The UNIVERSITY of NEWCASTLE
AUSTRALIA

KNOWLEDGE SHARING IN THE MALAYSIAN CONSTRUCTION INDUSTRY

by

ABANG HATTA ABANG TAHA
B. Sc. (Electrical Engineering), MBA (Project Management)

A Dissertation submitted in partial fulfillment of the requirements for
the degree of Doctor of Business Administration (DBA)
in the Faculty of Business and Law, University of Newcastle, Australia

FEBRUARY 2009

STATEMENT OF ORIGINAL AUTHORSHIP

I hereby certify that the work embodied in this Dissertation Project is the result of original research and has not been submitted for a higher degree to any other University or Institution.

Abang Hatta Abang Taha
Student No. 3025234

ACKNOWLEDGEMENTS

I am grateful to my supervisor, Dr. Andrew Dempster, for guiding me through this dissertation.

I wish to thank Datuk Ir. Hamzah Hasan, the Chief executive of the Construction Industry Development Board, Malaysia, for his support towards my research survey.

My fullest gratitude to my wife, Roshima and my daughters, Farah, Nadia and Farzana for their immeasurable support, patience and sacrifices during the duration of the DBA course.

Lastly, sincere thanks to Nicholas Amin, without whose help this dissertation would probably have not been concluded.

DEDICATION

This dissertation is dedicated to my late father and my mother, both of whom persevered to provide me with a good education.

TABLE OF CONTENTS

Statement of Original Authorship ..... **ii**

Acknowledgements ..... **iii**

Dedication ..... **iv**

Table of Contents ..... **v**

List of Tables ..... **ix**

List of Figures ..... **xi**

Abstract ..... **xii**

CHAPTER 1 INTRODUCTION

1.1 Background of the Research 1

1.2 Literature Search and Review 2

1.3 Research Problem, Question, Hypotheses and Conceptual Frameworks 3

1.3.1 Research Problem 3

1.3.2 Research Questions 4

1.3.3 Variables 4

1.3.4 Hypotheses 5

1.3.5 Research Frameworks 7

1.4 Research Design and Methods 8

1.5 Data Collection and Analysis 9

1.5.1 Population 9

1.5.2 Sampling Frame 10

1.5.3 Sample Size 10

1.5.4 Survey Instrument 11

1.5.5 Pilot Study 11

1.5.6 Ethical Issues 12

1.5.7 Data Analysis 12

1.6. Expected Outcomes, Limitations and Constraints of the Project 13

1.7 Structure of the Project 14

1.8. Organization of the Study 15

1.9 Conclusion 16

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction 17

2.2 Organizational Knowledge Management 19

2.2.1 Knowledge Management Processes and Frameworks 21

2.2.2 Knowledge Management Strategies 26

2.3 Organizational Learning 30

2.3.1 Learning From Projects 30

2.3.2 Problems of Project Learning 31

2.3.3 Concepts for Project Learning 32

2.3.4 Cross-Project Learning 35

2.3.5 Problems of Cross-Project Learning 36

2.3.6 Suggestions Towards More Effective Cross-Project Learning 38

2.3.7 Communities of Practice 39

2.4 Knowledge Management in Construction 40

2.4.1 Knowledge Management Strategies in Construction 40

2.4.2 Information Management in Construction .... .42

2.4.3 Knowledge Capture and Sharing in Construction Project Organizations 44

2.3.4 Designer Construction Knowledge 46

2.4.5 Design – Construction Interface 47

2.4.6 Design Constructability and Constructability Review 48

2.5 Conclusion 52

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction 54

3.2 Research Paradigms 54

3.2.1 Positivism 55

3.2.2 Interpretivism 56

3.3 Research Methodologies 57

3.3.1 Quantitative Methods 57

3.3.2 Qualitative Methods 57

3.4 Research Design 58

3.4.1 Purpose of the Study ... 58
3.4.2 Types of Investigation ... 59
3.4.3 Extent of Researcher Interface ... 60
3.4.4 Study Setting ... 60
3.4.5 Unit of Analysis ... 61
3.4.6 Time Horizon of the Study ... 62
3.5 Measurement ... 62
3.5.1 Measurement Scale ... 63
3.5.2 Response Scale ... 64
3.6 Data Collection Methods ... 65
3.6.1 Interviews ... 65
3.6.2 Tests and Measures ... 66
3.6.3 Observation ... 66
3.6.4 Questionnaires ... 67
3.6.5 Questionnaire Design ... 69
3.6.6 Ethical Issues ... 70
3.7 Sampling Design ... 71
3.7.1 Probability Sampling ... 72
3.7.2 Non-Probability Sampling ... 73
3.7.3 Sample Size ... 74
3.8 Data Analysis and Intrepretation ... 77
3.9 Conclusion ... 80

CHAPTER 4 DATA ANALYSIS AND RESULTS
4.1 Introduction ... 81
4.2 Descriptive Statistics ... 81
4.3 Data Analysis ... 82
4.3.1 Organisational Profile ... 83
4.3.2 Organisational Background ... 88
4.3.3 Descriptive Statistics of variables ... 93
4.4 Evaluation of Measurements in the Study ... 94

4.4.1 Reliability Analysis ... 94
4.4.2 Factor Analysis ... 103
4.4.3 Analysis of the Main Construct With Respect to Improved Designer Construction Knolwedge ... 104
4.5 Hypothesis Testing ... 110
4.5.1 Hypothesis 1 ... 111
4.5.2 Hypothesis 2 ... 112
4.5.3 Hypothesis 3 ... 113
4.5.4 Hypothesis 4 ... 113
4.5.5 Hypothesis 5 ... 114
4.5.6 Hypothesis 6 ... 114
4.5.7 Hypothesis 7 ... 115
4.5.8 Hypothesis 8 ... 116
4.5.9 Hypothesis 9 ... 116
4.6 Results of Multiple Regression Analysis ... 119
4.7 Conclusion ... 126

CHAPTER 5 CONCLUSION AND IMPLICATIONS
5.1 Introduction ... 128
5.2 Overview of Research Findings ... 128
5.2.1 Research Questions ... 132
5.3 Conclusions on Research Problems ... 143
5.4 Research Implications for Theory ... 146
5.5 Research Implications for Policy and Practice ... 147
5.5.1 Private Sector Managers ... 147
5.5.2 Public Sector Policy Makers ... 147
5.6 Limitations of the Research ... 148
5.7 Implications for Further Research ... 149
5.8 Conclusion ... 152
6.0 REFERENCES ... 153
7.0 APPENDICES ... 163

LIST OF TABLES

Table 2.1 Knowledge Management Strategies and Project Memories 27

Table 2.2 Comparison of the Cognitive and Community Approaches to Knowledge Management 29

Table 4.1 Type of Business Organisations Surveyed and Response Rate 83

Table 4.2 Professional Background and Training of Respondents 83

Table 4.3 Number of Years of Experience in Construction Industry 84

Table 4.4 No. of Years as Project Manager 84

Table 4.5 Years of Experience in Construction Industry and as Project Manager 85

Table 4.6 Formal Project Management Qualification by Years of Experience in Construction Industry 86

Table 4.7 Type of Qualifications of Project Managers 87

Table 4.8 Professional Background by Years of Experience in Construction Industry 87

Table 4.9 Organisation Size: Number of Employees 88

Table 4.10 Type of Organisation by Number of Employees 89

Table 4.11 Type of Organisation by ISO 9001:2000 Certification 89

Table 4.12 Average Yearly Project value in Ringgits (RM) 90

Table 4.13 Average Yearly Project value by Type of Organisation 91

Table 4.14 Type of Organisation by Formal Procedures for Project Knowledge Sharing 92

Table 4.15 Type of Knowledge Sharing Procedures and Guidelines Used......................... 93

Table 4.16 Summary of Reliability Analysis... 102

Table 4.17 Summary of Reliability Analysis for the Knowledge Sharing Construct........ 102

Table 4.18 Mean Differences of Crucial Construction Knowledge areas for both IT and Non IT-Based Tools 105

Table 4.19 Knowledge Sharing Tools/Approaches and Frequency of Knowledge Sharing Among Organizations 108

Table 4.20 Summary Statistics of Tools/Approaches of Knowledge Sharing Among Organizations 109

Table 4.21 Summary of the relationship between the hypothesized constructs and improved designer construction knowledge (I_Design Knowledge)............... 118
Table 4.22 Regression Output of the Model 1 (RC) 121
Table 4.23 Overall Model Summary of Regression Models 122
Table 4.24 ANOVA (b) 123
Table 4.25 ANOVA (i) of the Overall Model 124
Table 4.26 Summary of Multiple Regression Coefficients(a) 125
Table 5.1 Comparative Rankings of Non-IT Tools of Knowledge Sharing 142
Table 5.2 Comparative Rankings of IT Tools of Knowledge Sharing 142

LIST OF FIGURES

Figure 1.1 Proposed Conceptual Framework...7

Figure 2.1 Generic Knowledge Management Framework....................................25

Figure 2.2 Four Knowledge Strategies...26

Figure 3.1 Questionnaire Design Process..70

Figure 4.1 Types of Business Organizations...88

Figure 4.2 Mean Differences of Crucial Construction Knowledge Areas and Non IT – based Tools...106

Figure 4.3 Mean Differences of Crucial Construction Knowledge Areas and IT – based Tools..107

ABSTRACT

The fragmented nature of the construction industry leads to poor sharing of knowledge between the designers and constructors of projects. Most construction problems arise because of deficiencies in the design. More often than not, these problems are left to the constructors to solve at the site. However, the knowledge gained by the constructors in solving these problems is unlikely to be shared with the designers in such a way that the same design deficiencies will be avoided in future projects.

Effective knowledge sharing contributes towards improving the designer construction knowledge. There are a number of design-construction interfaces in construction projects, during which information exchange and knowledge sharing could take place between designers and contractors. This information exchange and knowledge sharing will help to overcome the design deficiencies as well as problems during construction attributed to these deficiencies.

Construction project and organizational knowledge that are crucial to the designers and Knowledge Management tools for locating and sharing project knowledge are identified. This research used responses from forty-two (42) respondents to test the relationships between the application of knowledge sharing tools and the improvement of designer construction knowledge, with respect to the crucial construction project and organizational knowledge areas identified in the Malaysian construction industry. At the same time, the frequencies with which the sharing of construction knowledge between designers and constructors occurs through the various approaches were compared.

The results of the analysis confirmed positive relationships between the application of all the knowledge-sharing approaches (except brainstorming)

and the designer construction knowledge. The positive relationships between the variables for the non-IT knowledge sharing tools support the findings of studies carried out by earlier researchers which suggest that in the construction industry, knowledge sharing and learning depend heavily on the informal social processes and practices that lean towards a community approach.

However, whilst respondents in this study perceive that there is a positive relationship between applying the IT based knowledge sharing tools and the improvement of designer construction knowledge, studies by various other researchers indicate otherwise, in which it was concluded that the ICT-based approach to sharing of project knowledge has not been very effective.

The rankings for the choice of knowledge sharing tools indicate a similar pattern as those arrived at in a UK study except for research collaboration.

CHAPTER 1

INTRODUCTION TO THE RESEARCH

1.1 BACKGROUND OF THE RESEARCH

Traditional project and construction management practices covering the project process groups and knowledge areas focus on planning, organizing, directing and controlling resources to achieve specific goals on time and within budget (Disterer, 2002, p 519). However, it has been agreed that this traditional project management as laid down in the Project Management Body of Knowledge (PMBOK) is too static to match and capture the dynamic flow of tacit knowledge through an organization, resulting in project knowledge becoming fragmented and project learning being neither captured nor shared internally and to other projects. These findings point towards the need to put more focus on knowledge management as an essential part of project management (Leseure & Brookes, 2004, pp 103, 116).

This research looks at the broad issues of knowledge management in projects in general, and in construction projects in particular. It then explores issues with respect to knowledge sharing in construction projects, focusing on the designer's construction knowledge. Problems that arise during the construction phase due to design deficiencies are discussed. These deficiencies include 'design errors (both materials selection and dimensional), ambiguous specifications, project features that will be difficult or exceedingly costly to construct, project features that exceed the capability of industry to properly build and project features that are difficult to interpret and will be hard to accurately bid' (Gransberg and Douglass III, 2003).

Effective knowledge sharing contributes towards improving the designer construction knowledge. Designer construction knowledge is relevant in view of its contribution to effective construction documentation (Gransberg and Douglass III, 2005, p PM.01.1). Sound construction knowledge on the part of the designers will help minimize design deficiencies. Effective construction documentation ensures efficient information exchange at the design-construction interface in projects (McCarthy et al., 2000, p 1). There are a number of design-construction interfaces in construction projects, during which information exchange and knowledge sharing could take place between designers and contractors (McCarthy et al., 2000, p 1). It will be argued that this information exchange and knowledge sharing will help to overcome the design deficiencies discussed above as well as problems during construction attributed to these deficiencies.

1.2 LITERATURE SEARCH AND REVIEW

This study has reviewed and analyzed knowledge management literature focusing on knowledge capture in projects and project organizations, discussed research themes that emerge and developed questions that will initiate further research. The literature falls under two categories, namely, parent literature and intermediate literature.

The parent literature comprises articles covering the broader topics on knowledge management under Organizational Knowledge Management, Knowledge Management Processes and Frameworks, Knowledge Management Strategies and Organizational Learning.

The intermediate literature covers studies on organizational learning in project organizations - Learning from Projects, Cross-Project Learning and Communities of Practice. The intermediate literature also includes research covering Knowledge Management Strategies in Construction, Knowledge Capture and Sharing in Construction Project Organizations, Designer Construction Knowledge and Design Constructability.

1.3 RESEARCH PROBLEM, QUESTION, HYPOTHESES AND CONCEPTUAL FRAMEWORKS

1.3.1 Research Problem

The fragmented nature of the construction industry leads to poor sharing of knowledge between the designers and constructors of projects. As highlighted by Gransberg and Douglass III (2005), most construction problems arise because of deficiencies in the design. More often than not, these problems are left to the constructors to solve at the site. However, the knowledge gained by the constructors in solving these problems is unlikely to be shared with the designers in such a way that the same design deficiencies will be avoided in future projects.

Kamara et al. (2002, p 63) suggest that project knowledge capture, transfer and reuse is achieved through reassigning people from one project to another, using standards and best practices guides, contractual agreements, intranets and specific activities like post-project reviews. They also identify construction project and organizational knowledge that are crucial to the designers (Kamara et al., 2002, p 58).

Carrillo et al. (2004, pp 52, 53) identified Knowledge Management tools for locating and sharing project knowledge in the UK construction sector. The non-IT tools include research collaboration, conferences and seminars, brainstorming, job rotation and observation and Communities of Practice. The IT tools include intranets, database systems, documentation systems and electronic discussion forum.

The first objective of this research is to test the relationships between the application of knowledge sharing tools and the improvement of designer construction knowledge, with respect to the crucial construction project and organizational knowledge areas identified by Kamara et al. (2002, p58), in the Malaysian construction industry.

Secondly, the research aims to investigate and determine the relative frequency with which the sharing of construction knowledge between designers and constructors occurs through the various approaches.

1.3.2 Research Questions

With the above objective in mind, the study reviewed and analyzed the relevant literature, discussed research themes that emerge and developed the following research questions that it aims to address:

- Is there a positive relationship between the application of the various knowledge sharing tools and the improvement of designer construction knowledge?
- How often does sharing of crucial construction knowledge occur between designers and constructors through the different approaches?

1.3.3 Variables

The independent variables applied for testing in this study are the knowledge sharing tools identified by Carrillo et al. (2004, pp 52, 53) as follows:

- Research Collaboration (RC)
- Conferences and Seminars (CS)
- Brainstorming (BS)
- Job Rotation and Observation (JR)
- Communities of Practice (COP)

- Intranets (ITNET)
- Database Systems (DBS)
- Document Management Systems (DMS)
- Electronic Discussion Forums (EDF)

The dependent variable is the 'Improved Designer Construction Knowledge' (I_Design Knowledge). The supporting dependent variables are the crucial knowledge areas as suggested from the findings of the research by Kamara et al. (2002, p 58) as follows:

- Knowledge of organizational processes and procedures, including statutory regulations and standards, management of interfaces between different stages of projects, in-house procedures and best practice guides (KOPP)
- Knowledge of a client's business and how to interpret business requirements into technical specifications for the construction team (KCB)
- Knowledge of how to predict outcomes, manage teams, focus on clients and motivate others KPO_MO)
- Technical/domain knowledge of design, materials, specifications and technologies (TDK)
- 'Know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors (KPSS)

1.3.4 Hypotheses

H_1 There is a positive relationship between the application of research collaboration and improved designer construction knowledge.

H_2 There is a positive relationship between the application of conferences and seminars and improved designer construction knowledge.

H_3 There is a positive relationship between the application of brainstorming and improved designer construction knowledge.

H_4 There is a positive relationship between the application of job rotation and observation and improved designer construction knowledge.

H_5 There is a positive relationship between the application of communities of practice and improved designer construction knowledge.

H_6 There is a positive relationship between the applications of the intranets and improved designer construction knowledge.

H_7 There is a positive relationship between the applications of database systems and improved designer construction knowledge.

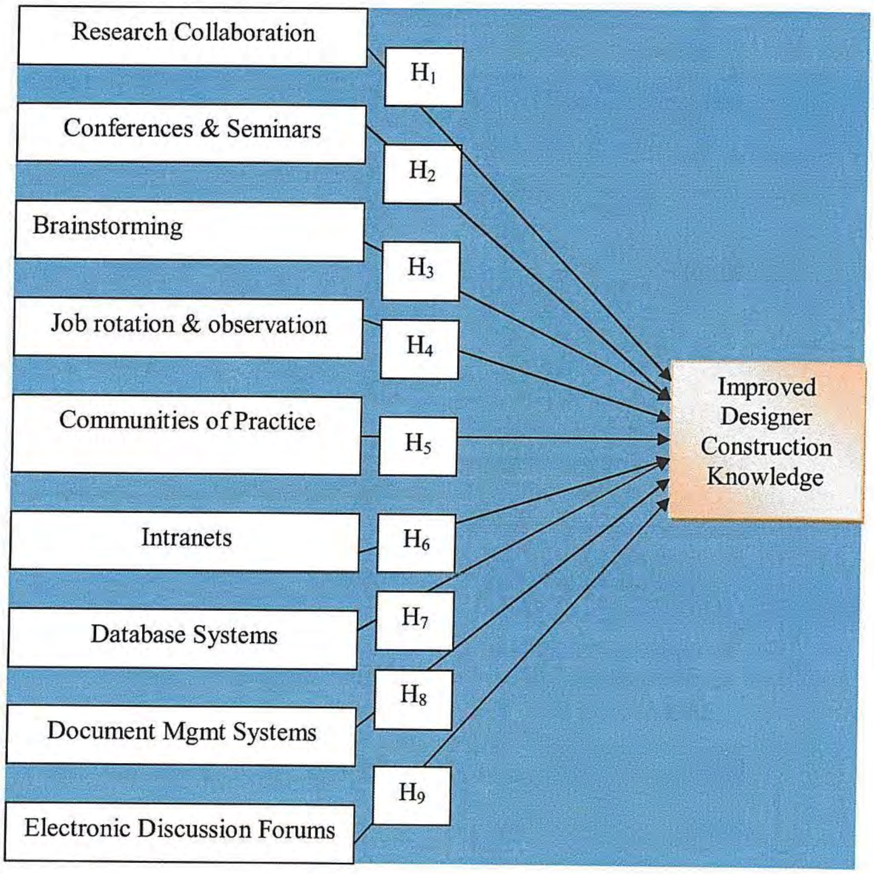
H_8 There is a positive relationship between the applications of document management systems and improved designer construction knowledge.

H_9 There is a positive relationship between the applications of electronic discussion forums and improved designer construction knowledge.

1.3.5 Research Frameworks

The conceptual frameworks adopted for this study are as shown in Figure 1.1 below:

Figure 1.1
Proposed Conceptual Framework



1.4 RESEARCH DESIGN AND METHODS

In order to investigate the research problem and answer the research question posed, the research design and methodology needs to be developed to provide the necessary data. The design for this study is guided by the research design model by Cavana, Delahaye and Sekaran (2001, p107). This model comprises the following aspects of research design:

- Purpose of the study
- Types of investigation
- Extent of researcher interference
- Study setting
- Unit of analysis
- Time horizon of the study
- Measurement
- Data collection methods
- Sampling design
- Data analysis

Studies may be exploratory, descriptive or conducted to test hypotheses (Cavana, Delahaye and Sekaran, 2001, p107). Hypothesis testing will be used in the first part of this study, with respect to the relationships between the various knowledge sharing approaches and the improvement of designer construction knowledge. In using data collected from architectural, engineering and construction firms (field data) to test findings from literature reviews, this study is typical of an analytic or explanatory survey (Kerlinger, 2000).

Similarly, out of the three approaches to the investigation – clarification, correlation and causal (Cavana, Delahaye and Sekaran, 2001, p107), the correlation approach is deemed as most appropriate, considering the study's aims. From the above, it follows that this study will adopt the positivist approach, employing a quantitative research methodology.

By taking on a correlation approach, the researcher collects data through a questionnaire. Apart from administering the questionnaire, the researcher will not interfere, in any way, with the normal activities of the respondent organizations. Hence, researcher interference will be minimal. As such, the study setting can be considered as non-contrived.

The study will be single stage and data will be gathered only at a single juncture. This type of study is referred to as a cross-sectional study (Cavana, Delahaye and Sekaran, 2001, p121).

Two major types of sampling designs are probability and non-probability sampling. A probability sample is one in which every member of the population has a known non-zero probability whereas a non-probability sample does not have a known or predetermined chance of being selected (Cavana, Delahaye and Sekaran, 2001, p257 and Zikmund, 2003, p71). Where every element in the population has a known and equal chance of selection, it is known as simple random sampling (Cavana, Delahaye and Sekaran, 2001, p257). Following from here, this study will choose the simple random sampling, which has the least bias and offers the most generalizability.

1.5 DATA COLLECTION AND ANALYSIS

1.5.1 Population

Target population is defined as the entire group of people, events or things of interest that the researcher wishes to investigate (Cavana, Delahaye and Sekaran, 2001, p252). For this study, the target population includes any firm that is involved in the construction industry in Malaysia, namely, Architectural and Engineering consultants and contractors. The consultant firms investigated were limited to bodies corporate and partnerships while contractors were randomly chosen from those listed under Grade G7 and with full contact information.

1.5.2 Sampling Frame

The sampling frame refers to the listing of all elements in the population from which the sample is drawn (Cavana, Delahaye and Sekaran, 2001, p252). In this instance, the sample frame will be construction firms registered with and listed in the directory of the Construction Industry Development Board (CIDB) and the Architectural and Engineering consultant firms registered with and listed in the directories of their respective associations.

