Jenning and Holt, 1998; Okaroh and Torrance, 1999; Fong and Choi, 2000), the integration of AHP and DSS is developed to assist in contractor selection based on the multiple criteria listed in tender's document. This application is also assist in allocation of resources in rehabilitation project (Igal M. Shohet, M.ASCE, and Eldad Perelstein, 2004). In this

research, the extensive literature review focused in 3 major subjects, first, the responsibilities, characteristic, problem and challenges faced by a construction project manager. Second, the selection process of project manager and finally the decision making process. This can provides a theoretical background and form the basis for continuing further into the research.

1.2.1 CONSTRUCTION PROJECT MANAGER

This section gives an overview of responsibilities, characteristic, problems and challenges faced by construction project managers now days in construction industry. Construction management is usually defined as the organization and direction of man, materials, and equipment to accomplish the purpose of the designer. Historically, construction project managers have been contractors that have gained experiencing running projects or construction inspectors that have moved up the ranks while gaining valuable experience. It also can be an employee of the contractor or a potential project owner, which referred to as a construction project manager. The construction project manager then coordinates and communicates the entire project process which may include project feasibility, planning, design, construction, and project implementation. The primary objective is to minimize time and cost while maintaining project quality.

1.2.2 SELECTION PROCESS

This section gives an overview on how to find qualified personnel. Explained are the steps in locating candidates, interviewing applicants, and selecting the correct employee. A hiring checklist provides step to ensure success. Form of job specification, employment application, interview notes, and applicant evaluation are investigated to help in selection process. This information provides a theoretical support in the research.

1.2.3 DECISION MAKING

This section gives a basic concept of decision making including its definition and phases. The chapter then describes Multi-criteria Decision Making (MCDM) in

terms of its method and justified why Analytic Hierarchy Process (AHP) as one of the MCDM methods was selected for this research. In addition the background and theoretical aspect of the AHP are presented to give a clear perspective of this powerful decision support tool. Next, the chapter reviews the basic concept of Decision Support System (DSS) and justifies why Expert Choice software was selected as the DSS tool to used in the research.

1.3 PROBLEM STATEMENT

Construction management is a process by which a potential owner engages an agent, referred to as a construction manager or Project manager. The project manager then coordinates & communicates the entire project process which may include project feasibility, planning design, construction, and project implementation. The primary objective is to minimize time and cost while maintaining project quality.

The project manager has the obligation to serve the owner as if he or she is an employee of the owner. A construction project manager has the legal authority to represent the owners and to carry out business dealing in the owners behalf. Besides working with the owner and general contractor, the project manager has to work with the designer, testing labs, and equipment suppliers. On each project, the project manager has a group of inspector to supervise. The project managers has to be familiar with standard construction practice and keep abreast of new development and changes in the field. The project managers performs a wide variety of services such as detail planning and scheduling, construction estimating, operating procedures, supervision, inspection, plan review, submittal review, property management, correspondence and testing.

The project managers play a challenging and dynamic role in a construction company. Thus, the selection of the position of company's project managers may need careful consideration. It is not easy to select qualified professional among a numbers of candidates. Although the selection process can based on the knowledge, preferences and experience of decision makers, it is more preferable that the company develop a systematic method to assist in the selection process. The AHP and Expert choice was integrated into overall decision making process. It is believe that this

systematic approach will reduce the time in selection process, save manpower resources and provide a structured guideline in the selection of the most qualified candidates for the position of project manager to assist in future decision making application.

1.4 RESEARCH AIM AND OBJECTIVE

The main aim of the research is to develop a decision support system to aid the search committee in the selection of most qualified candidate for the position of project manager. The specific objectives were:

- i) To understand the responsibilities, characteristic and challenges of a project manager;
- ii) To identified the selection process of project manager in various type of construction company;
- iii) To investigate and define the criteria which effect the selection process of project manager; and
- iv) To develop and evaluate a decision support system to assist in the selection of most qualified candidate for the position of project manager.

1.5 SCOPES OF STUDIES

The scopes of studies are focused on local construction's company to capture preliminary knowledge especially in identified the criteria which is significant in the selection process of a construction project manager.

1.6 RESEARCH METHODOLOGY

Research methodology is the research method used to achieve the specific objective of the research. A brief description of the research method used is given in this section. The detailed research methodology is presented in Chapter 3.

i) Literature Review

The extensive literature review focused in two major subject. First, the responsibilities, characteristic and challenges of a construction project manager. Secondly, the selection process of project manager in various type of Construction Company. Literature reviews on these two subjects provide a theoretical background and form the basis for continuing further into the research. Review of literature was achieved through several sources, which includes: books and publication from library, internet searching, and INFOLAN of University library to assess report, thesis, journals and conferences papers related to the subject.

ii) Knowledge Acquisition

The process involved capturing and transforming appropriate knowledge from several sources such as books, publications, journals and experienced expert into some manageable form in order to develop a decision support system in selection of a most appropriate project manager. This research used large scale survey approach or questionnaire survey to capture preliminary knowledge especially in identified the criteria which affect the selection process of a project manager. The depth survey approach, interviews and protocol analysis were used to validate and to gain a better understanding on the knowledge capture from previous approach.

iii) Prototype Development

The development of the proposed decision support system was based on the result capture from the knowledge acquisition process. A decision hierarchy is developed based on the requirement of the position. Rapid prototyping methodology was used in the prototype development.

iv) Evaluation

The complete prototype was evaluated before and after the development process to access it functionality and usability. The evaluators were drawn from

company's managers and researchers. The selection process of project managers in 5 construction companies was used as a case study in the evaluation process. The evaluators were requested to complete a questionnaire that assessed the prototype from various perspectives.