1.5.3 Sample Size

Using the sample size calculator developed by Kennedy Research Inc., (Appendix E) described by Dillon, Madden and Firtle (1994, pp252, 253), the appropriate sample size for this study was determined. The sample size depends on the precision or accuracy needed, the confidence level desired and the percentage response rate considered acceptable. Dillon, Madden and Firtle (1994, p 235) recommended the minimum size of 200 for strategic studies. Roscoe (cited in Cavana, Delahaye and Sekaran, 2001, p 279) suggested a size within the range of 30 and 500.

According to Cavana, Delahaye and Sekaran (2001) (p 240), the return rates of mail questionnaires are typically low and that a 30 percent response rate is considered acceptable. Bourque and Fielder (1995) (cited in Carrillo et al., 2004, p 48), 'noted that a postal questionnaire without any incentive could probably expect no better than a 20 percent response rate'. Hussey and Hussey (1997) noted that it is not uncommon to obtain a response rate of about 10% in a mail survey.

For this study, a sample size of 200 is obtained using the calculator, based on an estimated response rate of 30 percent and a 10 percent error in responses at 99.7 percent confidence.

1.5.4 Survey Instrument

Data collection is via a mail questionnaire survey, which is most appropriate considering the respondents' locations being over a wide area. The literature review is used to provide the basis for identifying a number of structured questions on which the questionnaire is developed. The questionnaire consists of a number of sections, covering the respondents' background, the organizations' background, measures of the relationship between the application of the various knowledge sharing approaches and improvement of designer construction knowledge and the frequency of occurrence of sharing of crucial construction knowledge between designers and constructors through these various approaches. The questionnaire is anonymous and the respondents and their organizations are not identified.

1.5.5 Pilot Study

To check the questionnaire validity, the questionnaire is pilot tested on a group of six respondents comprising two each from the architects, engineers and contractors. The pilot study is necessary to ensure the relevance of the questionnaires to the research questions and to obtain comments on the understandability of the questions, the length of the survey and whether additional questions need to be included.

1.5.6 Ethical Issues

The ethical issues that may arise in relation to the researcher and the research participants must be taken into consideration. Issues about ethical principles in business research usually revolve around the following areas:

- Whether there is harm to participants.
- Whether there is a lack of informed consent.
- Whether there is an invasion of privacy.
- Whether there is deception involved.

(Diener and Crandall, 1978)

The above issues are addressed as follows:

- Harm to participants – by maintaining the confidentiality of records and anonymity of accounts;
- Informed consent – participants can agree or disagree to participate based on the information given to them;
- Privacy – by participating in the survey, respondents are taken as having 'acknowledged surrendering their right to privacy for that limited domain';
- Deception – the survey information sheet clearly states the purpose of the study and the manner in which the data will be used, so that the possibility of intended deception does not arise.

  (Bryman and Bell, 2003).

1.5.7 Data Analysis

Sections A and B of the survey instrument cover the demographics or organizational profiles of the respondents. The Likert scale survey for the study investigates the relationship between the applications of various knowledge sharing approaches and the improvement of designer construction knowledge, as covered under Section C of the questionnaire. The survey also investigates the frequency of usage of the various approaches for the sharing of construction knowledge between designers and constructors (Section D).

The survey data are analyzed using the Statistics Package for Social Sciences (SPSS) and are applied to provide answers to the research questions. Descriptive statistics is used to obtain the mean and standard deviation, variance, skewness, and kurtosis of the variables.

For Section C of the survey, a response of 5 (based on the Likert scale of 1 to 5) indicates the respondent's strong agreement with the statement and a response of 1 shows a strong disagreement. For Section D, a response of 5 indicates a high frequency of occurrence as perceived by the respondent while a response of 1 indicates the respondent's perception of a very low frequency.

Measurements obtained from the responses on the Likert scale surveys are evaluated by performing the reliability and factor analyses. The reliability of the scales used in the study is tested using the Cronbach's Alpha Coefficient test. To arrive at a smaller number of variables that can be used to convey as much information as would be possible with a larger number of variables, the Principal Component Analysis (PCA) is applied (Leech, Barrett and Morgan, 2005, p 76). The hypotheses developed for the study are tested using the Pearson Product-Moment Correlation matrix. The Multiple Regression Analysis is used to investigate predictor independent variables on the outcome of the dependent variables.

1.6 EXPECTED OUTCOMES, LIMITATIONS AND CONSTRAINTS OF THE PROJECT

The research is expected to identify some positive relationships between the various knowledge sharing approaches and the improvement in construction knowledge among design professionals in the construction industry in Malaysia. The research is also extended to obtain an indication of the relative frequency of occurrence of the different knowledge sharing approaches.

The research will be carried out on organizations located over a wide area throughout Malaysia. Taking this into consideration, a total of eight weeks will be allocated for the data collection. Analysis of the collected data is expected to take two weeks. The total cost of carrying out the project, covering the costs of paper, printing, envelopes and postage, is not expected to exceed five thousand ringgit.

Whilst the results may be able to be generalized to the target population, they may not be applicable elsewhere due to, for example, the different maturity levels of the indnstry at different locations.

1.7 STRUCTURE OF THE PROJECT

The project will be structured as follows:

Title : Knowledge Sharing in the Malaysian Construction Industry.

Chapter 1: Introduction to the Research

This chapter provides the introduction and background to the research. The research questions are posed and hypotheses developed. Presented in this chapter are the brief literature review, research framework, research design and methods, data collection and analysis and the expected outcomes and limitations of the research.

Chapter 2: Literature Review

This chapter discusses the extant literature relevant to the focus of the study.

Chapter 3: Research Methodology

This chapter discusses the research paradigms and approaches, develops the theoretical and conceptual frameworks, research design and methods and data collection. Discussions on data collection cover sample characteristics and size, key variables and measurements and survey instrument design.

Chapter 4: Data Analysis and Results

This covers the statistical analysis of the data collected using the Statistical Package for Social Sciences (SPSS) software.

Chapter 5: Conclusions and Implications

Here, the conclusions that can be drawn from the analysis are presented and recommendations for further research proposed.

1.8 ORGANIZATION OF THE STUDY

The first chapter provides an introduction of the research by discussing the background of the study, its purpose, the research problems, significance of the study, theoretical framework, research design, the terminology used, study scope and limitations. Chapter Two reviews the relevant literature, citing the various theories and concepts, creates the theoretical framework, identifies the research problems and the poses the questions on which the study will focus. Chapter Three provides the methodological justification for the research proposal to be adopted and describes the method chosen in detail. Interview and survey details are developed and described. Chapter Four presents the analysis of the questionnaire responses. Chapter Five presents the conclusions that can be drawn from the results of the analysis presented in Chapter Four and identifies areas where further research is recommended.

1.9 CONCLUSION

This chapter forms the basis for the dissertation. The research objectives, overview of the literature, research problem and issues and conceptual framework are introduced. The research methodology and definitions are presented and justification is offered for the research. The delimitation of the research, the report structure and the organization of the study are given. With these, the preparation of the report proceeds with a detail description of the research. An in-depth review of the extant literature follows in Chapter 2.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Over the past several decades, project management has become accepted as an intensive organizational learning platform. This has resulted in a marked increase in the use of a project management approach and the segmentation of the implementation of a business strategic need through projects. Traditionally, project management has focused on planning, organizing, directing and controlling resources to achieve specific goals on time and within budget (Disterer, 2002, p 519). Such a traditional approach, however, as laid down in the Project Management Body of Knowledge (Project Management Institute, 2004), is agreed to be too static to match and capture the dynamic flow of tacit knowledge through an organization. This new state of affairs has resulted in knowledge developed in a projects becoming fragmented, and thus project learning is neither captured nor disseminated internally nor made available to other projects.

These findings raise issues concerning the application of knowledge management to projects. They also point towards the need to put more focus on knowledge management as an essential part of project management (Leseure & Brookes, 2004, pp 103, 116).

Kamara et al. (2002) highlighted the recognition of the necessity for the management of both the project and organizational knowledge in order for the construction business to remain competitive. They also stressed that with project knowledge being neither captured nor shared, it will lead to reinventing the wheel, which in turn, will lead to wasted activity and thus negatively affect project performance.

Alarcon and Mardones (1998) noted that in construction projects, while it is understood that customer requirements, constructive aspects and quality standards are defined during the design stage, it is usually carried out with little interaction between design and construction teams. This poor interaction during the design-construction interface is seen to be the main cause of problems during the construction stage.

Considering the above, the researcher is concerned with knowledge management and sharing in both projects and project organizations, with emphasis on knowledge sharing in construction projects, especially as regards the contribution of knowledge sharing towards improving design construction knowledge and construction project implementation. Given these concerns, the purpose of this chapter is to review, analyze, and synthesize literature on organizational knowledge management and learning, especially as it pertains to design construction knowledge, and then to develop questions of relevance for further research.

To achieve this goal, the literature review and related discussion is classified under two categories, namely, parent literature and intermediate literature. The parent literature comprises articles covering the broader topics on knowledge management, which may be grouped under Organizational Knowledge Management, Knowledge Management Processes and Frameworks, Knowledge Management Strategies and Organizational Learning.

The intermediate literature covers research on both organizational learning in project organizations, which is subdivided into the topics of Learning from Projects, Cross-Project Learning and Communities of Practice, and knowledge sharing in construction project organizations, which is further subdivided into the topics of Knowledge Management Strategies in

Construction, Information Management in Construction, Knowledge Capture and Sharing in Construction Project Organizations, Design Construction Knowledge, Design-Construction Interface and Design Constructability.

2.2 ORGANIZATIONAL KNOWLEDGE MANAGEMENT

Over the last few years, knowledge has been treated as a significant organizational resource (Alavi and Leidner, 2001, p 107). Firms achieve success by exploiting their existing knowledge as well as continually exploring new knowledge to develop future strategies for competitive advantage (Sambamurthy, Bhadrawaj and Grover, 2003, p 238).

Knowledge is distinguished from data and information. Data are considered as raw elements, which, when patterned in a certain manner, are transformed into information. Applying certain rules or heuristics to this information creates knowledge in the form of actionable information for producing value-added benefit (Liebowitz and Megbolugbe, 2003, p 190). Following from this, knowledge may be viewed as a "fluid mix of framed experience, values, contextual information and expert insights that provide a framework for evaluation and incorporating new experiences and information" (Davenport and Prusak, 1997, cited in Sambamurthy and Subramani, 2005, p 1).

There are basically two types of knowledge – tacit and explicit knowledge (Newell et al., 2002, p 3, 104 and Tiwana, 2002, p 44). Tacit knowledge, also referred to as 'know-how', is highly personal and developed from experience. It is hard to formalize and difficult to communicate (Newell et al., 2002, p 3, 104 and Carrillo et al., 2004, p46). Explicit knowledge, referred to as 'know-what', is formal, systematic and is extractable from the knowledge holder for sharing with other individuals (Carrillo et al., 2004, p 46 and Sambamurthy and Subramani, 2005, p 1).

Organizational knowledge is created through cycles of socialization, externalization, combination and internalization that transform knowledge between tacit and explicit modes – the SECI model (Nonaka, 1994, p 19). Knowledge creation or knowledge generation is normally accomplished by a team of people as opposed to individuals working alone (Newell et al., 2002, p 47).

Knowledge management is about identifying and leveraging the collective knowledge in an organization for its competitive advantage (von Krogh, 1998). That is, the emphasis in knowledge management is on identifying, extracting and capturing the 'knowledge assets' of the firm so that they can be protected and exploited fully for competitive advantage (Newell et al., 2002, p 16).
Knowledge management is also viewed as a business activity that picks up and lays out the intellectual assets of an organization, creating new knowledge to build up the competitive advantage for the organization, promoting knowledge collection, storage and retrieval and sharing as well as applying knowledge management enablers to carry these out. In looking at knowledge management within organizations, focus is made on how the practices of knowing are managed and on the managing of knowledge through managing people and their interactions (Newell et al., 2002, p 7).

Various definitions of knowledge management by other authors are also highlighted. Tsai (2000), cited in Liu, Chen and Tsai (2004) defined knowledge management as knowledge obtaining, refining, storing and sharing. Knowledge management can be defined as the identification, optimization and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage (Webb, 1998, cited in Carrillo et al., 2004).

At the same time, Al-Ghassani et al. (2004, p 349,350) defined knowledge management as a systematic process of capturing, transferring and sharing knowledge to add competitive value (citing Drucker, 1993; Hjertzen and

Toll, 1999; Scarbrough and Swan, 1999; Skyrme and Amidon, 1997) and to improve performance (citing Robinson et al., 2001). Meanwhile, Chase (1997) (cited in Leseure and Brookes, 2004, p113), reasoned that "in its simplest form, knowledge management is about encouraging people to share knowledge and ideas to create value-adding products and services".

2.2.1 Knowledge Management Processes and Frameworks

Knowledge management may be broken down into four interlinked processes, namely, knowledge creation, knowledge storage and retrieval, knowledge transfer and knowledge application (Alavi and Leidner, 2001, p 115).

2.2.1.1 Knowledge Creation

Pentland (1995) views knowledge creation as the development of new or replacement of existing content of an organization's tacit and explicit knowledge. Knowledge creation is also developed as the SECI (Socialization, Externalization, Combination and Internalization) model which places emphasis on the dialogue and interaction processes (Nonaka, 1994, p 19). Socialization refers to the conversion of tacit knowledge to new tacit knowledge through organizational members' interacting and sharing of experience. Combination refers to the merging, categorization, reclassification and synthesis of existing explicit knowledge to new explicit knowledge. Externalization involves converting tacit knowledge to new explicit knowledge through communication of best practices and/or lessons learnt. Internalization is when new tacit knowledge is created from explicit knowledge which may be from reading or discussion (Alavi and Leidner, 2001, p116).

2.2.1.2 Knowledge Storage/Retrieval

Argote, Beckman and Epple, (1990) and Darr, Argote and Epple, (1993) note that organizations tend to forget the knowledge that they created and learned. Effective knowledge management thus calls for the storage, organization and retrieval of organizational knowledge. This process is referred to as organizational memory (Stein and Zwass, 1995; Walsh and Ungson, 1991) and consists of knowledge in various component forms such as written documents, electronic databases, codified human knowledge stored in expert systems, organizational procedures and processes and tacit knowledge captured by individuals and network of individuals (Tan et al., 1998).

El Sawy, Gomes and Gonzalez, (1996) and Stein and Zwass, (1995) identify organizational memory as semantic or episodic: semantic memory being the general, explicit and articulated knowledge such as organizational archives of annual reports; and episodic memory being the context–specific and situated knowledge.

2.2.1.3 Knowledge Transfer

Disterer (2002) (p 514) describes knowledge transfer between routine organizations and projects. Project work is getting increasingly complex because of the growing volume of technical and social relationships and interfaces that need to be considered. Existing knowledge is highly valued to deal with this complexity as well as to increase efficiency. For this reason, knowledge and experiences need to be adapted for transfer from routine organizations to projects and vice versa (Disterer, 2002, p 514).

Knowledge transfer from routine organizations to projects occurs when project team members bring in knowledge and experience from their daily work into the project team. At the same time, internal documentation and standard operating procedures contain knowledge which is reusable in projects (Disterer, 2002, p 514).

The transfer of knowledge from projects to routine organizations forms part of the project management process. These include documentations in the form of technical drawings, user manuals and operating instructions and training courses and materials (Disterer, 2002, p514).

Knowledge transfer happens at various levels, namely, between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups and from the group to the organization (Alavi and Leidner, 2001, p 119).

In organizational settings, an important knowledge management process is the transfer of knowledge to locations where it is needed and where it can be utilized. This process may not be straight–forward as organizations sometimes do not know and have weak knowledge locating and retrieval systems for their resident knowledge (Huber, 1991).

Knowledge transfer in organizations is driven by communication processes and information flows. Of the knowledge transfer elements, focus is on knowledge transfer channels; these can be informal or formal, personal or impersonal (Holtham and Courtney, 1998, cited in Alavi and Leidner, 2001, p120). Informal mechanisms which include unscheduled meetings, informal seminars and coffee break conversations are effective in promoting socialization. Formal transfer mechanisms such as training sessions and plant tours ensure greater knowledge distribution but inhibit creativity (Alavi and Leidner, 2001, p121). Personal channels, such as apprenticeships and personnel transfer are effective for distributing highly context–specific knowledge while impersonal channels such as knowledge repositories are effective for knowledge that can be generalized to other contexts (Alavi and Leidner, 2001, p121).

2.2.1.4 Knowledge Application

The source of competitive advantage for a knowledge–based organization lies in the application of knowledge rather than the knowledge itself. Three mechanisms to integrate knowledge for organizational capability creation are directives, organizational routines and self–contained task teams (Grant, 1996b).

Directives are specific sets of rules, standards, procedures and instructions developed through the conversion of specialists' tacit knowledge to explicit knowledge for efficient communication to non–specialists (Demsetz, 1991). Organizational routines refer to the development of task performance and coordination patterns, interaction protocols and process specifications that allow individuals to apply and integrate their specialized knowledge without the need to articulate and communicate what they know to others. The third mechanism relies on the creation of self–contained task teams of individuals with prerequisite knowledge and skills for problem solving.

2.2.1.5 Knowledge Frameworks

A review was also made of literature covering studies on knowledge management implementation framework. Wong and Aspinwall, (2004) reviewed existing knowledge management implementation networks to come up with a proposal for a set of guidelines for constructing them. The guidelines proposed are as follows:

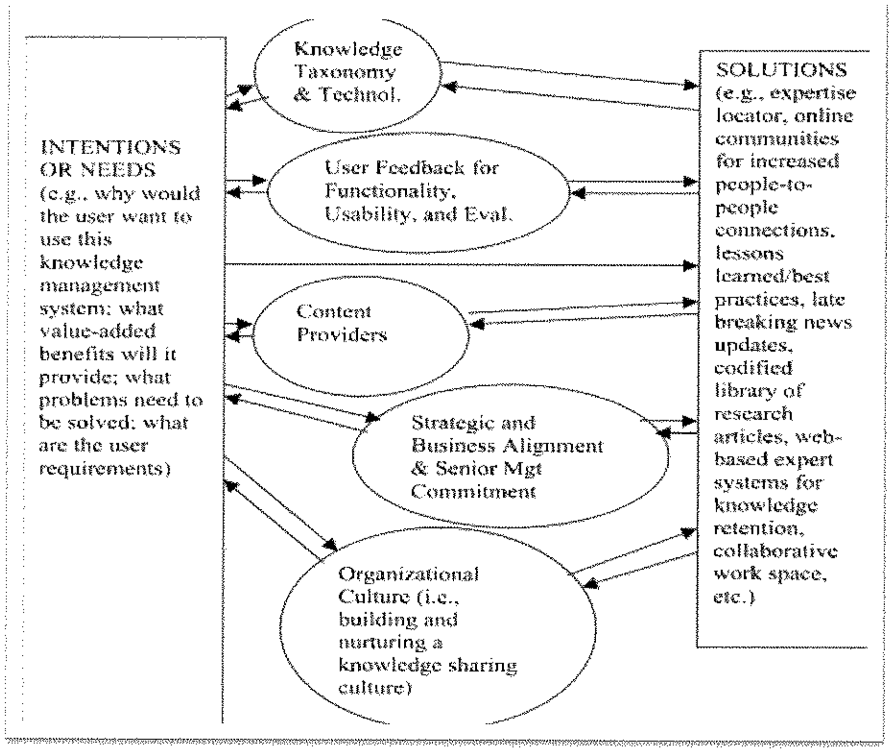
1. Develop a clear structure to organize the tasks
2. Address the different knowledge resources or types
3. Include the knowledge management processes or activities that manipulate the knowledge
4. Identify and highlight the influences that can affect the performance of knowledge management

5. Provide a balanced view between a technological and a social perspective (Wong and Aspinwall, 2004, p100).

Liebowitz and Megbolugbe, (2003) (p 191) analyzed various literatures and synthesized the knowledge management frameworks proposed, to arrive at a generic knowledge management implementation framework as shown in Figure 2.1.

In this framework, users have intentions or needs to use the knowledge management system. Solutions are provided to meet these needs. Factors contributing to the solutions include organizational culture, alignment with the strategic and business goals, content provider's input and user feedback on the functionality, usability and evaluation of the system and the knowledge taxonomy and technologies applied.

Figure 2.1
Generic Knowledge Management Framework



Source: Liebowitz and Megbolugbe, 2003.

Another framework, developed by von Krogh, Nonaka and Aben, (2001) (p 426), consists of four strategies for managing knowledge whereby companies can leverage their knowledge throughout the organization, use existing expertise to expand their knowledge further, extract and apply knowledge from partners and other organizations and probing new technologies or markets to develop new expertise. Central to the execution of these strategies are the two core processes of knowledge creation and transfer as well as the company's knowledge domains (von Krogh, Nonaka and Aben, 2001, p 426). The matrix showing the four strategies is shown in Figure 2.2.

Figure 2.2
Four Knowledge Strategies

		Knowledge Process	
		Transfer	Creation
Knowledge Domain	Existing	Leveraging Strategy	Expanding Strategy
	New	Appropriating Strategy	Probing Strategy

Source: von Krogh, Nonaka and Aben, 2001.

2.2.2 Knowledge Management Strategies

From the knowledge management discussions, two camps have emerged. One fully embraces information technology and information control, while the other focuses on knowledge, know-how and skills. This polarization develops into a categorization of knowledge management strategies into two, namely, codification and personalization (Koskinen, 2004, p 17 and Kasvi, Vartiainen and Hailikari, 2003, p 572).

In codification, the process centres on the use of technology. Here, the knowledge is properly codified and stored in databases, for easy access and use by authorized users. The personalization process centres on the individual, knowledge being closely tied to the developer of the knowledge and shared through direct person-to-person contacts. Technology is used to help in communicating the knowledge, rather than store it (Koskinen, 2004, p 17).

Kasvi, Vartiainen and Hailikari, (2003), (p 572) also discuss the concept of project memory, which they describe as 'knowledge from a project's history that can be brought to bear on the present' and the project memory system being the means by which project memory is realized. The relationships between the knowledge management strategies and project memories are shown in Table 2.1.

Table 2.1
Knowledge management strategies and project memories

	Project memory system	**Project memory**
Codification Strategy	Traditional and new information and communication technologies (e.g. documents, databases, email)	Explicit and declarative knowledge (e.g. specifications, instructions, definitions)
Personalisation Strategy	Memory representations, personal interaction (e.g. mental models, dialogues, seminars)	Tacit and procedural knowledge (e.g. competences, values, norms)

Source: Kasvi, Vartiainen and Hailikari, 2003.