1.7 EXPECTATION

Integration of analytical hierarchy process (AHP) and Decision Support Software (DSS)-Expert Choice into overall decision making process will give a more structured and systematic guideline in the selection process of most qualified candidates for the position of project manager in construction's companies.

1.8 HYPOTHESIS

The AHP and Expert choice was integrated into overall decision making process. This systematic approach will reduce the time in selection process, save manpower resources, and provide a guideline in decision making process.

1.9 LIMITATIONS OF STUDY

- i) The fundamental construction of a decision hierarchy was the single most important aspect of the research. So, the criteria or exact requirement of the position may need careful consideration. Wrong and inadequate information will effect and reduce the usability of the system.
- ii) The research focused on selected construction companies only due to the limitation of resources. It may affect the overall efficiencies of the system developed.

7.7 CLOSING REMARKS

The research has revealed that, the current human resources selection practice performed by human resources specialist are based on their knowledge, feeling and experience without any systematic procedure that can be followed to support the decision making process. This research has demonstrated how the prototype system developed provides the users with a clear, systematic and structured framework that could improve current decision making process. AHP in particular, with the use of Expert Choice software can enhance the decisions made by decision makers. The human resources specialist in construction industry should take advantage of the prototype system developed in this research as it presents many benefits in terms of technical aspect in human resources planning and development to ensure a faster, easier and structured selection process.

REFERENCES

- Arham Bin Abdullah (2003). "Intelligent Selection of Demolition Techniques." Thesis PhD.
- Biju A. George, B. R. S. Reddy, N. S. Raghuvanshi, and W. W. Wallender. (2002) "Decision Support System for Estimating Reference Evapotranspiration" J. Irrig. and Drain. Engrg. 128, 1.
- Braham, Barbara J. (1992) "Problem solving and decision making." Cincinnati, OH : South-Western Pub. Co.
- Brinkers, Henry S. (1972) "Decision-making : creative, judgement, and systems" Columbus : Ohio State Uni. Press.
- Byars, Lloyd L.(1991) "Human resource management" Homewood, Ill. : Irwin.
- Charles McIntyre, Merlin Kirchenman, and Scott Seltveit. (1999). " Applying Decision Support Software in Selection of Division Director." J. Constr. Engrg. and Mgmt.
- David I. Cleland, Lewis R. Ireland. (2000) "Project manager's portable handbook ." New York : McGraw-Hill.
- Deborah J. Fisher, Michael W. O'Neill, and Jeffrey C. Contreras. (1995) "Drilled Shaft Decision Support System" J. Constr. Engrg. and Mgmt. 121, 86.
- Fong and Choi, Jennings and Holt, Okaroh and Torrance. (1998,1999,2000). "A Decision Framework for Contractor Selection." J. Constr. Engrg. and Mgmt.
- Ford, Robert Clayton. (1980) "Principles of management : a decision-making approach" Reston, Va. : Reston.
- George T Milkovich, John W Boudreau. (1991) "Human resource management." Homewood, IL : Irwin.
- Igal M. Shohet and Eldad Perelstein. (2004). "Decision Support Model for the Allocation of Resources in Rehabilitation Projects." J. Constr. Engrg. and Mgmt. 130, 249.
- Jeffrey K. Pinto, O. P. Kharbanda. (1995) "Successful project managers : leading your team to success." New York : Van Nostrand Reinhold.
- Karumanasseri, G and AbouRizk, S. (2002) " Decision Support System for Scheduling Steel Fabrication Projects" J. Constr. Engrg. and Mgmt. 128, 392.
- Koorosh Gharehbaghi and Kerry McManus. (2003) "Effective Construction Management" Leadersh. Manage. Eng. 3, 54.

- Liberatore, Matthew. (2003) "Decision technology : modeling, software and applications." Hoboken, New Jersey : John Wiley & Sons.
- Lloyd L. Byars, Leslie W. Rue. (1991) "Human resource management." Homewood, Ill. : Irwin.
- Milkovich, George T. (1991) "Human resource management" Homewood, IL : Irwin.
- Mohammed Fadhil Dulaimi and David Langford. "Job Behavior of Construction Project Managers: Determinants and Assessment." J. Constr. Engrg. and Mgmt. 125, 256.
- Neuman, William Lawrence. (1991) "Social research methods : qualitative and quantitative approaches" Boston : Allyn and Bacon.
- Pinto, Jeffrey K. (1995) "Successful project managers: leading your team to success" New York : Van Nostrand Reinhold.
- Rafikul Islam. (2003) "The analytic hierarchy process : an effective multi-criteria decision making tool." Kuala Lumpur : International Islamic University Malaysia.
- Ralph L Keeney. (1976) "Decisions with multiple objectives : preferences and value tradeoffs." New York : Wiley.
- Robert J. Thierauf, Robert C. Klekamp. (1975) " Decision making through operations research." New York : John Wiley.
- Robert J. Thierauf. (1988) "User-oriented decision support systems : accent on problem finding." Englewood Cliffs, N.J. : Prentice-Hall.
- Royer. King. (1974) "The construction manager" Englewood Cliffs, New Jersey : Prentice-Hall.
- Royer, King. (1981) "The construction manager in the 80's." Englewood Cliffs, N J : Prentice-Hall.
- Saaty, Thomas L. (Thomas Lorie). (1991) "Prediction projection and forecasting : applications of the analytic hierarchy processes in economics, finance, politics, games and sports" Boston : Kluwer Academic Pubs.
- Thierauf, Robert J.(1988) "User-oriented decision support systems : accent on problem finding" Englewood Cliffs, N.J. : Prentice-Hall.