Hansen et al. (1999), cited in Newell (2004, p13), also identify the personalization and codification strategies to knowledge sharing in their research. They suggest that the codification strategy relies on information and communication technology to store knowledge and learning in databases and is appropriate for experts having a common understanding and focus of a particular knowledge area to share explicit knowledge. At the same time, it is suggested that the personalization strategy relies on conversations and face-to-face interactions with little information and communication technology support so that it is appropriate for people from differing backgrounds to share tacit knowledge.

Another similar classification applied to approaches to the management of knowledge is described by Newell et al. (2002). The two approaches are tagged as the cognitive model and the community model (Newell et al., 202, p 107).

The cognitive model, like the codification strategy, adopts the information and communication technology-based approach to knowledge management. In this approach, the tacit knowledge inside people's heads as well as knowledge located in successful organizational practices are identified and captured as input to be processed via Information and Communication Technology (ICT) tools, with the resulting output applied in new contexts. In this way, this knowledge becomes readily available. This approach takes on the assumption that technology enables effective knowledge sharing (Newell et al., 2002, p107).

The community model, like the personalization strategy, considers relationships, shared understandings and attitudes towards knowledge creation and sharing as important (Kofman and Senge, 1993, cited in Newell et al., 2002, p 108). Individuals who have a common understanding and value system are more likely to easily share knowledge among them. The community model puts the stress on continuous negotiation of knowledge through networks as opposed to linear information flows (Newell et al., 2002, p 108).

Notwithstanding the fact that these dialogues may be facilitated by the various information and communication technologies, it must still be borne in mind that the passive codification, storage, mining and transfer of knowledge do not necessarily lead to knowledge sharing. The two models are compared in Figure 2.2 below.

Table 2.2
Comparison of the cognitive and community approaches to knowledge management

Cognitive Model	Community Model
Knowledge is equal to objectively defined concepts and facts.	Knowledge is socially constructed and based on experience.
Knowledge can be codified and transferred through text: information systems have a crucial role.	Knowledge can be tacit and is transferred through participation in social networks including occupational groups and teams.
Gains from Knowledge Management include exploitation through the recycling of existing knowledge.	Gains from Knowledge Management include exploration through the sharing and synthesis of knowledge among different social groups and communities.
The primary function of Knowledge Management is to codify and capture knowledge.	The primary function of Knowledge management is to encourage knowledge sharing through networking.
The critical success factor is technology.	The critical success factor is trust and collaboration.
The dominant metaphors are the human memory and the jigsaw (fitting pieces of knowledge together to produce a bigger picture in predictable ways).	The dominant metaphors are the human community and the kaleidoscope (creative interactions producing new knowledge in sometimes unpredictable ways).

Source: Newell et al., 2002, p 107.

2.3 ORGANIZATIONAL LEARNING

2.3.1 Learning from Projects

While it is acknowledged that learning lessons from projects is important, a number of authors highlighted that project post-mortems rarely occur in practice (Williams, 2004, p 273).

Recent works by authors such as Williams (2003) and Williams et al. (2001) suggest that this may be due to 'the difficulty in identifying the "hard", non-intuitive lessons from projects, such as those resulting from feedback and dynamic, systemic effects which are difficult to discern intuitively and can greatly exacerbate initially small effects' (Williams, 2004, p273).

Whether project-oriented organizations succeed or not depends very much on their having an effective means of 'learning from experience' on projects. This learning provides for the combination of explicit knowledge with tacit knowledge in such a way that people are encouraged to learn, embedding that learning into the continuous improvement of project management processes and practices (Terry Cooke-Davis, 2003). Turner et al. (2000) stress that 'end of project reviews play a vital part in capturing experience within organizations'.

Project work is being chosen by more and more organizations as flexible and reliable structures for the development and production of their goods and services. Due to their special nature as a secondary type of organizational form in terms of the limited time and resources, pressure, great complexity and new teams, projects are especially suitable for learning (Damm and Schindler, 2002, Smith and Dodds, 1997 and Lundin and Midler, 1998). Schindler and Eppler (2003) carried out research with various project teams, in the areas of product development, controlling, consulting and financial services, over the course of three years. The research shows, among other things, that knowledge and experiences gathered in different projects are not being systematically integrated into the organizational knowledge base and that there is a great discrepancy between the need for project debriefing and its actual deployment (Schindler and Eppler, 2003, p 219).

Systematically retaining project experiences enables a company to compare its various projects in a more orderly manner and document its most effective problem solving mechanisms. In addition, the systematic documentation of mishaps, mistakes or potential pitfalls assists the company to control and reduce project risks. From a long term perspective, systematic project learning enables the enterprise to develop project competencies that lead to a sustainable competitive advantage (Schindler and Eppler, 2003, p 219).

2.3.2 Problems of Project Learning

Notwithstanding the importance of project learning, it is not without its problems. Schindler and Eppler (2003) (p 219) highlighted some of these problems and they are discussed below.

Experiences are by definition bound to the people who are personally involved in the corresponding problem solving processes. However, they are often not a part of a project's documentation and are seldom transferred to other people during the course of a project. Project team members return to their line functions (or they are being moved into other functions) after having completed their tasks in the project (Argyris, 1999), and they usually take their new experiences with them (Kanter, 1996). These experiences are then only accessible through informal networks (Argyris, 1999 and Bowen et al., 1994).

Relevant project documentation such as a feasibility study, a summary, a technical report or a user manual, which has to be produced to meet minimal documentation standards is often superficial and merely focuses on capturing standardized business figures or the description of the project's results. Recordings of failure reasons or how particularly efficient solutions have been built or how certain special issues have been addressed are often not included.

The end of a project thus corresponds to the end of collective learning. The staff involved move on to new projects or they are reintegrated into their line functions. If their specific knowledge of that project is not directly needed, organizational amnesia begins. In addition, external partners or consultants, who have provided crucial project inputs, leave the company after the completion of a project. In the event that their specific knowledge is needed (for example, if similar problems occur in other projects) it is even harder to identify and can only be reconstructed partly without their personal support. Some consulting companies have realized this problem and emphasize the thorough documentation of their project work. However, clients have often been reluctant to pay extra fees for this documentation effort.

The risk of a knowledge loss at a project's end is a serious problem for organizations, especially in knowledge-intensive industries, such as pharmaceuticals, financial, engineering, or high-tech sectors. Companies could save considerable costs, which result from redundant work and the repetition of mistakes, if they master the project learning cycle.

2.3.3 Concepts for Project Learning

According to Chinowsky and Carrrillo (2007), changes in most industries during the 21st century, including in the engineering-construction industry, require organizations to take a more active role in developing both learning organization and knowledge management initiatives. Today, a primary challenge throughout industry is the need to retain knowledge within the organization as well as focus on continuous human resource development throughout all levels of the organization. This means, in turn, that it is necessary to focus on the link between knowledge management and learning organizations, with special concern about how to transform an organization from a focus on knowledge management to a focus on developing a learning culture. To do this, the authors claim one must have efficacious models of each of these concepts and that a high level of knowledge management implementation must be in place before an organization has the capacity to move to a learning focus.

Puddicombe (2006) claims the ability to create new knowledge through learning is a key to success, and explores two facets of the process of knowledge creation and their impact on project outcomes. The first facet deals with knowledge which is related to learning about the project, and is associated with the arrangement of the planning process, the characteristics of the project, and the behaviours of the project participants. The second type of knowledge creation deals with the project participants' learning about each other and involves the activities and behaviours that take place early in the project and their effect on the activities that take place during the project.

According to Puddicombe (2006), investigation of these two types of knowledge creation, based on learning about both the project and the participants, leads to three interesting conclusions about the impact of planning on project success as follows:

1. the ability to manage change on an ongoing basis rather than the ability to plan appears to be the key to project management success;
2. the conditions necessary to manage change evolve over the duration of the project;
3. the planning activities that occur early in the project are important in determining the path of the evolution of the project.

Schindler and Eppler (2003) (p221) identified a number of concepts in the literature to foster learning from project experiences. They can be classified into two groups:

1. Process-based methods of gathering lessons learned from completed projects
2. Documentation-based methods to learn from project experiences.

Process-based methods stress the relevant steps and their sequence in the course of a project's time line while documentation-based methods focus on aspects of the contents of the documents in their representation of the experiences and the storage of contents within the organization.

Schindler and Eppler (2003) (p227) summarized the following points as key success factors to gain lessons learned in end of project reviews. They have been identified by the authors as a result of over a dozen project debriefing workshops:

1. Regularly capture the most important project experiences directly after important milestones with the entire project team.
2. Have an external, neutral moderator of the debriefing workshop (not to be done by project managers or other team members).
3. Perform the lessons learned gathering graphically, e.g. collecting and structuring the project experiences along a time line (e.g. as a process map with mistakes, successes, insights etc.) and provide a workshop documentation in a poster format visible for all staff involved.
4. Ensure a collective, interactive evaluation and analysis of experiences made by individual team members.
5. Strive to gain a commitment in the sense of action consequences from the gathered insights (consider possible forms of implementation and who should be responsible for them).
6. The most frequent problems, which arose in such workshops, were administrative ones, in particular finding an appropriate time slot for all participants and ensuring a proper documentation. However, if the gathering of crucial project experiences is done on a regular basis, these administrative difficulties should disappear quite soon.

7. A permanent, conscious and systematic gathering, analysis and communication of project experiences requires an adjustment of the role understanding of project teams, as well as reconsidering the final reports and their main functions.

Kotnour (2000) (p394), on the other hand, uses the plan-do-study-act (PDSA) cycle model, borrowed from quality management (Juran 1988), as representative of the learning process in a project environment.

In the "plan" step, the project team identifies the nature of the problem and prepares a plan comprising a set of expectations about the steps to take and the expected results.

The "do" step represents the implementation part of the plan. Implementation produces results about the actions taken and associated performance such as cost, schedule, or technical performance.

In the "study" step, the project team reflects on and compares the associated plans, and results to produce and compile the lessons learned.

The "act" step is the closing of the loop to apply lessons learnt for the planning of the next project.

The PDSA steps resemble the project management process steps, "planning" is the same, "do" is "executing", and "studying" is "control". The "act" step uses the lessons learnt on the next project during the planning phases. "Study" is used over "control" to emphasize the learning and improvement needs.

2.3.4 Cross-Project Learning

Cross-project learning is the process of combining and sharing of lessons learnt across projects for the application and development of new knowledge (Kotnour, 2000, p 395). Supporting tools for inter-project learning include information technology tools and employee groups to share knowledge across the organization (Fiksel and Hayes-Roth 1985; Niwa 1990; Smith 1994; Shane and Schumacher 1996; Sullivan and Yates 1988; Williams and Kotnour 1993). Sidell (1993) describes an on-line system that recognizes, documents, validates and makes available lessons learnt for an organization. Van Aken, Monetta and Sink (1994) describe the use of peer groups to share lessons learnt within and outside of the organization.

Organizations increasingly make use of temporary project teams to carry out specific tasks (Rubery et al. 2002). The project teams comprise individuals from different functions and backgrounds to capture the required breadth and depth of knowledge and expertise (Dunn, 2001). These cross-functional teams can either be extremely productive (Wheelwright and Clark, 1992), or their work can be delayed, fall short of the requirements and face cost overruns (for example, Johnson, 1995 and Hastings, 1993). Apart from such project failures, a major concern for an organization is that the learning achieved during a project is not available for use in other projects or other contexts. As a result, each new project tends to be started from scratch without incorporating any relevant previous project experience (Prusak, 1997, cited in Newell, 2004, p 12).

2.3.5 Problems of Cross-Project Learning

The main problem of cross-project learning seems to be that most attempts focus on "pushing" (supplying) product knowledge through information and communication technologies to those who do not need the knowledge and/or are not able to capture knowledge. On the other hand, where a particular project team requires this learning because of a current need for problem solving, then lessons from previous projects about similar problems can be useful (Newell, 2004, p 17).

Managing knowledge and learning across projects poses a number of challenges. One of the key challenges is to construct a collective knowledge base (Leseure and Brookes, 2004, p106). The following key problems were highlighted by the authors:

1. Incentives for members of the organization to contribute to the knowledge base;
2. Ambiguity pertaining to knowledge ownership; and
3. Life-cycle management of knowledge.

Incentives to contribute: It is often highlighted that there is little incentive for individuals based in project teams to help develop a collective base of knowledge captured from projects. The complaint is that not enough time was spent on post project reviews and on formulating and compiling the experience gained. The substantial amount of time spent during a project towards helping to formulate organizational knowledge may create a negative perception of the project performance. Some people may see the time spent on compiling lessons learnt as being unproductive (Leseure and Brookes, 2004, p 106).

The drivers for incentives to contribute are generally linked to, among others, cultural mores at work, individual values, the need to be seen as being proactive and the need to gain credit and respect. However, there has been no evidence of explicit approaches being developed to propagate these drivers (Leseure and Brookes, 2004, p106).

Knowledge ownership: In order for a knowledge base to be developed, mechanisms are necessary to recognize who owns what knowledge among individuals and/or groups; however, this has proven difficult to achieve. Transfers of knowledge were usually feasible where configuration and rights of ownership of knowledge are specific and accepted. Similarly, the converse is true; failures to transfer knowledge often occurred when it was not clear who owns which or what knowledge (Leseure and Brookes, 2004, p106).

Life-cycle management of knowledge: Knowledge, as it is with other useful resources, has a life-cycle. A new knowledge form is created. It is then refined through the application of a number of business processes to achieve its full worth. After that its usage is decreased until another new knowledge form comes in to replace it (Siemieniuch and Sinclair, 1999, p521). However, the conservativeness of the process of collective construction of knowledge soon became apparent. Existing knowledge beliefs were challenged by innovation and the formulation of new knowledge. One of the toughest tests to be confronted during the construction of this collective knowledge base is that of striking a strategic balance between stability and innovation (Leseure and Brookes, 2004, p106).

2.3.6 Suggestions towards more effective cross-project learning

Newell (2004) (p18) suggested that a lot more effort is required to encourage project team members to focus on how they have achieved their goals, rather than on what they have achieved. That is, focus should be on the procedure instead of the product. This necessitates a change to the usual focus of project milestone reviews asking project teams to focus only on knowledge capture with respect to their achievements (Newell 2004) (p18).

A suggestion is also made for efforts to encourage teams to realize that they can learn from the experiences of others, because lessons learnt by others with respect to procedures and the like will be of use to them. It is therefore important that project teams should be encouraged to take into consideration the procedural-type problems that are likely to be faced while at the same time accept that the team can learn from how problems have been solved by other teams. So, despite the uniqueness of the project, the implementation processes will most likely be similar to those used in past projects (Newell, 2004) (p18).

Newell (2004)(p19) further suggested that efforts at developing personal networks are more effective than the capture of lessons learned that have been codified by setting up of a database. In other words, a community approach to cross-project learning is more effective than the information and communication technology approach.

2.3.7 Communities of Practice

The community approach to managing knowledge sees knowledge being created as a result of social interaction and learning amongst groups. The kind of community discussed in this instance is one based on communities. Communities of practice are organized around circumscribed sets of activities and their members are generally in direct contact with each other. As members of these communities, individuals can develop their practice through sharing experience and ideas with the other members (Newell et al., 2002, p 119).

Rather than just being an informal social network of friends, communities of practice directly support the work process by enabling individuals to share their work experience. This, in turn, helps to improve their understanding of their work. Knowledge sharing is enhanced due to the generally higher level of trust among members as well as their willingness to reciprocate (Newell et al., 2002, p 120).

Another distinguishing feature of communities of practice lies in the manner in which knowledge is shared among the members. They develop their own routines, formal and informal "rules", and stores of shared assumptions and knowledge. Over time, they often create their own languages, which may contain jargon and colloquialisms whose meanings are obscure to outsiders. As a result of learning, practices evolve. However, community members may also import knowledge from similar communities or more disparate sources. How much a community of practice learns internally or captures new knowledge externally from other communities of practice depends on the nature of the practices it undertakes. In many complex technology projects, knowledge acquired from external sources, that is, from other communities of practice, is crucial (Garrety, Robertson and Badham, 2004, p352).

In communities of practice, knowledge is constructed as individuals share ideas through collaborative mechanisms such as narration and joint work. It is this process of constructing meaning through joint endeavour that provides organizational members with identity and cohesiveness and which provides the basis for effective learning. It is also important to recognize that the creation, diffusion and application of knowledge is situated and thus heavily influenced by the context of practice (Pavitt 1984, cited in Bresnen et al., 2003, p159).

2.4 KNOWLEDGE MANAGEMENT IN CONSTRUCTION

2.4.1 Knowledge Management Strategies in Construction

According to Carrillo and Chinowsky (2006), construction companies have always relied on their knowledge assets to provide services to clients. Only in recent years, however, the phrase "knowledge management" has been used in common parlance. Knowledge management (KM), among other things, seeks to formalize the manner in which companies exploit their knowledge assets by harnessing organizational knowledge, promoting greater collaboration between groups with similar interests, and capturing and using lessons learned on previous projects. Given this background and perspective, Carrillo and Chinowsky (2006) investigated how major United States engineering design and construction firms implement knowledge management initiatives, in order to identify best practice. Using a case study methodology to investigate companies' strategy and implementation, people aspects, and metrics for performance, the researchers found there is a clear distinction between the knowledge management activities undertaken by large engineering design firms and those of construction firms. There is also a much greater emphasis on knowledge sharing, which is just one component of knowledge management. Moreover, some companies have specific KM initiatives while others have activities that are part of their normal business processes.

A major reason for the failure of many knowledge management projects is the absence of a well-defined strategic plan to guide implementation (Shankar et al., 2003, p190). In their paper, they discuss the strategic planning needs of the knowledge management deployment process, and develop a framework that could be used specifically by engineering firms to guide the knowledge management implementation process.

The "road-map" for knowledge management implementation requires the conversion of organizational goals into tactics that can be easily implemented. Thus, strategic planning for knowledge management should begin with the definition of a set of end goals that knowledge management aims to achieve (Shankar et al., 2003 p194).

Kamara et al., (2002) (p53) undertook two research projects, the findings of which are used to assess current knowledge management strategies in the architecture, engineering and construction firms. They describe knowledge management strategies as being either 'mechanistic' or 'organic'. Mechanistic approaches heavily focus on technology to manage explicit knowledge. These include knowledge-based expert systems and knowledge codification through information and communication technology tools. Organic approaches include storytelling and 'communities of practice', which focus on managing tacit knowledge. Storytelling is used in organizations to build up descriptive capability as well as to create resilience, robustness and redundancy in organizations through sustained interventions (Snowden, 1999, cited in Kamara et al., 2002, p 55). They concluded that even though it is not labeled as knowledge management, knowledge is being managed in the construction industry through people-based strategies, in conjunction with other organizational and contractual arrangements (Kamara et al., 2002, p66).

However, there is an absence of a proactive strategy so that the intellectual assets of the construction firms are not fully exploited. Integrated strategies reflecting the specific contexts of these firms and incorporating both organic and mechanistic knowledge management systems are required (Kamara et al., 2002, p66).

2.4.2 Information Management in Construction

Lin, Wang and Tserng (2006) focused on how to apply knowledge management techniques, such as map-based knowledge management (MBKM) systems, to the construction phase of construction projects. Knowledge management involves creating, securing, coordinating, combining, retrieving and distributing knowledge. Through these processes, engineers and allied experts can share knowledge to enhance construction activities and reduce the cost and time needed to solve problems. The authors claim that a new, practical method to both capture and present knowledge related to construction projects is the use of network knowledge maps (NKM). These maps give users a synopsis or summary of both available and missing knowledge in core areas of a project. As a result, the engineers and allied experts are better able to manage both tacit and explicit knowledge. Based on case studies that used map-based knowledge management (MBKM) systems in a high-technology factory building enterprise in Taiwan, the authors report the results indicate the effectiveness of the systems, especially for sharing knowledge in the construction phase. From the results, Lin, Wang, and Tserng (2006) concluded that knowledge can be captured as well as managed to improve projects by using information and web-based technologies effectively during the construction phase of a project.

Akinci et al. (2006) conducted a case study of construction personnel on a highway construction project that demonstrated how missing and inaccurate data result in communication loops that are non-value adding

(NVA) among the personnel. This phenomenon has both time and cost implications of extra work associated with deficiencies in manual data collection and transfer, which are detrimental to the project but have been poorly quantified. To improve this situation, the researchers describe a simulation-based framework they used to model information flow processes from a job site to a field office to measure and highlight existing deficiencies, as well as to model and demonstrate the effect of using automated reality capture technologies, such as laser scanners and radio frequency identification, to streamline the data collection process for the same project. The simulation results showed that, by utilizing data collection technologies, the NVA times of each agent involved in the information flow could be reduced. Based on these findings, Akinci et al. (2006) claimed that construction practitioners and researchers can apply this framework to:

1. identify inefficiencies quantitatively from the current information flow at sites, and
2. appreciate the benefits of using automated reality capture technologies to reduce these inefficiencies.

Gyampoh-Vidogah, Moreton and Proverbs (2003) (pp157, 171) found from their exploratory case studies in the construction industry that the current management of information shows that:

1. Information exchange between project parties is mainly through the paper medium in which retrieval is very slow and inefficient;
2. Functional departments maintain their own data suited for their particular needs;
3. Most information searching and transfer between project parties and clients are paper-based; a main cause of delays;
4. No efficient electronic interfaces exist between departmental systems for information access; and
5. The impact of IT investment to date has been limited.

2.4.3 Knowledge Capture and Sharing in Construction Project Organizations

Fong and Chu (2006) conducted a study of the Hong Kong construction industry, with the general focus on knowledge sharing. They were especially concerned with how to link individual learning within the organizational context, so that individuals' knowledge can be shared by others during a project to achieve organizational goals. They point out that, before the 20th century, people did not realize how critical knowledge is for the success of a company and organizational growth. Within an organization today, however, employees have much knowledge and experience about such things as products, customers, internal processes, histories, technologies, and competitors, but their knowledge is usually scattered, both throughout individuals and locations within the organization. In addition, learning by individuals is usually a one-time event, and workers rarely share the new knowledge gained with others in an organization. In order to gain a deeper understanding of the current situation of knowledge sharing at the departmental level in contracting companies, the authors sought to investigate the main barriers to knowledge sharing, and also to find out the critical factors for and benefits resulting from effective knowledge sharing in the tendering departments of contracting companies in Hong Kong and the United Kingdom. In their study, they reviewed existing theories of knowledge and knowledge sharing and provided an explorative account supported by empirical evidence. The findings strongly suggested that management must continuously anticipate and support knowledge sharing activities related to the successful management of construction projects within their particular organizations.

To find out how significant social factors play a part in the project environment with regards to the enhancement of capabilities in knowledge management, Bresnen et al. (2003) carried out a case study research on the construction industry. The main finding from the case study is that knowledge capture, knowledge transfer and the learning process in projects rely heavily upon social patterns, practices and processes in ways which places a strong emphasis on taking up a community-based approach.

Similarly, Styhre, Josephson and Knauseder (2004, p 965) report that the result of the case study they carried out on six construction projects suggests that organizational learning in construction projects is heavily dependent on the informal process and personal contacts instead of the more formal reporting and management control systems which are computer-based.

Kamara et al. (2002, p 63) suggest that project knowledge capture, transfer and reuse is achieved through reassigning people from one project to another, using standards and best practices guides, contractual agreements, intranets and specific activities like post-project reviews. They also identify construction project and organizational knowledge that are crucial to the designers (Kamara et al., 2002, p 58).

Carrillo et al. (2004, pp 52, 53) identified Knowledge Management tools for locating and sharing project knowledge in the UK construction sector. The non-IT tools include research collaboration, conferences and seminars, brainstorming, job rotation and observation and Communities of Practice. The IT tools include intranets, database systems, documentation systems and electronic discussion forum.

Fong (2005) examines the knowledge sharing aspects of construction organizations' activities, the mechanisms used, the benefits to be reaped and incentives used to encourage knowledge sharing. The knowledge sharing approaches that were identified include 'searching the internet for answers, using personal network such as friends and relatives, searching for information from databases and company publications, using published sources and data, using own knowledge and experience, discussing with project team during project meetings, seeking help from supervisors and seeking help from peers'. His findings indicate that when problems are encountered, personalization approaches of knowledge sharing are used, that knowledge sharing is seen as beneficial in preventing reinventing the wheel and in leveraging on the knowledge assets of the firm. The studies also indicate that peer recognition and informal encouragement from superiors are greater incentives than money for most professional in the industry (Fong, 2005).

2.4.4 Designer Construction Knowledge

Yates and Battersby (2003, p 637) highlight the importance of the designers' knowledge about construction techniques and methods for the success or failure of a project. The authors also highlight that the fragmentation of the construction industry leads to a reduction of input by design professionals during construction, leading to a reduction in their construction knowledge (Yates and Battersby, 2003, p 637).

The findings of the study by Yates and Battersby, indicate a general agreement that in order to produce effective construction documentation, the architects and engineers must have extensive construction experience. It is also agreed that the 'constructor should be allowed to be involved in the design from conceptualization' (Yates and Battersby, 2003).

In the architecture-engineering-construction (AEC) industry, design decisions usually are based on many factors, including basic data from outside the project, previously defined project data and project specifications, domain knowledge, general knowledge, and other design decisions (Howard, 1991). Capture and communication of project-specific knowledge supporting these decisions can facilitate design verification, speed redesign, reduce errors in design and construction, aid facility management, simplify rehabilitation and retrofitting, and provide a knowledge base of experience for future projects. To make effective use of project-specific knowledge in the AEC industry, Howard (1991) claims experts must be able to solve formidable problems in knowledge acquisition, including locating sources of project-specific knowledge, categorizing the knowledge, finding likely users of the knowledge, and identifying knowledge flows that can provide the greatest benefits when captured and communicated effectively.

2.4.5 Design - Construction Interface

This refers to the interface between designers and constructors during which information exchange and knowledge sharing takes place. There are a number of forms of the design-construction interface. The initial interface takes the form of information sharing during contractor briefings prior to the tendering process. Formal information sharing takes place after contract award (McCarthy et al., 2000).

The fragmented nature of typical construction projects means that their design and construction are carried out by different organizations. Usually, a significant period will have lapsed between the completion of design and commencement of construction (McCarthy et al., 2000).

Alarcon and Mardones (1998) identified the lack of interaction between design and construction teams during the design-construction interface as the main cause of problems during construction. Consequently, this results in knowledge not being shared between designers and constructors.

The lack of construction knowledge among designers leads to problems in the designs, caused by 'errors of the designers themselves and the lack of coordination among specialties'. Other problems in the designs are caused by 'late changes introduced by the owner and the designers, the inconsistency between drawings and specifications and specifications with little technical content' (Alarcon and Mardones, 1998).

2.4.6 Design Constructability and Constructability Review

In an effort to improve the interaction between the design and construction disciplines, the concept of constructability has been developed. Constructability is defined as 'the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives' (CII, 1986, cited in Gransberg and Douglass III, 2005). Constructability encompasses a detailed review of design drawings, specifications and construction processes by a highly experienced construction engineer before a project is put out for bids (Gransberg and Douglass III, 2005, p PM.01.1). Specific items in a design have been highlighted for identification by Gransberg and Douglass III (2005).

The constructability of a design, according to Glavinich (1995) (p 73), 'refers to the ease with which the raw materials of the construction process (labour, production equipment and tools and materials and installed equipment) can be brought together by a builder to complete the project in a timely and economic manner'. In other words, a higher degree of constructability will allow the builder to carry out the construction more efficiently and economically (Glavinich, 1995, p 73).

The Construction Industry Institute (CII) (cited in Jergeas and van der Put 2001, p 286) sets out the principles of constructability to be applied to the various phases of projects as follows:

Conceptual Planning Phase

1. A formal constructability programme is made an integral part of the project execution plans;
2. Early project planning actively involves construction knowledge and experience;
3. Construction personnel are involved in developing the project contracting strategy;
4. Project schedules are sensitive to construction requirements;

5. Basic design approaches consider major construction methods such as modularization or preassembly;
6. Site layouts promote efficient construction (eg. Adequate space for laydown and fabrication yards and efficient site access);
7. Project team participants responsible for constructability are identified early in the project;
8. Advanced information technologies such as 3d computer modeling or field notebook computers are applied.

Design and Procurement Phases

9. Design and procurement schedules are construction-sensitive;
10. Designs are configured to enable efficient construction considering issues like simplicity, flexibility, sequencing of installation and labour skill and availability.
11. Design elements are standardized including maximum use of manufacturers' standards and standardized components;
12. Construction efficiency is considered in specification development including prior review of specifications by construction personnel;
13. Modular/preassembly designs are prepared to facilitate fabrication, transportation and installation;
14. Designs promote construction accessibility of personnel, materials and equipment;
15. Designs facilitate construction under adverse weather;
16. Design and construction sequencing facilitates system turnover and start-up;

Field Operations Phase

17. Innovative construction methods are used such as innovative sequencing of field tasks or use of temporary construction systems or innovative use of construction equipment.

Jergeas and van der Put (2001) (p 287) grouped these seventeen principles into seven broad themes for their study on the benefits of constructability in construction projects, as follows:

1. Up-front involvement of construction personnel, covering Principles 1 to 4;
2. Construction-sensitive schedules, covering Principles 5 and 6;
3. Modularization and preassembly, covering Principles 7 and 8;
4. Standardization; covering Principle 9;
5. Designs facilitate construction efficiency, covering Principles 10 to 14;
6. Innovative construction methods, covering Principles 15 and 16;
7. Advanced computer technology, covering Principle 17.

According to Pulaski and Horman (2005), construction contractors have significant constructability expertise to contribute to the design process of projects. To utilize this expertise most effectively, however, the right information must be made available to the design team at the proper point in time and at the appropriate level of detail. Current methods for utilizing construction knowledge in design have made significant advances to improving projects. They are, however, typically rudimentary, i.e., they are unstructured, not very efficient, and rely heavily on reviews. Organizing constructability information according to its use in the design process will allow project teams to take the best advantage of the construction expertise, according to the authors. They thus introduce a model for organizing constructability information, which they claim is different from current approaches because it is based both on timing and levels of detail. They illustrate its applicability and efficacy through six case studies of different types of projects, including a detailed study of the Pentagon renovation project that shows how the model can be used as a metric to guide constructability input during design.

In the Malaysian context, little research has been done with respect to the problem of constructability in construction projects (Nima et al., 2001). Nima et al. (2001) concluded from their survey of the Malaysian construction industry that 'generally Malaysian engineers accepted the constructability concepts from the theoretical point of view but did not apply these concepts in their practices'.

To allow input of construction knowledge and experience into the design process, a constructability review is carried out. According to Gransberg and Douglass III (2005), the purpose of the constructability review is to 'identify design errors (both materials selection and dimensional), ambiguous specification, project features that will be difficult or exceedingly costly to construct, project features that exceed the capability of industry to properly build and project features that are difficult to interpret and will be hard to accurately bid'.

Young III (1998) (p 33) defines constructability review as 'a term used to describe the attempt to forecast design documents into the future, in effect seeing them as bricks and mortar, or labour and money. He also considers the following subjects pertaining to design to be worthy of a constructability review: phasing, sequencing, detailing, systems selections, safety and contract strategy and delivery design.

The benefits of applying a constructability review include reduced cost, shorter schedules, improved quality, enhanced safety, better control of risk, fewer change orders and fewer claims (Gibson Jr. et al., 1996, p 276). The application of constructability effectively enables knowledge sharing for improving the designer construction knowledge.

According to Young III (1998), quoting the Constructability Implementation Guide (Publication no. 34-1, May 1993), 'the best consequence of implementing constructability is that owners accrue an average reduction in the total project cost and schedule of 4.3 and 7.5 per cent, respectively. These savings have been shown to represent a 10:1 return on investment in the constructability effort'.

According to Fischer and Tatum (1997), constructability should be an important objective in all phases of a construction project, and designers play an important role in achieving superior constructability. Most projects, however, do not receive constructability input, though prior research has demonstrated the benefits of such input. One reason for this lack of constructability input, the authors claim, is the lack of formal, explicit constructability knowledge bases that link constructability issues to design decisions and that can be made available on-line to interested parties. To address this problem, the researchers compiled and formalized constructability knowledge related to reinforced concrete structures; and to ensure appropriate and specific constructability input, they classified the knowledge by construction methods and structural elements. In particular, in order to make this specific knowledge available to designers at the right time during design development, they further divided it into the following five groups: application heuristics, layout knowledge, dimensioning knowledge, detailing knowledge, and exogenous knowledge. Through this process, the researchers found an improved ability to collect and formalize this knowledge, and to make it readily available to designers to enhance project performance.

2.5 CONCLUSION

A review of the literature has provided an overview of studies carried out on the subject of knowledge management in projects, in general, and knowledge sharing in construction projects, in particular. The study is further focused on the designer construction knowledge. From the overview, the following general conclusions are made:

1. Sharing of project know-how, information and experience in construction projects relies heavily on informal and personal contacts (Styrhe, Josephson and Knauseder, 2004, p965).
2. The ICT-based approach to sharing of project knowledge has not been very effective (Newell, 2004, p 13).
3. The fragmented nature of the construction industry contributes to poor sharing of knowledge between designers and constructors of projects, leading to problems during construction because of deficiencies during design (Gransberg and Douglass III, 2005).
4. The incorporation of project constructability and constructability reviews during design allows for the effective sharing of past knowledge and experience to improve the designer construction knowledge (Gransberg and Douglass III, 2005).

In light of the above, investigations may be initiated to determine:

1. Whether the different approaches to knowledge sharing are effective in improving the designer construction knowledge;
2. The frequency with which sharing of crucial knowledge between designers and constructors occurs through the various approaches.

By answering the above questions in the context of the construction industry in Malaysia, extensions may be made to the existing ideas and models relating to subject of knowledge sharing in construction projects.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter Two reviewed and analyzed the relevant literature on the subject of knowledge management in projects in general and knowledge sharing in construction projects in particular. From the review, a number of research themes emerged, resulting in research questions being posed.

In this chapter the selections of the research methodology and design are discussed starting with an examination of the research paradigms. This is followed by discussions on the development and administration of the data collection method. The questionnaire design, the reliability and validity measures and sample selection are also discussed.

This chapter develops the research framework and methodology to investigate the research problems and answer the research questions. The framework upon which this study was designed is guided by the research design model of Cavana, Delahaye and Sekaran (2001, p107).

3.2 RESEARCH PARADIGMS

To design a research study, one begins by selecting a topic and a paradigm (Creswell, 1994). Research paradigms have been widely discussed by a number of authors (Creswell, 1994; Guba, 1990). A paradigm may be described as a set of beliefs that guides actions (Guba, 1990) which, in the context of business research, provides directions and guidelines for the research to be conducted (Creswell, 2003). Research paradigms may be thought of in terms of a continuum, represented by positivism at one end and interpretivism at the other (Carson et al., 2001, p8).

In comparing the positivist and interpretivist research paradigms, their philosophical assumptions, based on the ontological, epistemological and methodological perspectives, are discussed.

3.2.1 Positivism

In terms of the ontological assumptions, positivist research assumes that individuals have direct access to the real world and that there is a single external reality (Carson et al., 2001, pp 4, 6). The positivist ontology views the world as being external and objective (Carson et al., 2001, p 5).

From the epistemological perspective, positivism believes that human beings are rational and independent and that science is value-free. Positivist research attempts to explain cause and effects and focuses on generalization and abstraction, with thought governed by hypotheses and stated theories (Carson et al., 2001, pp 5, 6).

Positivist research focuses on description and explanation. Researchers distance themselves from the object of research, maintain emotional neutrality and distinguish clearly between reason and feeling, science and personal feeling and facts and value judgements (Carson et al., 2001, pp 5, 6). Positivist research applies reasoning by deduction to identify universal laws to control and predict events of human activity (Cavana, Delahaye and Sekaran, 2001, pp 8, 34). Research methods adopted are usually statistics and mathematical techniques for quantitative processing of data (Carson et al., 2001, pp 5, 6).

3.2.2 Interpretivism

In terms of the ontological assumptions, interpretivist research construes reality subjectively (Carson et al., 2001, p 6; Cavana, Delahaye and Sekaran, 2001, p135).

From the epistemological perspective, interpretivist research focuses on the specific and concrete. It seeks to understand specific context and, in this contextual setting, discover how meanings are constructed (Carson et al., 2001, p 6; Cavana, Delahaye and Sekaran, 2001, p 34).

The methodology perspective is discussed with respect to the research focus, the researcher's role and the research techniques used. Interpretivism focuses on understanding and interpreting the phenomenon being studied (Carson et al., 2001, p 6; Cavana, Delahaye and Sekaran, 2001, p 134) and is concerned with generating theories (Hussey and Hussey, 1997, p 54; Carson et al., 2001, p 9).

The researcher is involved with the study and interacts with what is being researched (Creswell, 1994, p 5). The research is value-laden and biased (Creswell, 1994, p 5), with no clear distinction between facts and value judgements and is subject to influence from science as well as personal experience (Carson et al., 2001, p 6).

Interpretivist research uses qualitative techniques (Carson et al., 2001, p 6). It is characterized by the use of small samples. Nevertheless, the data gathered is rich and subjective (Hussey and Hussey, 1997, p 54).

This study seeks to explain the relationships between the application of various knowledge sharing approaches and the improvement of designer construction knowledge. It also seeks to determine the frequency with which the sharing of construction knowledge occurs through the various approaches and the extent to which sharing and applying past knowledge and experience to current projects results in their improved implementation. Consequently, the positivist approach is deemed appropriate for adoption for the study. Typically, within this positivist research paradigm, quantitative research methods are used (Cavana, Delahaye and Sekaran, 2001, p 340). The choice of this method is further supported by virtue of the objective of the study being to test identified relationships rather than develop theory.

3.3 RESEARCH METHODOLOGIES

Business research may be carried out using two methods, namely, quantitative and qualitative methods (Cavana, Delahaye and Sekaran, 2001, p 12).

3.3.1 Quantitative Methods

Quantitative methods involve the researcher measuring the phenomena being investigated (Cavana, Delahaye and Sekaran, 2001, p 12). These methods apply a deductive process where the researcher develops a theoretical proposition and then works towards gathering empirical evidence that will either support or reject the propositions (Cavana, Delahaye and Sekaran, 2001, p 34). Quantitative methods include questionnaires and field and laboratory experiments (Cavana, Delahaye and Sekaran, 2001, p 12).

3.3.2 Qualitative Methods

Qualitative research may be described as "methods and techniques of observing, documenting, analyzing and interpreting attributes, patterns, characteristics and meanings of specific, contextual or gestaltic features of the phenomena under study" (Leininger, 1985, p 5). Strauss and Corbin (1990, p 17) provided a more succinct description of qualitative research as "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification". Qualitative methods generally include interviews, observations, focus groups and case studies (Cavana, Delahaye and Sekaran, 2001, pp 36, 37).

3.4 RESEARCH DESIGN

In order to investigate the research problems and answer the research questions, the research design needs to be developed to provide the necessary data. The design for this study was guided by the research design model developed by Cavana, Delahaye and Sekaran (2001, p 107). This model comprises the following aspects of research design:

- Purpose of the study
- Types of investigation
- Extent of researcher interference
- Study setting
- Unit of analysis
- Time horizon of the study
- Measurement
- Data collection methods
- Sampling design
- Data analysis

3.4.1 Purpose of the Study

Research studies fall into three general categories, namely, exploratory, descriptive and hypothesis testing. Exploratory research places a focus on idea discovery (Churchill and Iacobucci, 2002). Zikmund (2003, p 74) asserts that exploratory research is chosen when only the general nature of a problem is known, so that it is not expected to give conclusive evidence but only to clarify problems. Cavana, Delahaye and Sekaran (2001, p 108) describe an exploratory study as one that is undertaken when little is known about the situation at hand or when no information is available on how similar problems or research issues have been resolved in the past.

Descriptive research focuses on determining the frequency of an event occurring and on the relationship between two variables (Churchill and Iacobucci, 2002). It is undertaken in order to ascertain and be able to describe the characteristics of the variables of interest in a situation (Cavana, Delahaye and Sekaran, 2001, p 109). It is conducted to enhance the description of the problem when there is only some prior understanding of its nature (Zikmund, 2003, p 74).

Hypothesis testing is used to explain the nature of certain relationships or establish the differences among groups or the independence of two or more factors in a situation. It is undertaken to explain dependent variable variance or predict organizational outcomes (Cavana, Delahaye and Sekaran, 2001, p 111).

This study tests hypotheses to explain the relationships between knowledge sharing in the construction industry and the improvement of designer construction knowledge. It also compares the frequency of application of the different knowledge sharing approaches with respect to the crucial knowledge areas.

3.4.2 Types of Investigation

The researcher has three approaches to investigation to choose from. These are clarification, correlation and causal (Cavana, Delahaye and Sekaran, 2001, p 113).

A clarification investigation is used to gain a clear understanding of concepts involved in the research problem. Exploratory and descriptive studies fall under this approach (Cavana, Delahaye and Sekaran, 2001, p 113).

Having clearly understood the concepts, the researcher needs to look into the relationship between the concepts or variables, differentiating between a correlation and a causal relationship. A causal study is undertaken to establish cause and effect relationships whereas if the purpose of the research is to identify the important variables associated with the problem, then a correlation study is carried out (Cavana, Delahaye and Sekaran, 2001, p 113). Based on the foregoing, this study takes on a correlation approach as well as being exploratory in nature.

3.4.3 Extent of Researcher Interference

As this research studied the relationship between variables, the hypothesis-testing method, utilizing structured questionnaires was applied. Beyond administering the questionnaire to a respondent, the researcher will not interfere with the normal activities of the respondent organization. Hence, researcher interference will be minimal.

3.4.4 Study Setting

Business research is undertaken in the natural environment with work proceeding normally (referred to as non-contrived settings), or in artificial contrived, settings (Cavana, Delahaye and Sekaran, 2001, p 117). Studies may be classified as field studies, field experiments and lab experiments (Cavana, Delahaye and Sekaran, 2001, pp 117, 119).

During field studies, various factors are studied within the natural setting with normal activities going on and researcher interference minimal (Cavana, Delahaye and Sekaran, 2001, p 119). These include exploratory, descriptive and correlational studies undertaken in organizations (Cavana, Delahaye and Sekaran, 2001, p 117).

Field experiments are studies in which correlation or cause and effect relationships are examined in natural settings with work going on normally but with some researcher interference (Cavana, Delahaye and Sekaran, 2001, p 119).

When the researcher studies cause and effect relationships with a high degree of control in an artificially created contrived setting, the study is termed a laboratory experiment (Cavana, Delahaye and Sekaran, 2001, p 119). The present study is thus classified as a correlation cum exploratory study in a non-contrived setting.

3.4.5 Unit of Analysis

The unit of analysis represents the level of aggregation of the data collected and is determined by the research objective. The unit of analysis may be an individual, a dyad (group of two persons), a group, an organization or a culture (Cavana, Delahaye and Sekaran, 2001, p 119). The unit of analysis may help guide or determine the data collection methods, sample size and variables included in the framework (Cavana, Delahaye and Sekaran, 2001, p 120).

This research seeks to study the relationship between the various knowledge sharing tools and approaches and the improvement of the designer construction knowledge, from the perspectives of the architectural and engineering design organizations and the constructor organizations. These three organizations represent the units of analysis in this case.

3.4.6 Time Horizon of the Study

Studies may be categorized into either longitudinal or cross-sectional studies. Studies in which data on the dependent variable are gathered at different times to answer the research question are termed longitudinal studies (Cavana, Delahaye and Sekaran, 2001, p122).

Cross-sectional studies are those in which data are collected once over a period of days, weeks or months, in order to meet a research objective (Cavana, Delahaye and Sekaran, 2001, p 121). This research on knowledge sharing in the construction industry falls under this category.

3.5 MEASUREMENT

A concept or construct is defined as 'a generalized idea about a class of objects, attributes, occurrences or processes' (Zikmund, 2003, p294). Bryman and Bell (2003, p 71) define a concept or construct as 'the building blocks of theory and represent the points around which business research is conducted'.

For a concept to be used in quantitative research, it must be measured (Bryman and Bell, 2003, p 71). Prior to initiating the measurement process, the constructs or concepts relevant to the problem must be identified. In order to be measured, a construct must be made operational (Zikmund, 2003, p 294). This is achieved by specifying the activities or operations necessary to measure it (Kerlinger, 1973, cited in Zikmund, 2003, p 294). Once measured, concepts or constructs take the form of independent or dependent variables (Bryman and Bell, 2003, p 71).

3.5.1 Measurement Scale

Various types of measurement scale can be applied to measure the different variables. A scale is a tool or mechanism used to distinguish individuals from one another based on the variables of interest to the study (Cavana, Delahaye and Sekaran, 2001, p 195). There are basically four types of measurement scale, namely, nominal, ordinal, interval and ratio. The nominal scale is the least sophisticated, the level of sophistication increasing progressively from nominal to the ratio scale (Cavana, Delahaye and Sekaran, 2001, p195).

For a nominal scale, the numbers or letters assigned serve to identify or classify objects (Zikmund, 2003, p 296). It is used to obtain personal data such as gender and to group individuals or objects (Cavana, Delahaye and Sekaran, 2001, p 199).

An ordinal scale arranges objects or alternatives based on their magnitudes (Zikmund, 2003, p 297), to rank product preferences or usage and to rank-order individuals, objects or events (Cavana, Delahaye and Sekaran, 2001, p 199).

In addition to arranging objects or alternatives based on magnitude, an interval scale also organizes the arrangement in units of equal intervals. However, the location of the zero point is arbitrary (Zikmund, 2003, p 298). An interval scale is used when the measurement of a variable can be represented on a five-point (or seven-point) scale and be averaged across the items (Cavana, Delahaye and Sekaran, 2001, p 200).

A ratio scale has an absolute instead of relative quantities and it has an absolute zero (Zikmund, 2003, p 298). This allows it to measure the differences between points on the scale as well as the proportions of the differences (Cavana, Delahaye and Sekaran, 2001, p 198).

3.5.2 Response Scale

Response scale may be categorized into two, namely, the rating scale and the ranking scale (Cavana, Delahaye and Sekaran, 2001, p 203). Rating scales require respondents to estimate the magnitude of a characteristic or quality with respect to the object, event or person being studied (Zikmund, 2003, p 309, Cavana, Delahaye and Sekaran, 2001, p 203).

Rating scales often used in business research include, amongst others, the dichotomous, category, Likert, numerical, semantic differential, itemized rating and the fixed or constant sum rating scales (Cavana, Delahaye and Sekaran, 2001, p 203). Ranking scales include the paired comparison, forced choice and comparative scales (Cavana, Delahaye and Sekaran, 2001, p 208).

The semantic differential and Likert scales are most frequently used in business research (Cavana, Delahaye and Sekaran, 2001, p 208) and are among the most popular and reliable scales (Davis et al., 1988, Sarantakos, 1995, cited in Grace, 1999, p 47). The choice of scale is dependent on the information required for the study, the respondent characteristics and the survey administration (Tull and Hawkins, 1990, cited in Grace, 1999, p 48). Taking these into consideration, the choice was made for the Likert scale. The use of the Likert scale is expected to be effective in extracting information from respondents, namely, architects, engineers and contractors in this instance. It is also compatible with the mail survey data collection, easy to construct and administer and consequently cost effective (Emory and Cooper, 1995, Tull and Hawkins, 1990, cited in Grace, 1999, p 48).

3.6 DATA COLLECTION METHODS

Four main ways of gathering quantitative data are interviews, tests/measures, observation and questionnaires (Easterby-Smith, Thorpe and Lowe, 2002, p 130).

3.6.1 Interviews

Interviews find extensive use in surveys utilized for market research or opinion polls to gather quantitative data. Here, the interviewer will ask a list of precisely worded questions and will expect either a factual answer or a less precise one. Where an imprecise answer is expected, the interviewer will be provided with multiple choice alternative answers, one of which will be selected as a response (Easterby-Smith, Thorpe and Lowe, 2002, pp 130, 131). Interviews include face-to-face and telephone interviews (Cavana, Delahaye and Sekaran, 2001, p 243).

3.6.1.1 Face-to-face Interviews

This takes the form of a direct communication whereby the interviewer asks respondents questions face-to-face. It is a two-way conversation between the interviewer and the respondent (Zikmund, 2003, p 199).

A face-to-face interview allows for the richness of data collected through feedback and establishes a close rapport between the interviewer and respondents so that complex issues may be explored and understood. However, face-to-face interviews may introduce interviewer bias and are expensive to conduct on a large sample (Cavana, Delahaye and Sekaran, 2001, p 243).

3.6.1.2 Telephone Interviews

Telephone interviews are those in which respondents are contacted by telephone to gather responses to survey questions (Zikmund, 2003, p 207). It is a way of collecting data efficiently when fast responses to specific questions from geographically spread respondents are needed (Cavana, Delahaye and Sekaran, 2001, p 243).

Telephone interviews are advantageous in being cheaper to conduct, able to reach respondents over a wide geographic area and affording greater anonymity of respondents. Nevertheless, they also have their negative side in terms of the fact that non-verbal cues cannot be read by the interviewer and that interviewees can block a call (Cavana, Delahaye and Sekaran, 2001, pp 253, 245).

3.6.2 Tests and Measures

Tests often utilize a series of written questions to solicit yes or no answers. These are used to analyze how or what individuals think without having any implications for which responses are right or wrong. Tests include personality tests like Eysenck's EPI and Cattell's 16-PF and diagnostic tests in educational settings (Easterby-Smith, Thorpe and Lowe, 2001, p 131).

3.6.3 Observation

Observation may be described as 'the systematic process of recording the behavioural patterns of people, objects and occurrences as they are witnessed' (Zikmund, 2003, p 235). The researcher collects data by witnessing and recording information on events as they occur. Observations may be visible or hidden, the former being when subjects know of the observer's presence and the latter when they are unaware (Zikmund, 2003, p 236).

3.6.4 Questionnaires

A questionnaire is designed as 'a pre-formulated written set of questions to which respondents record their answers, usually within closely defined alternatives' (Cavana, Delahaye and Sekaran, 2001, p226). Where what is required of the variables and how to measure them are known, data can be efficiently collected using questionnaires. These questionnaires may be administered personally if the survey is confined to a local area or sent by post to respondents where a wide geographical area is covered in the survey. Alternatively, questionnaires may be sent to respondents via email (Cavana, Delahaye and Sekaran, 2001, pp 239-2400.

Compared to other data gathering methods such as structured interviews, self-completion questionnaires offer advantages in terms of the following:

1. They are cheaper to administer especially where the sample is geographically dispersed
2. They are quicker to administer. Large quantities of questionnaires can be sent out by post or distributed otherwise at the same time
3. Absence of interviewer effects whereby the answers that people give may be affected by the interviewer characteristics
4. Absence of interviewer variability in terms of their asking questions in a different order or in different ways
5. Convenience for respondents in being able to complete the questionnaires in their own time (Bryman and Bell, 2003, p 142).

Notwithstanding the advantages, questionnaires are not without disadvantages. These include the following:

1. Low response rates

2. Inability to help respondents if they have difficulty answering the questions
3. No opportunity to probe respondents to elaborate an answer
4. Inability to collect additional data
5. Possibility of 'respondent fatigue' especially if the questionnaires are too long
6. Possibility of not having the right person answering the questionnaire (Bryman and Bell, 2003, pp 143-144).

A mail questionnaire (Appendix A) survey, consisting of structured questions, was employed to gather data from the architectural, engineering design and construction organizations. The structured questions were identified based on the literature review as well as the personal experience of the researcher.

The questionnaire used in this study is divided into a number of sections. The demographics or organisational profile of the respondents are covered in Sections A and B of the survey instrument. Section C focuses on the hypothesis statements on nine (9) major approaches or tools of knowledge sharing, namely, research collaboration (RC), conferences and seminars (CS), brainstorming (BS), job rotation and observation (JR), communities of practices (COP), intranets (ITNET), database systems (DBS), document management systems (DMS) and electronic discussion forums (EDF). Questions were set using a 5-point Likert type scale. Section D sets the questions on the frequency of knowledge sharing (FKS) by organisation using a 5-point Likert type scale on the nine (9) approaches or tools mentioned above.

It is acknowledged that organizations differ in their interpretation of what Knowledge Management means (Carrillo et al., 2004, pg 48). To ensure that respondents have a common understanding of the definitions used for Knowledge Management in the context of this study, guidance notes (Appendix B) were attached to the questionnaire. These guidance notes provided accepted definitions of Knowledge Management as well as explanations with respect to the variables used in the study.

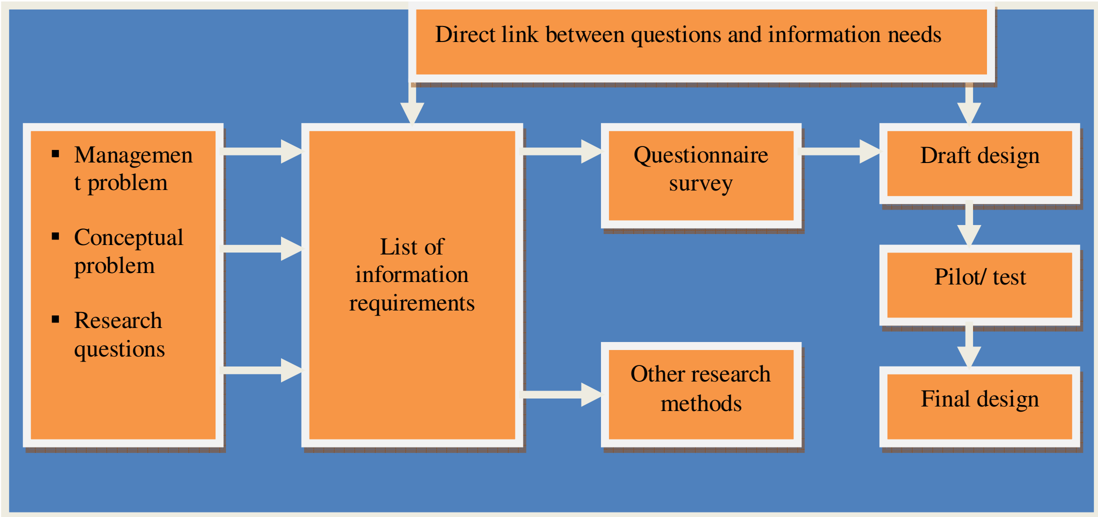
Mangione (1998) suggested that in order to obtain satisfactory data from a mail survey, it must be accompanied by a clear and concise respondent letter. In the letter, the respondent is assured of confidentiality. The respondent letter for this study took the form of a survey information sheet prepared on the University of Newcastle letterhead (Appendix C). The survey information sheet explained the objectives of the research, stressed the voluntary nature of the survey and gave an assurance pertaining to the confidentiality of the respondent. To encourage response, a self-addressed and stamped envelope was enclosed with each questionnaire package. A letter of support from the CIDB (Appendix D) was also included as part of the package that was sent out.

3.6.5 Questionnaire Design

The design of the questionnaire used in the survey was guided by the questionnaire design process shown in Figure 3.1. The design process started with examining the management problems and policies and the research questions that needed to be addressed, followed by listing down the information required to address these problems (Ticehurst and Veal, 2000, pg 144). Emphasis was placed on the necessity for the questions to be linked back to the research problems.

The questionnaire design also took into consideration previous research on a related topic carried out by Carrillo et al. (2004). In particular, the questionnaire format described by Carrillo et al. (2004) (pg 48), provided input towards the final form of the questionnaire for this study.

Figure 3.1
Questionnaire Design Process



Source: Ticehurst and Veal, 2000, pg 144.

3.6.6 Ethical Issues

In this research, the ethical issues that may arise in relation to the researcher and the research participants have been taken into consideration. Issues about ethical principles in business research usually revolve around the following areas, as identified and laid down by Diener and Crandall (1978) (cited in Bryman and Bell, 2003, p 539):

1. Whether there is harm to participants.
2. Whether there is a lack of informed consent.
3. Whether there is an invasion of privacy.
4. Whether there is deception involved.

The issue of harm to participants in this study was addressed by maintaining the confidentiality of records and anonymity of accounts. This confidentiality covers the identities and records of individuals and organizations (Bryman and Bell, 2003, p 539).

For an anonymous mail questionnaire survey such as this one, there was no issue as to a lack of informed consent. The participants were provided with the opportunity for informed consent whereby they can agree or disagree to participate based on the information given to them. Completion of the questionnaire is taken as informed consent (Bryman and Bell, 2003, p320).

Privacy is linked to the notion of informed consent. By consenting to participate in the survey, respondents 'more or less acknowledge surrendering their right to privacy for that limited domain' (Bryman and Bell, 2003, p 544).

Deception happens when the researcher presents his or her research to participants as something other than what it actually is (Bryman and Bell, 2003, p 545). The present study is straight forward in its objectives which are clearly set out in the questionnaire. Thus, the possibility of any intended deception did not arise. The covering Survey Information Sheet (Appendix C) with each questionnaire, clearly stated the purpose of the study and the manner in which the data was going to be used.

3.7 SAMPLING DESIGN

The sampling process involves selecting enough elements from the population such that by studying the sample to understand the properties or characteristics of the sample subjects or sample units, these properties and characteristics can be generalized to the population elements (Cavana, Delahaye and Sekaran, 2001, p 253). In order for the findings from the sample to be generalizable to the population from which it was selected, the sample must be representative (Bryman and Bell, 2003, p 91). A sample is representative when it exhibits similar characteristics as the population so that the sample statistics can be used as estimates of the population parameters (Cavana, Delahaye and Sekaran, 2001, p 254). The selection of a sample by researchers generally goes through sequential stages including defining the target population, selecting a sampling frame, choosing between a probability and non-probability sampling method, determining the sample units, determining the sample size, selecting the actual sample units and execution (Zikmund, 2003, p 372).

Population or target population is defined as the specific entire group of people, events or things relevant to the research project (Zikmund, 2003, p 373; Cavana, Delahaye and Sekaran, 2001, p 252), while an element refers to a single member of the population (Cavana, Delahaye and Sekaran, 2001, p252). The sampling frame is the list of all elements in the population from which a sample is drawn (Cavana, Delahaye and Sekaran, 2001, p 252). A sample refers to a selection of some members from the population, forming a sub-set of the population whereas a sample unit or subject represents a single member of the sample (Cavana, Delahaye and Sekaran, 2001, p 253).

The target population in this study comprised organisations involved in the construction industry in Malaysia. The sampling frame consisted of contractors registered with and listed in the directory of the Construction Industry Development Board (CIDB) and architectural and engineering consultancy firms listed in the directories of their respective associations. The sample units or subjects refer to the individual architectural, engineering and contractor organizations.

Two major types of sampling designs are probability and non-probability sampling.

3.7.1 Probability Sampling

Probability sampling is one in which every element in the population has a known non-zero probability of selection (Zikmund, 2003, p 379). Probability samples are based on chance selection procedures which include simple random sampling, systematic sampling, stratified sampling and cluster sampling (Zikmund, 2003, p 398).

In simple random sampling, each member of the sampling frame is assigned a number and the researcher selects sample units by a random method (Zikmund, 2003, p 393). This allows every element in the population to have a known and equal chance of being selected as a subject. Simple random sampling has the least bias and is the most generalizable (Zikmund, 2003, p 257).

For systematic sampling, an initial starting point is randomly selected and then every nth element in the population is selected (Zikmund, 2003, p 386; Cavana, Delahaye and Sekaran, 2001, p 258). In cluster sampling, groups or clusters of elements (ideally with heterogeneous members within each group), as opposed to the individual elements in the population, become the primary sampling units (Zikmund, 2003, p 389).

3.7.2 Non-Probability Sampling

In non-probability sampling, the elements in the population do not have a known or predetermined chance of being selected as subjects (Cavana, Delahaye and Sekaran, 2001, 257). This does not allow for the findings of the study of the sample to be generalizable to the population. Non-probability sampling techniques fall into two main categories, namely, convenience sampling and purposive sampling (Cavana, Delahaye and Sekaran, 2001, p 262).

Convenience sampling is a procedure in which information is collected from members of the population most conveniently available (Cavana, Delahaye and Sekaran, 2001, p 262 and Zikmund, 2003, p 380). Convenience sampling is considered as the quickest and most efficient method of gathering basic information and is normally used for exploratory research (Cavana, Delahaye and Sekaran, 2001, p 263).

Purposive sampling is made up of three major types – judgement sampling, snowball sampling and quota sampling (Cavana, Delahaye and Sekaran, 2001, pp 263). Judgement sampling is a technique in which a sample is selected by an experienced individual on the basis of some appropriate characteristic of the sample members who can best provide the required information (Zikmund, 2003, p 382 and Cavana, Delahaye and Sekaran, 2001, p 263). In snowball sampling, the initial sample group is selected by either probability or non-probability methods and additional respondents are selected from information provided by the initial respondents (Zikmund, 2003, p 384 and Cavana, Delahaye and Sekaran, 2001, pp 263, 264). Quota sampling is a type of purposive sampling where a quota is assigned to ensure that certain groups are represented to the required extent in the study (Zikmund, 2003, p 383 and Cavana, Delahaye and Sekaran, 2001, p 264).

3.7.3 Sample Size

Cavana, Delahaye and Sekaran (2001, p 275) suggested that researchers need to consider a number of aspects when deciding on the sample size for the research. These include the extent of variability in the population, the precision or accuracy required, the confidence level desired and the type of sampling plan applied. Other relevant considerations refer to those pertaining to time and cost impacts of varying the sample size (Bryman and Bell, 2003, p 101).

Dillon, Madden and Firtle (1994, pp 252, 253) describe the use of the sample size calculator developed by Kennedy Research (Appendix E). This involves the use of a chart to determine the sample size from an expected favourable response rate and the desired maximum error level and confidence level (Dillon, Madden and Firtle, 1994, p 252).

Cavana, Delahaye and Sekaran (2001) (p 240) suggested that the return rates of mail questionnaires are typically low, with a 30 percent response rate being considered acceptable. Bourque and Fielder (1995) (cited in Carrillo et al., 2004, p 48), noted that 'a postal questionnaire without any incentive could probably expect no better than a 20 percent response rate'.

The survey was targeted on a total population of 2,092 respondent organizations comprising 714 and 755 bodies corporate and partnerships registered with the architectural and engineering consultancy associations respectively as well as 623 contractors categorized under the top category of G7 with the Malaysian Construction Industry Development Board (CIDB) and whose full contact details were available.

A sample size of 200 was arrived at for this study using the calculator, based on an estimated response rate of 30 percent and a 10 percent error in responses at 99.7 percent confidence. The choice for a 30 percent response rate was made after taking cue from Cavana, Delahaye and Sekaran (2001) (p. 240) who considered 30 percent as being acceptable. The target population comprising professional bodies corporate and partnerships and contractors are licensed to operate in their respective fields by virtue of their being registered with the relevant boards and associations. To qualify to be thus registered, these firms have to meet specific criteria in terms of management skills, educational and professional qualifications, financial standing and relevant experience, among others. This being the case, plus the similar and complementary nature of their businesses, it can be affirmed that there is little variability within the population. This low variability allows for a high level of confidence (in this case, 99.7%).

A similar study by Carrillo et al. (2004) titled 'Knowledge Management in UK Construction' used a sample size of 170, obtaining a response rate of 31.2 percent.

For this research, the questionnaires were posted to the following:

1. 70 architectural design consultancies, randomly selected from the Association of Architects, Malaysia Directory 2006
2. 70 engineering design consultancies, randomly selected from the Association of Consulting Engineers, Malaysia Directory 2005
3. 60 contractor firms registered under Grade 7, selected from the CIDB Directory 2005.

The sample for the study shows a cross-section of the majority of the bodies corporate and partnerships as registered with the professional bodies in Malaysia as well as G7 category contractors registered with the Malaysian Construction Industry Development Board (CIDB). Though the number of respondents was comparatively small, the data profiles of the firms or establishments obtained from the study show a close representation or depiction of the status of the construction industry in Malaysia. This can be attested to by the fact that the industry is dominated by relatively young professionals who are more suited to the dynamic environment surrounding the industry, as can be seen from the analysis in Chapter 4. The Malaysian construction industry, over the past several years, has seen a surge of younger and more educated professionals who are more apt to adopt a more techno-savvy approach to the operations and the development of the industry. Hence this study is directed to this set of entrepreneurs where the concept of knowledge sharing may already be a common practice; this is what this study attempts to uncover.

3.8 DATA ANALYSIS AND INTERPRETATION

Data obtained from the questionnaire survey are analyzed using the SPSS statistical software package. The objectives of analyzing data are as follows:

1. Getting a feel for the data
2. Testing the goodness of data
3. Testing the hypotheses developed for the research

(Cavana, Delahaye and Sekaran, 2001, p 319).

The feel for the data will indicate how good the scales are and whether the coding and entering of data have been properly done. This is achieved by checking the central tendency and the dispersion to determine the normality of the distribution (Cavana, Delahaye and Sekaran, 2001, p 319). The important measures for central tendency and dispersion include the mean, standard deviation and variance. Other descriptive statistics used are skewness and kurtosis.

The mean is a measure of central tendency and it is the sum of a set of scores or data divided by the total number of scores or data in the dataset being analysed. The standard deviation measures the spread or variability of data around the mean of a distribution. It is the square root of the variance. The variance is the sum of squared deviations divided by N-1, where N is the total number of the data or observation. It is a measure of the variability of data around the mean.

Skewness is a measure of deviation from symmetry. Negative skewness describes a distribution where a greater number of values lie above the mean and positive skewness describes a distribution with a greater number of values below the mean. In other words, negative skewness occurs when the median of the data array is larger than the mean. In positive skewness, the mean is larger than the median.

Lastly, kurtosis is a measure of deviation from normality (normal curve). A kurtosis value near zero (0) indicates a shape that is close to normal. A positive value for the kurtosis indicates a distribution more peaked than normal while a negative kurtosis shows a flatter shape than the normal distribution. A kurtosis value between $\pm$ 1.0 is considered excellent for measurement purposes.

Testing the goodness of data, which is essentially a test of the reliability and validity of the measures, is achieved by doing reliability analysis and factor analysis on the data. For this study, the data were tested by working out the Cronbach's Alpha Coefficient and applying the Principal Component Analysis respectively.

Hypothesis testing is carried out using the relevant statistical test chosen from the appropriate menu of the SPSS programme (Cavana, Delahaye and Sekaran, 2001, p 319).

The study used the correlation analysis procedure to test whether the data support the hypothesized relationships. Correlation analysis is used to describe the strength and the direction of the linear relationship between two variables, the dependent variable (DV) and the independent variables (IVs).

In this study, the procedure for obtaining and interpreting a Pearson product-moment correlation coefficient (r) is used as the study deals with interval level or continuous variables. The Pearson correlation coefficients (r) take the value of -1 to +1 denoting a negative or positive correlation of relationship between the IV and DV. If the value of r is positive, it mean that as one variable increases, the other will increase too and vice versa for the negative correlation. The size of the absolute value, gives an indication of the strength of the relationship. A perfect correlation of 1 or – 1 indicates that the value of one variable can be determined exactly by knowing the value on the other variable. A correlation 0 means that there is no relationship existing between the two variables. When interpreting the values of the coefficient r, a number of issues have to be borne in mind. These include the effect of non-linear relationship, outliers, restriction of range, correlation versus causality and statistical versus practical significance. The assumption of normality is crucial in the interpretation of the correlation results. The values of the two variable involved in the analysis must be approximately normally distributed. When variables are not normally distributed, the Spearman correlations analysis is a more appropriate measure to use. Cohen (1988) suggests the following guidelines in the interpretation of the value of the Pearson correlation (r),

r = .10 to .29 small,

r = .30 to .49 medium, and

r = .50 to 1.0 large

By squaring the correlation (r) - we get the coefficient of determination, the r^2, and then multiplying by 100 to determine the percentage of the variability shared between the two variables. Thus we can say variable X shares about Y per cent of its variability with variable Z. The level of significance (Sig. 2 tailed) is used in the analysis even though the hypotheses above are unidirectional. This is to check for the actual situation depicted by the data. It is worth noting that the significance r is strongly influenced by the sample size.

The full analysis is presented in Chapter Four and the findings and interpretation of the analysis is presented in Chapter Five.

3.9 CONCLUSION

The research methodology and design has been selected after examining the research paradigms and giving due consideration to the development and administration of the data collection methods. Notwithstanding the processes that had been gone through to arrive at its final selection, the research method and design chosen are not without limitations. Amongst others, low response rates typical of mail questionnaires may impact upon the sample bias. Also, individuals who respond to the survey may already have an interest in and hence a positive bias towards the subject of the survey. Hence, they would be more likely to respond positively to the questions.

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

This Chapter presents the results of the analyses of the survey data. A total of 200 questionnaires were mailed to various construction business organisations in Malaysia (Table 4.1) but only 48 were received. Of these, only 42 or 21.0 % were completed and are used in the analyses. The sampling frame was obtained from the Association of Architects, Malaysia Directory 2006, the Association of Consulting Engineers, Malaysia Directory 2005 and contractor firms registered under Grade 7, in the Construction Industry Development Board, Malaysia Directory 2005.

The Chapter contains seven (7) sections. The first section presents the introduction of the chapter, followed by the descriptive statistics of the variables referred to in the study. The third section contains the data analysis on the respondents' profiles, their organisational backgrounds, and the summary statistics of variables incorporated in the study. The fourth section discusses the evaluation of measurements used in the study, namely the reliability analysis and factor analysis (primarily the principal component analysis, PCA). In this section, findings from the principal component analyses were used to check the measurement of models in the study. The fifth and sixth sections contain the results of the hypothesis testing, primarily correlation analyses, and multiple regression analyses on specified equations. The last section concludes the chapter.

4.2 DESCRIPTIVE STATISTICS

In a research survey, descriptive statistics is normally used to gauge the profile of the sample characteristics. It provides the 'feel' for the data prior to undertaking further analyses on them. Generally, there are two fundamental reasons for doing so. Firstly, this is to check for outliers or abnormalities in the data array; coding and data entry errors may be suspect and hence correction can be made prior to further data processing. Secondly, it is to check for unusually large amounts of missing data which may render the results of the analyses invalid or make it difficult to undertake in depth analyses without data modifications.

The survey data were analysed using the Statistical Package for Social Sciences (SPSS version 14). The SPSS output give descriptive statistics (see Appendix F1, F2 and F3) and histograms with superimposed normal curves for all nominal variables (Appendix F4). In this study, the scale variables include the nine (9) tools and approaches of knowledge sharing.

The main assumption to be checked from each output is normality. This is done by carrying out a check on the skewness of the normal curve which must be within plus or minus one (Leech, Barett and Morgan, 2005. P.28) and that the kurtosis is within plus or minus 1.96 (Hair et.al., 1998: 73) for the variable to be at least approximately normal. The details of these are explained within the analyses of each variable in this chapter.

4.3 DATA ANALYSIS

This section will analyse the data in the study based on their respective Sections in the survey instrument. Section A has five (5) questions on the respondent's professional background, number of years of experience in construction industry, number of years as project manager, formal project management qualification and type. Section B covers the organizational background of the respondent business establishments or organisations. It has five (5) multiple-type questions and one (1) open-ended question. The section focuses on the size of organization (by employee numbers), the type of organisation, average yearly value of projects undertaken by the organisation, ISO certification and the knowledge sharing procedures in the organisation and one open-ended question specifying the type of knowledge sharing procedures and guidelines used by the organisation. Section C contains a set of 5 questions on each of the nine knowledge sharing tools under investigation by the study. Section D examines the frequency of knowledge sharing among the organisations in relation to the nine tools identified.

4.3.1 Organisational Profile

The respondents for this study comprised architects, engineering design consultants and contractors involved in the construction industry in Malaysia. From Table 4.1 below, the majority of the respondents were contractors. The number of architects and engineers were about equal at 10 and 12 establishments respectively. The response rate from the contractors is the highest among the three at 33.3%, while those of the other two professional organisations were 14.3% and 17.1% for architecture and engineering firms respectively.

Table 4.1
Type of Business Organisations Surveyed and Response Rate

Type of Organisation	Sample No. (n)	%	Population No.[1]	Response Rate (%)
Architectural Consultants	10	23.8	70	14.3
Engineering Consultants	12	28.6	70	17.1
Contractors	20	47.6	60	33.3
Total	42	100.0	200	21.0

Note: 1 The Populations of the respective business organisations are based on randomly selected based on the Association of Architects, Malaysia Directory 2006, the Association of Consulting Engineers, Malaysia Directory 2005 and contractor firms registered under Grade 7, of the CIDB Directory 2005, as described in Chapter 3.

In terms of professional background and trainings, the majority of the respondents (47.6%) were trained engineers, 23.8% contractors, 21.4% architects and only 7.1% quantity surveyors. This is shown in Table 4.2 below.

Table 4.2
Professional Background and Training of Respondents

No.	Professional Background	Frequency	Valid Percent
1.	Architect	9	21.4
2.	Engineer	20	47.6
3.	Quantity Surveyor[1]	3	7.1
4.	Contractor	10	23.8
Total		42	100.0

Note 1: The Quantity Surveyors responded to the study as Contractors

The survey indicated that the construction industry is anchored and managed by relatively young players. From Table 4.3 below, it is noted that about 29% of the respondents have less than 10 years of experience in the industry and cumulatively about 57.1% have less than 15 years of experience. Only 31% or 13 out of the 42 respondents have more than 20 years of working experience in the industry. In general, the current construction industry is run by relatively young managers in terms of experiences in the Malaysian construction industry. There are pros and cons to this. On the one hand, being relatively young and possibly inexperienced, they will have to undergo steep learning curve and are less exposed to the finer details of the industry. However, they are risk takers and are more eager to bring in or experiment with new methods and practices and inject fresh ideas and innovations to the industry. On the other hand, their handicap would be their limited experience, limited social networking and stiff competitions from the more experienced and financially stronger competitors both within and outside the country.

Table 4.3
Number of Years of Experience in Construction Industry

No.	Years of Experience	Frequency	Valid Percent	Cumulative Percent
1.	Less than 5 Years	4	9.5	9.5
2.	5 - 10 Years	8	19.0	28.6
3.	11 - 15 Years	12	28.6	57.1
4.	16 - 20 Years	5	11.9	69.0
5.	More than 20 Years	13	31.0	100.0
Total		42	100.0	

Table 4.4
No. of Years as Project Manager

No.	Years as Project Manager	Frequency	Valid Percent	Cumulative Percent
1.	Less than 5 Years	16	38.1	38.1
2.	5 - 10 Years	13	31.0	69.0
3.	11 - 15 Years	7	16.7	85.7
4.	16 - 20 Years	4	9.5	95.2
5.	More than 20 Years	2	4.8	100.0
Total		42	100.0	

The study shows that 38.1% of the respondents have less than 5 years of experience as project managers and less than 69% has 10 years of experience. These managers are thus relative newcomers to the industry. The number of years as project managers reflects that decisions are made by relatively inexperienced staff or personnel which may have a negative impact on the industry. Consequently, this may affect the results of the study in as far as knowledge sharing is concern. However, the younger project managers are likely to be more forward-thinking and techno savvy than their older counterparts.

Table 4.5
Years of Experience in Construction Industry and as Project Manager

Working Experience (in Years)	Experience in Construction Industry	Project Manager
	No. (%)	No. (%)
Less than 5 Years	4 (9.5)	16 (38.1)
5 - 10 Years	8 (19.0)	13 (31.0)
11 - 15 Years	12 (28.6)	7 (16.7)
16 - 20 Years	5 (11.9)	4 (9.5)
More than 20 Years	13 (31.1)	2 (4.8)
Total	42 (100.0)	42 (100.0)

Note: The numbers in brackets represent percentages (%) of the responses (n)

Table 4.5 above show the respondent's number of years of experience in the construction industry and as project managers. It is interesting to note that while 42.9% of the respondents have more than 16 years of experience in the construction industry in the country, only 14.3% have similar years of experience as project manager in the industry itself. At the lower end of the experiential ladder, less than 10% of the respondents have experienced of five years or less in the industry and similarly about 38.1% as project managers with similar length of experience. Therefore, it may be inferred from the findings that the construction industry is driven and managed by managers who are new to the industry. In total, 69.0% have 10 years and less as project manager and only 28.6% with experience in the construction industry.

Table 4.6
Formal Project Management Qualification by Years of Experience in Construction Industry

Formal Project Management Qualification	Years of Experience in Construction Industry					Total
	< 5	5 - 10	11 - 15	16 - 20	> 20	
YES	2 (50.0)	4 (50.0)	3 (25)	3 (60.0)	3 (23.1)	15 (35.7)
NO	2 (50.0)	4 (50.0)	9 (75)	2 (40.0)	10 (76.9)	27 (64.3)
Total	4 (100.0)	8 (100.0)	12 (100.0)	5 (100.0)	13 (100.0)	42 (100.0)

Note: The numbers in brackets () refer to the percentage % within Years of Experience in Construction Industry

Of the 42 business organisations surveyed, only 15 or 35.7% of the respondents possessed formal project management qualifications. The majority (64.3%) did not have any formal qualifications. Of the 15 respondents that have formal project management qualifications, only 6 or 40% are in the industry for less than 10 years and another 6 or 40% have between 11-20 years of construction industry experience. Only 3 (out of 15) or 20% have more than 20 years construction industry experience. It is safe to infer that the good majority of the project managers have no formal project management qualification. This is a cause for concern especially in the interest of long term sustainability and viability of the industry as well as to the quality of the industry over the long term.

Table 4.7
Type of Qualifications of Project Managers

No.	Type of Qualification	Frequency	Valid Percent	Cumulative Percent
1.	Certificate	1	2.4	2.4
2.	Diploma	5	11.9	14.3
3.	Degree	6	14.3	28.6
4.	Professional Membership	7	16.7	45.2
5.	None / No Response	23	54.8	100.0
	Total	42	100.0	

Table 4.7 show the various types of qualification of project managers. About 13 or 31% of the project managers have either a degree or professional membership in their respective professional bodies.

Table 4.8
Professional Background by Years of Experience in Construction Industry

No.	Professional Background	Years Of Experience In Construction Industry					Total
		< 5	5 - 10	11 - 15	16 - 20	>20	
1.	Architect	0[1]	0	4	2	3	9
2.	Engineer	1	4	3	3	9	20
3.	Quantity Surveyor[2]	2	0	1	0	0	3
4.	Contractor	1	4	4	0	1	10
	Total	4	8	12	5	13	42

Notes: 1. The numbers represent the frequencies (n) of responses with respect to each of the professional background of the respondents
2. The Quantity Surveyors responded as Contractors

From Table 4.8, we can discern that most architects in the survey have more than 11 years of experience in the construction industry as compared to engineers, surveyors and contractors.

4.3.2 Organisational Background

As explained earlier in section 4.3.1, the organisations that participated in the survey are contractors (47.6%), Engineering firms (28.6%) and Architectural firms (23.8%). The details are shown in Table 4.1 and Figure 4.1 below.

Figure 4.1
Types of Business Organisations

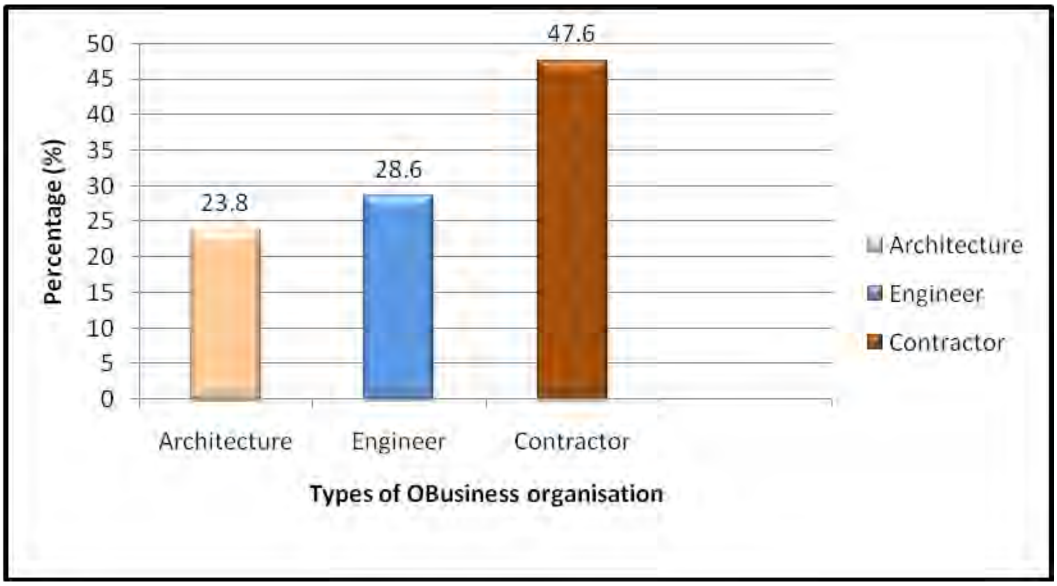


Table 4.9
Organisation Size: Number of Employees

No.	No. of Employees	Frequency	Valid Percent	Cumulative Percent
1.	Less than 10	3	7.1	7.1
2.	10-100	34	81.0	88.1
3.	101-1000	5	11.9	100.0
	Total	42	100.0	

Most of the business organisations surveyed (Table 4.9) employed less than 100 full-time employees which put them in a small business category. For instance, 37 or 81% employed 100 or less staff or employees. Only 5 out of the 42 establishments or 11.9% can be considered medium to large size firms. Being small business organisations, their practices, especially on knowledge sharing will differ considerably when compared to those of the larger establishments. Hence, this observation will have significant impact on the practices reported in this study. Similarly, as seen in Table 4.10, professional firms tend to have smaller number of employees than contractors; their scope of work require less workers or staff compared to that of the contractors.

Table 4.10
Type of Organisation by Number of Employees

No.	Type of Organisation	No. of Employees			Total
		Less than 10	10-100	101-1000	
1.	Architecture	2 (66.7)	8 (23.5)	0 (9.0)	10 (23.8)
2.	Engineering	0 (.0)	9 (26.5)	3 (60.0)	12 (28.6)
3.	Contractor	1 (33.3)	17 (50.0)	2 (40.0)	20 (47.6)
Total		3 (100.0)	34 (100.0)	5 (100.0)	42 (100.0)

Note: The numbers in brackets refer to % within Size of Organisation (Employees)

Table 4.11
Type of Organisation by ISO 9001:2000 Certification

No.	Type of Organisation	ISO 9001:2000 Certified		Total
		YES	NO	
1.	Architecture	1 (6.7)	9 933.3)	10 (23.8)
2.	Engineering	5 933.3)	7 (25.9)	12 928.6)
3.	Contractor	9 (60.0)	11 (40.7)	20 (47.6)
Total		15 9100.0)	27 (100.0)	42 (100.0)

Note: The numbers in brackets ( ) refer to % within Size of Organisation (Employees)

Table 4.11 shows that the number of business organisations with ISO 9001:2000 certification is very few as only 15 out of the 42 firms surveyed or 35.7% are

ISO–certified organisations. The response to the requirements for the ISO certification is slow in gaining momentum and this should be addressed by the industry players.

In terms of the average yearly project value of the firms surveyed, about 54.1% earned RM20 million or less (Table 4.12). These are essentially small size outfits in an industry controlled by a few big players. Table 4.13 shows the average yearly project value by the type of business organisation. From a cursory glance of the table, the contractors have higher yearly project value than the 'professional' outfits namely the architects and engineers.

Table 4.12
Average Yearly Project value in Ringgits (RM)

Project Value in (RM)	Frequency	Percent	Valid Percent	Cumulative Percent
500,000	1	2.4	2.7	2.7
2,000,000	2	4.8	5.4	8.1
3,000,000	1	2.4	2.7	10.8
4,000,000	1	2.4	2.7	13.5
5,000,000	1	2.4	2.7	16.2
8,000,000	1	2.4	2.7	18.9
10,000,000	5	11.9	13.5	32.4
15,000,000	4	9.5	10.8	43.2
18,000,000	1	2.4	2.7	45.9
20,000,000	3	7.1	8.1	54.1
50,000,000	7	16.7	18.9	73.0
60,000,000	1	2.4	2.7	75.7
100,000,000	3	7.1	8.1	83.8
200,000,000	2	4.8	5.4	89.2
250,000,000	1	2.4	2.7	91.9
600,000,000	1	2.4	2.7	94.6
710,000,000	1	2.4	2.7	97.3
800,000,000	1	2.4	2.7	100.0
Total	37	88.1	100.0	
Missing System	5	11.9		
Total	**42**	**100.0**		

Table 4.13
Average Yearly Project value by Type of Organisation

Project Value in (RM)	Types of Organisation			Total
	Architecture	Engineering	Contractor	
500,000	0 (.0)	1 (10.0)	0 (.0)	1 (2.7)
2,000,000	1 (11.1)	1 (10.0)	0 (.0)	2 (5.4)
3,000,000	0 (.0)	1 (10.0)	0 (.0)	1 (2.7)
4,000,000	0 (.0)	0 (.0)	1 (5.6)	1 (2.7)
5,000,000	0 (.0)	0 (.0)	1 (5.6)	1 (2.7)
8,000,000	0 (.0)	1 (10.0)	0 (.0)	1 (2.7)
10000000	1 (11.1)	0 (.0)	4 (22.2)	5 (13.5)
15,000,000	1 911.1)	1 (10.0)	2 (11.1)	4 (10.8)
18,000,000	0 (.0)	0 (.0)	1 (5.6)	1 (2.7)
20,000,000	0 (.0)	0 (.0)	3 (16.7)	3 (8.1)
50,000,000	2 (22.2)	2 (20.0)	3 (16.7)	7 (18.9)
60,000,000	0 (.0)	0 (.0)	1 (5.6)	1 (2.7)
100,000,000	1 911.1)	1 (10.0)	1 (5.6)	3 (8.1)
200,000,000	2 (22.2)	0 (.0)	0 (.0)	2 (5.4)
250,000,000	0 (.0)	0 (.0)	1 (5.6)	1 (2.7)
600,000,000	1 (11.1)	0 (.0)	0 (.0)	1 (2.7)
710,000,000	0 (.0)	1 (10.0)	0 (.0)	1 (2.7)
800,000,000	0 (.0)	1 (10.0)	0 (.0)	1 (2.7)
Total	**9** **(100.0)**	**10** **(100.0)**	**18** **(100.0)**	**37** **(100.0)**

Note: The figures in brackets ( ) represent % within Types of Organisation

Table 4.14
Type of Organisation by Formal Procedures for Project Knowledge Sharing

No.	Type of Organisation	Formal Procedures for Project Knowledge Sharing		Total
		YES	NO	
1.	Architecture	1 (7.7)	9 (31.0)	10 (23.8)
2.	Engineering	5 (38.5)	7 (24.1)	12 928.6)
3.	Contractor	7 (53.8)	13 (44.8)	20 (47.6)
Total		13 (100.0)	29 (100.0)	42 (100.0)

Note: The figures in brackets ( ) represent the percentage (%) within organizations having Formal Procedures or Guidelines for Project Knowledge Sharing

About a third (30.9%) of the organisations in the survey indicated that they have formal procedures or guidelines for project knowledge sharing. The rest (about 70%) did not have knowledge sharing procedures or guidelines in place for their organisations. They seem to be operating on their own with limited assistance from the others in undertaking their business operations.

Table 4.15 shows the responses from the respondents regarding the types of knowledge sharing procedures and guidelines used by their respective organisations. It is noted that out of the 42 respondents, 9 respondents (21.4%) responded to question B6 which is ... **'If Yes, please specify the type of Knowledge Sharing *Procedures and Guidelines Used'*.** Their comments are summarised in the Table 4.15 below.

Table 4.15
Type of Knowledge Sharing Procedures and Guidelines Used

No.	Comments from Respondents
1.	Based on Architectural Practice
2.	Community of Practice and databank
3.	EMS
4.	JKR and Board of Engineers
5.	Engineering workshop, internet
6.	Mentoring system, formal training courses, job swap, regular discussions / brain storming
7.	Quarry manual system
8.	Standard policy and procedures
9.	Never

Those responding to the question indicated that there are some forms of guidelines or procedures that they follow with the exception of one which stated that they never have any form of guidelines or procedures in place.

4.3.3 Descriptive Statistics of Variables

The measurements on the skewness and kurtosis of the variables in Sections A and B of the questionnaire are found in Appendix F1. The descriptive statistics on the independent variables of the study (Section C and D of the questionnaires) are found in Appendices F2 and F3. Appendix F4 (histograms) shows the normality of the curves explaining the skewness and kurtosis of each of the explanatory and independent variables.

The results of the cross tabulations on the relationship between the knowledge sharing tools and the improvement of designer construction knowledge in the crucial knowledge areas, based on the 5-point Likert scales are shown in Appendix F5. As can be observed from these tables, the majority of the respondents indicated that they either agree (Scale 4) or strongly agree (Scale 5) that the application of the various knowledge sharing tools improve the designer construction knowledge in respect of the crucial construction knowledge areas under study.

4.4 EVALUATION OF MEASUREMENTS IN THE STUDY

To evaluate the measurements, two critical tests were performed, namely, the reliability analysis and factor analysis. These preliminary assessments allow the data to be properly evaluated and validated prior to further analysis of the psychometric properties of the scales used in the variables to measure the key constructs.

4.4.1 Reliability Analysis

When using scales in a study, it is vital to check if the scales used are reliable. In other words, it is imperative that the internal consistency of the scales be tested and ascertained first. Reliability analysis procedure provides information about the relationship between individual items in the scale to see if the items used in the scale 'hang together'. The Cronbach's alpha coefficient test is used. Ideally the alpha value must be above 0.7 (Pallant, J., 2004; Hair et al, 1998, p118). When the number of items is less than ten (short scales), it is more appropriate to report their mean inter-item correlations. According to Briggs and Cheek (1986) an optimal range for the inter-item correlation must be between 0.2 and 0.4.

4.4.1.1 Cronbach's alpha for Application of Research Collaboration (RC) and 'improved designer construction knowledge'

In Appendix F6.1 the Cronbach's alpha is calculated for the research collaboration (RC) and the five (5) 'improved designer construction knowledge' constructs of RC-KOPP, RC-KCB, RC-KPO_MO, RC-TDK and RC-KPSS. The first table shows the case processing summary with a total of 42 items or variables and no missing data. The second table of reliability statistics indicates that the Cronbach's alpha based on unstandardized items is 0.766. The Cronbach's alpha value for the standardized items is higher by 2 basis points at 0.768. Thus, the alpha values obtained are higher than the minimum recommended value of 0.7. For most studies the standardized alpha value is adopted when the items in the scale have quite different means and deviations. The third table shows that the items in the scale have similar means and standard deviations and hence the Cronbach's alpha value based on the unstandardized items is applicable in this analysis. The mean score for RC-TDK is the highest (4.40) of all the 5 latent constructs under the research and collaboration variable, with RC-KCB and RC-KPSS having a similar score of 4.14.

Table 4 of Appendix F6.1 the SPSS reliability analysis output shows the inter-item correlations of each item in the scale with every other items being analysed. A higher correlation value denotes higher correlation among the respective items. Table 5 of Appendix F6.1 shows the table giving the mean, minimum, maximum, range and variance of the item~~s~~ means and inter-item correlations. Table 6 shows the summary of descriptive statistics for the scale as sum of the five (5) research collaboration (RC) items. The mean of 20.69 is the average of all the 5-items summated scale score for the 42 subjects or cases in the study.

The final Table 7 shows the item-total statistics. This table provides five pieces of critical information for each item in the scale. From the table, the two most beneficial statistics to take note are the 'Corrected Item-Total Correlation' and the last column of 'Cronbach's Alpha if item Deleted'. The former is the correlation of each specific item with the summated scale score where as the last column show the value of the Cronbach's alpha if the item be deleted from the analysis. For example deleting the RC-TDK would give the new coefficient alpha value of 0.768. In this particular case there is no improvement in the Cronbach's alpha value. Generally, deleting an item with lower alpha coefficient makes the alpha increase, but the improvement would be minimal since alpha value is based on the number of items as well as their average inter-correlations. If the item-total correlation is negative or too low (less than 0.30), it is recommended to either modify or delete such items (Leech, Barrett and Morgan, 2005:67). From the SPSS output in Table 7 of Appendix F6.1, it is noted that no items have item-total correlation less than 0.30. However, if such item exists for the subsequent variables it will be deleted from the scale to improve the alpha coefficient value.

From the analysis presented above, the application of research collaboration (RC) has good internal consistency, with a Cronbach's alpha coefficient of 0.766.

4.4.1.2 Cronbach's alpha for Application of Conferences and Seminars (CS) and' improved designer construction knowledge'

In Appendix F6.2 the Cronbach's alpha is examined for the application of conferences and seminar (CS) in relation to the five (5) 'improved designer construction knowledge' constructs of CS-KOPP, CS-KCB, CS-KPO_MO, CS-TDK and CS-KPSS. Table 2 of reliability statistics indicates that the Cronbach's alpha based on unstandardized items is 0.750. The Cronbach's alpha value for the standardized items is higher by 8 basis points at 0.758. Thus, the alpha values obtained are higher than the minimum recommended value of 0.7. Table 3 shows that the items in the scale have similar means and standard deviations and hence the Cronbach's alpha value based on the unstandardized items is applicable to this analysis. The mean score for CS-TDK and CS-KPO_MO is the highest (3.90) of all the five (5) latent constructs under the conferences and seminars (CS) variable and CS-KOPP has the lowest mean score of 3.74.

Table 6 shows the summary of descriptive statistics for the scale as sum of the five (5) conferences and seminars (CS) items. The mean of 19.26 is the average of all the 5-items summated scale score for the 42 subjects or cases in the study. From Table 5 of item-total statistics, no item in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column, no items can be deleted to increase the reliability measures above what is already obtained denoting that the scale rightfully measures what it is supposed to measure consistently.

From the analysis presented above, the application of conferences and seminars (CS) has good internal consistency, with a Cronbach's alpha coefficient of 0.750.

4.4.1.3 Cronbach's alpha for Application of Brainstorming (BS) and 'improved designer construction knowledge'

The Cronbach's alpha in Appendix F6.3 examined the application of brainstorming (BS) in relation to the five (5) 'improved designer construction knowledge' constructs as shown in the previous analysis. The reliability statistics in Table 2, indicates that the Cronbach's alpha based on unstandardized items is 0.831. The Cronbach's alpha value for the standardized items is higher by 3 basis points at 0.834. The mean score for BS-KCB (Table 3) has the highest mean (3.98) with BS-KPSS has the lowest mean score of 3.83.

The mean of 19.52 (Table 6) is the average of all the 5-items summated scale score for the 42 subjects. From the Table 5 of item-total statistics, no items in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of brainstorming (BS) has good internal consistency, with a Cronbach's alpha coefficient of 0.831.

4.4.1.4 Cronbach's alpha for Application of Job Rotation and Observation (JR) and 'improved designer construction knowledge'

In Table 2 of Appendix F6.4, the Cronbach's alpha test for the application of job rotation and observation (JR) shows alpha coefficient based on unstandardized items is 0.876. The Cronbach's alpha value for the standardized items is higher by a single point at 0.877. The mean score for JR-TDK is the highest at 3.88 (see Table 3) while JR-KOPP has the lowest mean score of 3.71. The mean of 18.93 is the average of all the 5-items summated scale score for the 42 subjects. From the Table 5, of item-total statistics, no item in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of job rotation and observation (JR) has good internal consistency, with a Cronbach's alpha coefficient of 0.876.

4.4.1.5 Cronbach's alpha for Application of Communities of Practice (COP) and 'improved designer construction knowledge'

The Cronbach's alpha for the application of Communities of Practice (COP) Table 2 of Appendix F6.5, based on unstandardized items is 0.932. The Cronbach's alpha value for the standardized items is similarly scored. The mean score (Table 3) for COP-KOPP and COP-KPSS are the highest at 3.86 while COP-KPO_MO has the lowest mean score of 3.67.

The mean of 18.93 is the average of all the 5-items summated scale score for the 42 subjects. From the Table 5 of item-total statistics, no items in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of Communities of Practice (COP) has good internal consistency, with a Cronbach's alpha coefficient of 0.932.

4.4.1.6 Cronbach's alpha for Application of Intranet (ITNET) and 'improved designer construction knowledge'

Appendix F6.6 shows the reliability test statistics for the domain of ITNET. For the application of Intranet (ITNET), the reliability statistics indicates that the Cronbach's alpha based on unstandardized items is 0.853 as shown in Table 2. The Cronbach's alpha value for the standardized items is higher by 1 basis point at 0.854. From Table 3, the mean score for ITNET-KOPP and ITNET-TDK are the highest at 3.88 while ITNET-KCB has the lowest mean score of 3.67.

The mean of 18.90 (Table 6) is the average of all the 5-items summated scale score for the 42 subjects. From the Table 5 of item-total statistics, no item in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of Intranet (ITNET) has good internal consistency, with a Cronbach's alpha coefficient of 0.853.

4.4.1.7 Cronbach's alpha for Application of Database Systems (DBS) and 'improved designer construction knowledge'

Appendix F6.7 shows the results of the reliability analysis for the relationship of the application of Database Systems (DBS) and the five (5) improved designer construction knowledge constructs. The reliability statistics indicates that the Cronbach's alpha as shown in Table 2, based on unstandardized items is 0.895. The Cronbach's alpha value for the standardized items is higher by 3 basis points at 0.898. The mean score for DBS-KCB has the highest mean (4.10) with DBS-KOPP having the lowest mean score of 3.90 (see Table 3).

The mean of 19.95 (Table 6) is the average of all the 5-items summated scale score for the 42 subjects. From Table 5 of item-total statistics, no item in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of brainstorming (BS) has good internal consistency, with a Cronbach's alpha coefficient of 0.895 as shown in Table 2 of Appendix F6.7.

4.4.1.8 Cronbach's alpha for Application of Document Management Systems (DMS) and 'improved designer construction knowledge'

The Cronbach's alpha is examined for the application of Document Management Systems (DMS) and the five (5) 'improved designer construction knowledge' constructs. The reliability statistics as shown in table 2 of Appendix 6.8 indicates that the Cronbach's alpha based on unstandardized items is 0.899. The Cronbach's alpha value for the standardized items is higher by 2 basis points at 0.901. DMS-KOPP has the highest mean score of 4.02 and DMS-KPSS has the lowest mean score of 3.86 as shown in Table 3 of the Item Statistics table.

The mean of 19.69 (Table 6) is the average of all the 5-items summated scale score for the 42 subjects. From Table 5 of item-total statistics, no item in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of Document Management Systems (DMS) has good internal consistency, with a Cronbach's alpha coefficient of 0.899 as shown in Table 2 of Appendix F6.8.

4.4.1.9 Cronbach's alpha for Application of Electronic Discussion Forum (EDF) and 'improved designer construction knowledge'

In Appendix F6.9, the Cronbach's alpha is examined for the application of Electronic Discussion Forums (EDF) and the five (5) 'improved designer construction knowledge' constructs. The reliability statistics indicates that the Cronbach's alpha based on unstandardized items is 0.923 as shown in table 2. The Cronbach's alpha value for the standardized items is higher by 1 basis point at 0.924. Table 3 shows that EDF-TDK has the highest mean (3.71) while EDF-KOPP has the lowest mean score of 3.50.

The mean of 17.83 (Table 6) is the average of all the 5-items summated scale score for the 42 subjects. From Table 5 of item-total statistics, no items in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

From the analysis presented above, the application of Electronic Discussion Forums (EDF) has good internal consistency, with a Cronbach's alpha coefficient of 0.923.

4.4.1.10 Cronbach's alpha for Frequency of Knowledge Sharing (FKS) with respect to the designated constructs covering the independent and dependent variables.

The Cronbach's alpha is examined for the 'Frequency of Knowledge Sharing' (FKS) variable against the nine (9) 'construction knowledge sharing approaches' constructs in RC, CS, BS, JR, COP, ITNET, DBS, DMS, EDF as well as I_Design Knowledge. The reliability statistics as shown in Table 2 of Appendix F6.10, indicates that the Cronbach's alpha based on unstandardized items is 0.918. The Cronbach's alpha value for the standardized items is higher by 3 basis points at 0.925. The highest mean score as shown in Table 3 is 3.7 for I_Design Knowledge and FKS-EDF has the lowest mean score of 2.64.

The mean of 31.877 (Table 6) is the average of all the 10-items summated scale score for the 42 subjects. From Table 5 of item-total statistics, no items in the corrected item-total correlation column has a value lower than 0.30. Thus, in the last column no items can be deleted to increase the reliability measures.

4.4.1.11 Cronbach's alpha for Overall Construct

The reliability statistics for the overall construct indicates that the Cronbach's alpha of 0.946 based on unstandardized items as seen from Table 2 of Appendix F6.11. The Cronbach's alpha value for the standardized items is higher by 4 basis points at 0.950. The mean score for the overall reliability analysis for the scaled variables of study's construct is 205.305 with a variance of 463.221 for 55 items (see Table 4).

From Table 3 of Appendix F6.11 on item-total statistics, there are several items in the corrected item-total correlation column have values lower than 0.30. These items are CS-TDK, BS-KOPP, BS-KCB and BS-KPSS. However, removing these items did improve the alpha coefficient slightly as seen from the Table 4.16 below.

Table 4.16
Summary of Reliability Analysis

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.948	.951	51

From the analysis presented above, the overall reliability analysis for the whole study (scale measurements) has good internal consistency, with a Cronbach's alpha coefficient reported of 0.946.

Table 4.17
Summary of Reliability Analysis for the Knowledge Sharing Construct

Construct	Cronbach's alpha
Research collaboration (RC)	0.766
Conferences and Seminars (CS)	0.750
Brainstorming (BS)	0.831
Job Rotation and Observation (JR)	0.876
Communities of Practice (COP)	0.932*
Intranet (ITNET)	0.853
Database Systems (DBS)	0.895
Document Management Systems (DMS)	0.899
Electronic Discussion Forum (EDF)	0.923*
Frequency of Knowledge Sharing (FKS)	0.918*
Overall Construct	0.946*
Corrected Overall Construct	0.948*

It is important to note that by deleting the items with the lowest corrected item-total correlation score of 0.30 did improve the reliability of some constructs as shown in with the asterisks (*) above. These items are Communities of Practice (COP), Electronic Discussion Forum (EDF), Frequency of Knowledge Sharing

(FKS) and the overall or total variables in the construct. A Cronbach's alpha of more than 0.90 means that the scale items are probably repetitive or that there are more items in the scale than what is needed for a reliable measure of the construct. As shown in Table 4.17 above, the Cronbach's alpha is greater than the threshold of 0.7, which means that most of the items in the scale are highly correlated with most of the other items and hence will fit into the psychometric scale used in this study.

4.4.2 Factor Analysis

Factor analysis is a data reduction technique by taking a large set of variables and look for a way that the data may be 'reduced' or summarised using a smaller set of factors or components. In this study, the principal component analysis (PCA) is used. The primary purpose of applying the PCA is to try to determine a relatively small number of variables used to convey as much information as possible in the observed variables (Leech, Barrett and Morgan, 2005:76)

4.4.2.1 PCA on Scale Variables

Appendix F7 shows the output for all scale variables. To analyse the output, rotation is usually necessary to assist with the interpretation of the factors. A correlation coefficient of 0.3 and above is sought when analysing the result. If none is detected in the correlation matrix then the use of factor analysis is considered. It is vital to check the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value which must not be less than 0.6. The Barlett's Test of Sphericity value must be significant at p-value of 0.05 or smaller.

The nine (9) knowledge sharing tools were subjected to the PCA using SPSS. The correlation matrix (Appendix F7), revealed the presence of many coefficients with values of 0.3 and above. The Kaiser-Meyer-Olkin value was 0.844, exceeding the recommended value of 0.6 (Kaiser, 1970, 1974) and the Barlett's test of

Sphericity (Barlett, 1954) reached statistical significance 0.001, supporting the factorability of the correlation matrix. However, none of the eigenvalues exceeded 1.0. A similar analysis is obtained for the overall construct and the results can be seen from Appendix F7.

4.4.3 Analysis of the Main Constructs With Respect To 'Improved Designer Construction Knowledge'

The Table 4.18 below shows the mean differences of knowledge sharing tools with respect to the various crucial construction knowledge areas identified in the study. For the purpose of the analysis, the knowledge sharing tools are categorised into non IT-based tools comprising Research Collaboration (RC), Conferences and Seminars (CS), Brainstorming (BS), Job Rotation and Observation (JR) and the Community of Practice (COP). The IT-based tools are Intranet (ITNET), Database Systems (DBS), Document Management System (DMS) and Electronic Discussion Forums (EDF). Overall mean differences show that RC scores higher than all the other non IT-based tools against TDK, scoring 4.405 out of the maximum 5.0 score value.

The IT-based tools show mixed results with the highest score of 4.095 for DBS against KCB. The use of EDF generally scores lower for all crucial construction knowledge areas considered. The graphs (Figure 4.2 and Figure 4.3) below compare the respondents' responses pertaining to the frequency with which the various tools are adopted for the sharing of crucial construction knowledge.

Table 4.18
Mean Differences of Crucial Construction Knowledge areas for both IT and Non IT-Based Tools

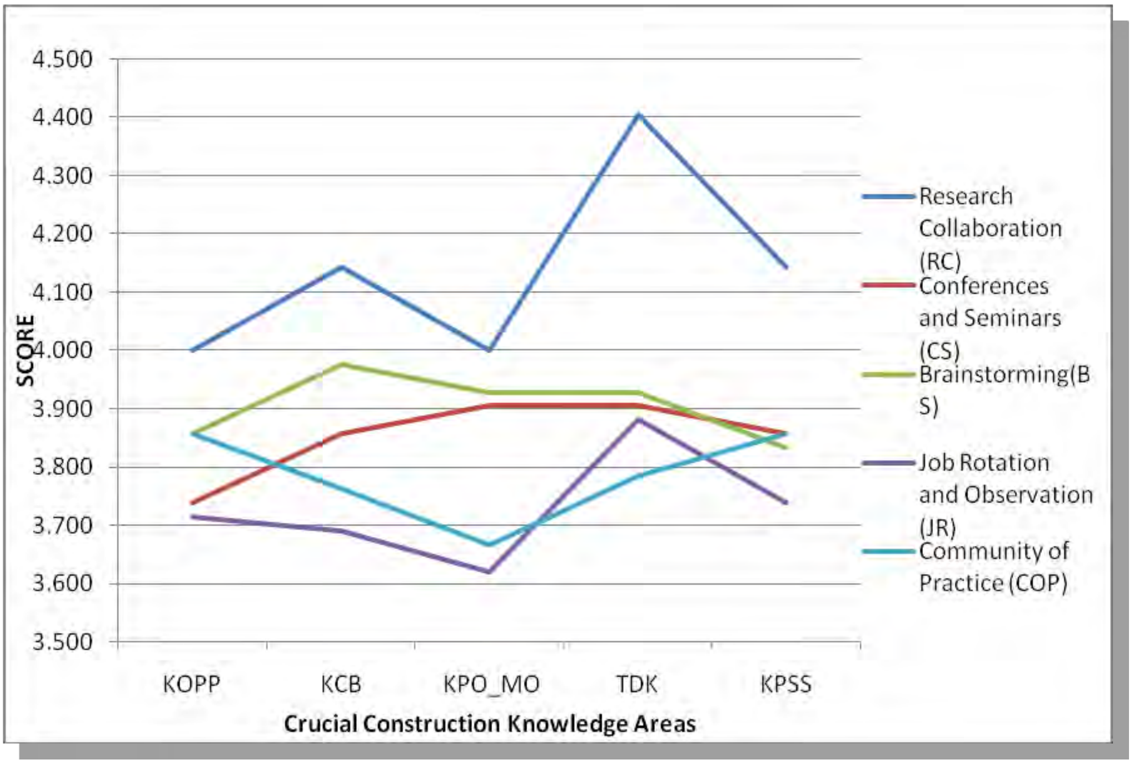
Knowledge Sharing Tools	Crucial Construction Knowledge Areas				
	KOPP	KCB	KPO_MO	TDK	KPSS
Non IT-Based**:**					
Research Collaboration (RC)	4.000	4.143	4.000	4.405	4.143
Conferences and Seminars (CS)	3.738	3.857	3.905	3.905	3.857
Brainstorming(BS)	3.857	3.976	3.929	3.929	3.833
Job Rotation and Observation (JR)	3.714	3.690	3.619	3.881	3.738
Community of Practice (COP)	3.857	3.762	3.667	3.786	3.857
IT-Based:					
_Intranet (ITNET)	3.881	3.667	3.738	3.881	3.738
Database Systems (DBS)	3.905	4.095	3.952	4.048	3.952
Document Management System (DMS)	4.024	3.929	3.929	3.952	3.857
Electronic Discussion Forums (EDF)	3.500	3.548	3.548	3.714	3.524

Notes: Figures refer to mean values of the respective Knowledge Sharing Tools with the respective crucial construction knowledge areas considered.

Crucial Construction Knowledge Areas

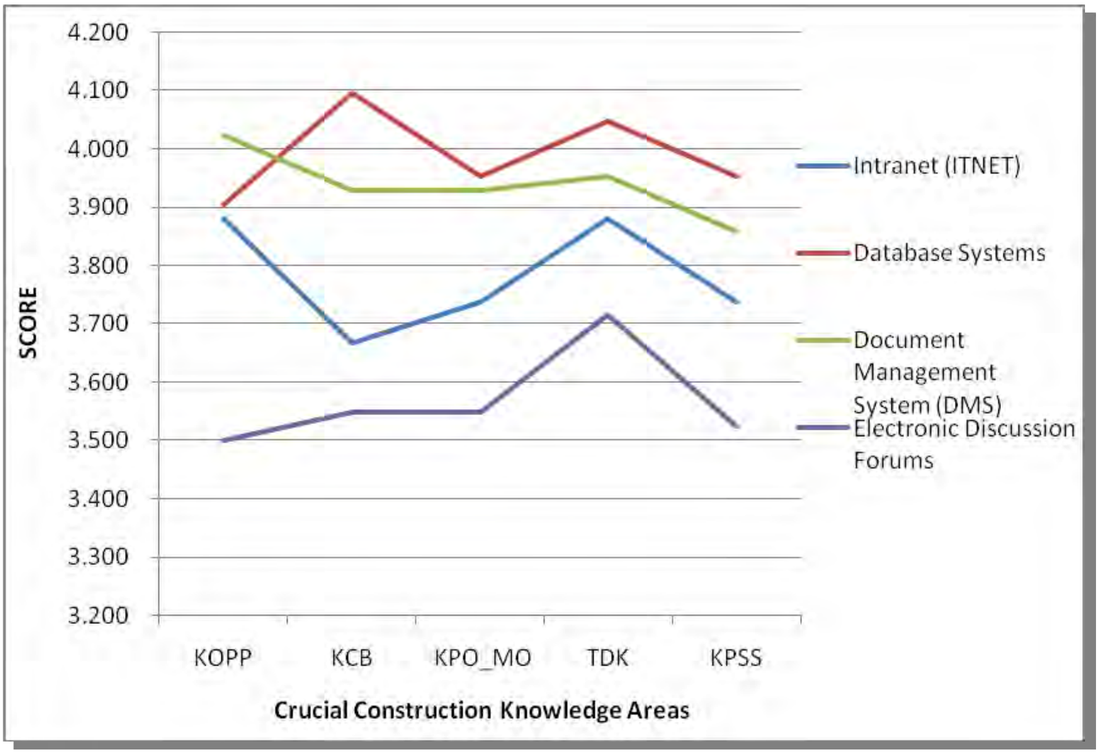
KOPP Knowledge of Organisational Processes and Procedures
KCB Knowledge of Client Business
KPO_MO Knowledge to Predict Outcomes and Motivate Others
TDK Technical or Domain Knowledge of design
KPSS Knowledge of People with Skills for Specific tasks

Figure 4.2
Mean Differences of Crucial Construction Knowledge Areas and Non IT-Based Tools



From the Figure 4.2 above, research collaboration is ranked highest, followed by brainstorming, and attendance at conferences and seminars. However, both job rotation and observation and community of practice ranked below the other tools used.

Figure 4.3
Mean Differences of Crucial Construction Knowledge Areas and IT-Based Tools



For the IT-based tools, database systems and document management systems fared much higher in terms of application than intranet and electronic discussion forums.

The details of responses to each of the questions pertaining to the relationship between 'improved designer construction knowledge' with respect to the crucial construction knowledge areas and the various knowledge sharing tools are shown in the respective tables in Appendix F5.

Table 4.19 below shows the frequency of use of the various knowledge sharing tools by the organizations.

Table 4.19
Knowledge Sharing Tools/Approaches and Frequency of Knowledge Sharing Among Organizations

Knowledge Sharing Tools	**Frequency of Knowledge Sharing**					**Total**
	Almost Never	Rarely	Sometimes	**Quite Often**	**Always**	
Research Collaboration	3 (7.1)	6 (14.3)	15 (35.7)	**14 (33.3)**	**4 (9.5)**	42 (100.)
Conference and Seminars	4 (9.5)	6 (14.3)	13 (31.0)	**16 (38.1)**	**3 (7.1)**	42 (100.)
Brainstorming	2 (4.8)	7 (16.7)	14 (33.3)	**15 (35.7)**	**4 (9.5)**	42 (100.)
Job Rotation and Observation	3 (7.1)	11 (26.2)	13 (31.0)	**14 (33.3)**	**1 (2.4)**	42 (100.)
Communities of Practices (COPs)	1 (2.4)	7 (16.7)	16 (38.1)	**16 (38.1)**	**2 (4.8)**	42 (100.)
Intranets	4 (9.5)	9 (21.4)	13 (31.0)	**15 (35.7)**	**1 (2.4)**	42 (100.)
Database Systems	4 (9.5)	7 (16.7)	11 (26.2)	**17 (40.5)**	**3 (7.1)**	42 (100.)
Document Management Systems	3 (7.1)	6 (14.3)	11 (26.2)	**17 (40.5)**	**5 (11.9)**	42 (100.)
Electronic Discussion Forums	7 (16.7)	12 (28.6)	12 (28.6)	**11 (26.2)**	**-**	42 (100.)

Note: The figures in brackets ( ) show the percentage of the row data to the total figure.

Table 4.20
Summary Statistics of Tools/Approaches of Knowledge Sharing Among Organizations

Knowledge Sharing Tools	SUMMARY STATISTICS									
	Mean	M.S. E.	S.D	Median	Mode	Variance	Skewness	Kurtosis	Range	Maximum
Research Collaboration	3.24	.163	1.055	3.00	3	1.113	-.374	-.206	4	5
Conference and Seminars	3.19	.168	1.087	3.00	4	1.182	-.518	.365	4	5
Brainstorming	3.29	.157	1.019	3.00	4	1.038	-.326	-.293	4	5
Job Rotation and Observation	2.98	.154	1.00	3.00		.999	-.258	-.748	4	5
Communities of Practice (COP)	3.26	.137	.885	3.00	3[a]	.783	-.332	-.150	4	5
Intranets	3.00	.160	1.036	3.00	4	1.073	-.415	-.683	4	5
Database Systems	3.19	.171	1.110	3.00	4	1.231	-.509	-.520	4	5
Document Management Systems	3.36	.170	1.100	4.00	4	1.211	-.540	-.296	4	5
Electronic Discussion Forums	2.64	.163	1.055	3.00	2[a]	1.113	-.135	1.170	3	4

Notes: a = Multiple modes exist. The smallest value is shown
M.S.E = Mean Std. Error
S.D = Std. Deviation
N = 42, no missing cases observed

Frequency Range: 1 = Almost Never, 2 = Rarely, 3 = Sometimes, 4 = Quite Often, and 5 = Always. .

The respondents were also asked to provide their comments to the open-ended question as to how they would propose to improve the designer construction knowledge in the industry in Malaysia. From the answers given, most project managers emphasized the need for practical or hands-on methods, or learning by doing since most projects have specific problems and solutions that are not generic in nature that can be tackled merely by using past experiences or text-book approaches to problem solving. These are tabulated in Appendix F8.

4.5 HYPOTHESIS TESTING

The research questions, the variables used and the hypotheses had been presented in Chapter 1. To test the hypotheses, the study used the correlation analysis procedure to test whether the data support the hypothesized relationships. Correlation analysis is used to describe the strength and the direction of the linear relationship between two variables, the dependent variable (DV) and the independent variables (IVs).

In this study, the procedure for obtaining and interpreting a Pearson product-moment correlation coefficient (r) is used as the study deals with interval level or continuous variables. The Pearson correlation coefficients (r) take the value of -1 to +1 denoting a negative or positive correlation of relationship between the IV and DV. If the value of r is positive, it mean that as one variable increases, the other will increase too and vice versa for the negative correlation. The size of the absolute value, gives an indication of the strength of the relationship. A perfect correlation of 1 or – 1 indicates that the value of one variable can be determined exactly by knowing the value on the other variable. A correlation 0 means that there is no relationship existing between the two variables. When interpreting the values of the coefficient r, a number of issues have to be borne in mind. These include the effect of non-linear relationship, outliers, restriction of range, correlation versus causality and statistical versus practical significance. The assumption of normality is crucial in the interpretation of the correlation results. The values of the two variables involved in the analysis must be approximately normally distributed. When variables are not normally distributed, the Spearman's rank-order correlation is a more appropriate measure to use.

Cohen (1988) suggest the following guidelines in the interpretation of the value of the Pearson correlation (r),

r = .10 to .29 small,

r = .30 to .49 medium, and

r = .50 to 1.0 large

By squaring the correlation (r) - we get the coefficient of determination, the $r^{2,}$ and then multiplying by 100 to determine the percentage of the variability shared between the two variables. Thus we can say variable X shares about Y per cent of its variability with variable Z. The level of significance (Sig. 2 tailed) is used in the analysis even though the hypotheses above are unidirectional. This is to check for the actual situation depicted by the data. It is worth noting that the significance r is strongly influenced by the sample size.

4.5.1 Hypothesis 1:

H_1	There is a positive relationship between the applications of research collaboration and improved designer construction knowledge

Table 9.1 of Appendix F9, shows the relationship between application of research collaboration (RC), (as measured by RC-KOPP, RC-KCB, RC-KPO_MO and RC-KPSS and RC-TDK) and ‘improved designer construction knowledge’ (as measured by I_Design Knowledge), as investigated by using Pearson product-moment correlation coefficient (r). Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasity. Only correlations significantly different from zero (0) at the 5% (*) or 1% (**) levels of significance are shown.

For the research collaboration approach, the overall results show that there are strong positive correlations with the ‘improved designer construction knowledge’ (I_Design Knowledge) for all of the five supporting variables (latent variables). For instance, there is a strong positive correlation between the (I_Design Knowledge) and RC-KCB [r = .568, n=42, p<.001 at 2-tailed). Thus, through research collaboration, there is an improvement in the designers’ knowledge of client’s business and how to interpret business requirements into technical specifications for the construction team. The above hypothesis is supported by result of the correlation analysis. In other words, we accept the null hypothesis that there is a positive relationship between the application of research collaboration (RC) and ‘improved designer construction knowledge’ in as far as knowledge of the client business is concerned. The correlation between research collaboration (RC) and 'improved designer construction knowledge' in respect of technical domain knowledge show a lower r of .372 with p-value of 0.015. All other constructs show a strong relationship between the variables in the research collaboration domain.

4.5.2 Hypothesis 2:

H_2	There is a positive relationship between the applications of conferences and seminars and improved designer construction knowledge.

The correlations between the application of conferences and seminars (CS) with respect to the five crucial construction knowledge areas and 'improved designer construction knowledge' (I_Design Knowledge) is shown in Table 9.2 of Appendix F9. It can be seen that the relationships between the constructs as measured by the CS-KOPP, CS-KCB, CS-KPO_MO and CS-KPSS and CS-TDK and 'improved designer construction knowledge' (as measured by I_Design Knowledge) shows strong positive correlations between them. From the results of the correlation analysis, the highest correlation or strongest relationship between CS and I_Design Knowledge is that with respect to CS-KPO_MO [r = .605, n=42, p<.001 at 2-tailed). There seems to be no change or difference in the value of r coefficients using the 1-tailed test. Thus, the role of seminars and conferences with respect to equipping oneself with the knowledge to predict outcomes, manage teams and focus on clients and how to motivate others ranked highest in terms of improving the designer construction knowledge. This is crucial as seminar and conferences provide the venue for the organizations to network and learn more about the industry. With the exception of CS-KCB and CS-TDK, the other variables have strong scores with respect to the 'improved designer' construction knowledge' domain. The results thus support the hypothesis that there is a positive relationship between the application of conferences and seminars (CS) and 'improved designer construction knowledge'.

4.5.3 Hypothesis 3:

H_3	There is a positive relationship between the application of brainstorming and improved designer construction knowledge.

From Appendix F9, Table 9.3, it can be seen that the application of brainstorming (BS) approach has mixed results when evaluated against 'improved designer construction knowledge'. Only two of the five constructs, BS KPO_MO and BS-TDK have strong and positive relationships with the 'application of brainstorming' domain. Brainstorming seems to have insignificant effect on improving the designers' construction knowledge in as far as knowledge of organizational processes and procedures (KOPP), knowledge of client's business (KCB) and know-who knowledge of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors (KPSS). These three hypothesized relationships are not supported by the results of the correlation analysis.

4.5.4 Hypothesis 4:

H_4	There is a positive relationship between the application of job rotation and observation and improved designer construction knowledge.

The correlation matrix between the application of job rotation and observation and improved designer construction knowledge is shown in Table 9.4 of Appendix F9. Overall, there are strong positive correlations between the I_Design Knowledge with respect to KOPP, KCB, KPO_MO, TDK and KPSS and the application of job rotation and observation (JR). For instance, there is a strong positive correlation between the 'improved designer construction knowledge '(I_Design Knowledge) and JR-KPO_MO [$r = .754$, $n=42$, $p<.001$ at 2-tailed). Job rotation and observation seems to be perceived as a vital element to learn and observe from other organizations in the hope of transferring or sharing the technical knowledge. The results of the analysis support the hypothesized relationship that there is a positive relationship between the use of job rotation and observation approach and 'improved designer construction knowledge'.

4.5.5 Hypothesis 5:

H_5	There is a positive relationship between the application of communities of practice and improved designer construction knowledge.

The correlation matrix between the application of communities of practice (COP) and 'improved designer construction knowledge' is shown in Table 9.5 of Appendix F9. From the result of the correlation analysis, there are strong positive correlations between the I_Design Knowledge with respect to the five crucial construction knowledge areas and the use of communities of practice (COP). The strongest correlation occurs between the 'improved designer construction knowledge' (I_Design Knowledge) and COP-KPO_MO [$r = .565$, $n=42$, $p<.001$ at 2-tailed). Communities of practice are perceived to be yet another venue for knowledge sharing among the practitioners in the construction industry in Malaysia. However, the practice is not very widespread and rather slow in picking up. The results of the analysis support the hypothesized relationship that there is a positive relationship between the adoption of the community of practice (COP) and the improvement of the designers' crucial construction knowledge.

4.5.6 Hypothesis 6:

H_6	There is a positive relationship between the applications of Intranets and improved designer construction knowledge.

The intranet and internet are widely used tools for knowledge management and knowledge sharing in business nowadays. The hypothesized relationship is to test whether there is any positive relationship between the applications of the intranets and 'improved designer construction knowledge'. The results of the correlation analysis depict the relationships in Table 9.6 in Appendix F9. The results show strong positive correlations between the I_Design Knowledge in all the five crucial knowledge areas and the use Intranets (ITNET). The strongest correlation is between the 'improved designer construction knowledge' (I_Design Knowledge) and ITNET-KCB [r = .659, n=42, p<.001 at 2-tailed). The adoption of internets and intranet has enabled firms or business organizations to use this tool widely for information sharing and keeping up to date with the development in the industry. The overall analyses support the hypothesized relationship that there is a positive relationship between the use of the use of intranet (ITNET) and the improvement of the designers' construction knowledge.

4.5.7 Hypothesis 7:

H_7	There is a positive relationship between the applications of database systems and improved designer construction knowledge.

The correlation matrix between the application of database systems (DBS) and 'improved designer construction knowledge' is shown in Table 9.7 of Appendix F9. From the result of the correlation analysis, there are strong positive correlations between the I_Design Knowledge and all of the five crucial construction knowledge areas in the database systems (DBS) domain. The strongest correlation is between the 'improved designer construction knowledge' (I_Design Knowledge) and DBS_KCB [r = .663, n=42, p<.001 at 2-tailed). For this case, it is perceived that the database system is viewed as an important source of knowledge as well as a knowledge management tool. Through the database systems, the business organizations are able to know how client's business operates and to relay this knowledge to their own organization to better equip themselves in dealing with their clients and for quality improvements. The results of the analysis support the hypothesized relationship that there is a positive relationship between the use of the database system (DBS) and the improvement of the designers' knowledge.

4.5.8 Hypothesis 8:

H_8	There is a positive relationship between the applications of document management systems and improved designer construction knowledge.

A document management system (DMS) is an important aspect of a quality organization. Easy access to information at all times is the hallmark of a dynamic and competitive organization. To test the hypothesized relationship as mentioned above, a correlation analysis is performed on the survey data. The result is shown in Table 9.8 of Appendix F9. From the result of the correlation analysis, it is shown that there are strong positive correlations between the I_Design Knowledge pertaining to all of the five crucial construction knowledge areas and the database management system (DMS) domain. The strongest relationship between DMS and the 'improved designer construction knowledge' (I_Design Knowledge) is DMS-KPSS [r = .501, n=42, p<.001 at 2-tailed). From the results of the analysis, there are strong correlations between the variables of interest and the designer construction knowledge domain. Thus, we can accept the null hypothesis, that there is a positive relationship between the applications of DMS and 'improved designer construction knowledge.'

4.5.9 Hypothesis 9:

H_9	There is a positive relationship between the applications of electronic discussion forum and improved designer construction knowledge.

The correlation matrix between the application of electronic discussion forums (EDF) and 'improved designer construction knowledge' is shown in Table 9.9 of Appendix F9. From the result of the correlation analysis, there are strong positive correlations between all of the five variables in the I_Design Knowledge variable and the electronic discussion forums (EDF) domain. The strongest correlation is between the 'improved designer construction knowledge' (I_Design Knowledge) and EDF-KPO_MO [$r = .632$, $n=42$, $p<.001$ at 2-tailed). It is perceived that the use of electronic discussion forum is an essential tool in the dissemination and sharing of knowledge among business organizations and professionals working within the organization. It is no small matter that EDF is perceived very strongly by the respondents with regards to the improvement in their knowledge in the designing aspect in the construction industry in Malaysia. The results of the analysis support the hypothesized relationship that there is a positive relationship between the applications of EDF and 'improved designer construction knowledge'.

The results of the above analyses of the relationships are summarized in the Table 4.21 below. The analysis provides a correlation based on 2-tailed test as there seems to be no difference in the result when 1-tailed test is applied. The listwise option is used in the SPSS procedure such that the system analyzes the data one by one rather than pairwise which would give would give a distorted view of the relationship as 'unpaired' data would be deleted from the analyses.

Table 4.21
Summary of the relationship between the hypothesized constructs and improved designer construction knowledge (I_Design Knowledge)

Construct	Hypothesis	r	p-value	Results
Research collaboration (RC)	H_{11} - KOPP	.561**	.001	Ho: Supported
	H_{12}- KCB	.568**	.001	Ho: Supported
	H_{13}- KP_MO	.552**	.001	Ho: Supported
	H_{14}-TDK	.373*	.015	Ho: Supported
	H_{15}-KPSS	.438**	.004	Ho: Supported
Conferences and Seminars (CS)	H_{21}- KOPP	.417**	.006	Ho: Supported
	H_{22}- KCB	.336*	.030	Ho: Supported
	H_{23}- KP_MO	.605**	.001	Ho: Supported
	H_{24}-TDK	.310*	.046	Ho: Supported
	H_{25}-KPSS	.436**	.004	Ho: Supported
Brainstorming (BS)	H_{31}- KOPP	.293	.059	Ho: not Supported
	H_{32}- KCB	.290	.062	Ho: not Supported
	H_{33}- KP_MO	.584**	.001	Ho: Supported
	H_{34} -TDK	.450**	.003	Ho: Supported
	H_{35}-KPSS	.241	.124	Ho: not Supported
Job Rotation and Observation (JR)	H_{41}- KOPP	.496**	.001	Ho: Supported
	H_{42}- KCB	.519**	.001	Ho: Supported
	H_{43}- KP_MO	.754**	.001	Ho: Supported
	H_{44} -TDK	.413**	.007	Ho: Supported
	H_{45}-KPSS	.530**	.001	Ho: Supported
Communities of Practice (COP)	H_{51}- KOPP	.474**	.002	Ho: Supported
	H_{52}- KCB	.556**	.001	Ho: Supported
	H_{53}- KP_MO	.565**	.001	Ho: Supported
	H_{54} -TDK	.510**	.001	Ho: Supported
	H_{55}-KPSS	.539**	.001	Ho: Supported
Intranet (ITNET)	H_{61}- KOPP	.509**	.001	Ho: Supported
	H_{62}- KCB	.659**	.001	Ho: Supported
	H_{63}- KP_MO	.609**	.001	Ho: Supported
	H_{64} -TDK	.412**	.007	Ho: Supported
	H_{65}-KPSS	.577**	.001	Ho: Supported
Database Systems (DBS)	H_{71}- KOPP	.613**	.001	Ho: Supported
	H_{72}- KCB	.663**	.001	Ho: Supported

	H_{73}- KP_MO	.453**	.003	Ho: Supported
	H_{74} -TDK	.570**	.001	Ho: Supported
	H_{75}-KPSS	.557**	.001	Ho: Supported
Document Management Systems (DMS)	H_{81}- KOPP	.419**	.006	Ho: Supported
	H_{82}- KCB	.498**	.001	Ho: Supported
	H_{83}- KP_MO	.399**	.009	Ho: Supported
	H_{84} -TDK	.397**	.009	Ho: Supported
	H_{85}-KPSS	.501**	.001	Ho: Supported
Electronic Discussion Forum (EDF)	H_{91}- KOPP	.625**	.001	Ho: Supported
	H_{92}- KCB	.464**	.002	Ho: Supported
	H_{93}- KP_MO	.632**	.001	Ho: Supported
	H_{94} -TDK	.551**	.001	Ho: Supported
	H_{95}-KPSS	.527**	.001	Ho: Supported

Notes: ** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Ho: the null hypothesis
n = 42

4.6 RESULTS OF MULTIPLE REGRESSION ANALYSIS

Multiple regression techniques can be used to investigate the effect of one or more predictor variables (predictors) (or independent variables, IVs) on an outcome of variable, the dependent variable (DV). Regression allows users to make statements concerning how well one or more independent variables will predict the value of a dependent variable. The multiple regression analysis is used to predict the variance in an interval dependent variable, based on linear combinations of interval, dichotomous or dummy independent variables. Using the multiple regression we can establish that a set of independent variables explains a proportion of the variance in a dependent variable at a set significant level usually at p=0.001 or p=0.005 percent and at the same time establish the relative importance of the independent variables by examining the beta value in the regression equation.

The regression equation is expressed in a generic form as follows;

$$Y = \beta o + \beta 1X1 + \beta 2X2 + \beta 3X3 \ldots\ldots \beta nXn$$

Where,

Y = dependent variable

X1, X2, …, Xn = independent variables

βo = intercept,

$\beta 1, \beta 2 \ldots\ldots \beta n$ = regression coefficients

The regression coefficients represent the amount the dependent variable Y changes when the independent changes by one unit. βo is the constant, where the regression line intercepts the Y axis. This represents the value of dependent variable Y when all the independent variables are zero (0).The standardized versions of the β coefficients are the beta weights. The ratio of the beta coefficients is the ratio of the predictive power of the independent variables. The R^2 is the percentage of variance in the dependent variable explained collectively by all of the independent variables. In a multiple regression involving many independent variables the adjusted R^2 is used to explain the strength of the regression equation relationship.

There are many assumptions to consider when conducting multiple regression analysis namely, linearity of relationships, multicollinearity and homoscedasticity. Linearity means that the variables possess a linear relationship between the dependent and other independent variables; homoscedasticity means that the same level of relationship is maintained throughout the range of the independent variable. Multicollinearity means that one independent variable is a linear function of other independent variables. Collinearity (or multicollinearity) represents an undesirable situation if it exists in the regression and the data then need to be reexamined to see which variables are involved so as to exclude from the regression.

A multiple regression analysis was conducted to see how well the proposed model predicted the improvement in the designers' construction knowledge with respect to the knowledge sharing tools and approaches adopted by the business organisations in the construction industry in Malaysia. Using the multiple regression models, we can study the effect of the independent variables on the dependent variable, which is the 'improved designers' construction knowledge' in the Malaysian construction industry. This should also allow the prediction of which variable(s) is / are significant with respect to quality improvements in the designing of projects and hence on quality improvement in project implementation over the long run.

The results below show the Model 1 of the study. This correlates with the first hypothesis (H_{11}).

Model 1: Application of Research Collaboration (RC) and 'Improved Designer Construction Knowledge' – in respect of KOPP, KCB, KPMO_MO, TDK and KPSS

Table 4.22
Regression Output of the Model 1 (RC)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.701(a)	.492	.421	.29744	.492	6.969	5	36	.000	2.573

a Predictors: (Constant), RC - KPSS, RC - TDK, RC - KPO_MO, RC - KCB, and RC - KOPP
b Dependent Variable: I_Design Knowledge (C1-D9)

The above table demonstrates that the linear combination of the proposed model was significantly related to the improvement of the designer construction knowledge (F=6.969, p-value=0.000 <.0.05). The sample correlation was 0.701, and the adjusted R^2 is .421 indicating that approximately 42.1 percent of the variance of the improvement of the designer construction knowledge in the sample can be accounted for by the linear combination of the proposed model. In this study as far as research and collaboration is concerned, there was a statistically significant linear relationship between the independent variable variables, RC - KPSS, RC - TDK, RC - KPO_MO, RC - KCB, and RC – KOPP. As a result, the proposed model was shown to be statistically significant to the improvement of the designer construction knowledge. Thus, we can summarize that the proposed model can predict the application of research and collaboration has significant effects on improvements in the designing knowledge needed in the construction industry. Similarly, that the Durbin Watson (D.W.) statistics of 2.573 is at an acceptable level shows that there is little multicollinearity in the model.

Tables in Appendices F9.1 to F9.11 show the summaries of all the models.

Table 4.23
Overall Model Summary of Regression Models

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.754(a)	.568	.557	.26018	.568	52.593	1	40	.000	
2	.862(b)	.743	.729	.20339	.175	26.455	1	39	.000	
3	.900(c)	.809	.794	.17733	.067	13.304	1	38	.001	
4	.924(d)	.854	.838	.15714	.045	11.392	1	37	.002	
5	.945(e)	.894	.879	.13609	.039	13.333	1	36	.001	
6	.957(f)	.915	.901	.12317	.022	8.948	1	35	.005	
7	.964(g)	.930	.916	.11362	.015	7.131	1	34	.012	
8	.969(h)	.940	.925	.10690	.010	5.410	1	33	.026	**2.119**

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB
g Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB
h Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB, BS - KPO_MO
i Dependent Variable: I_Design Knowledge (C1-D9)

Table 4.23 is the overall summary of the eight (8) models showing the regression relationships between the dependent variable of interest, that is the I-Design Knowledge and the respective predictors (the explanatory or independent variables) entered using a stepwise regression method. The final model (equation 8) shows the adjusted R^2 of 0.925 meaning that the model explains that approximately 92.5 per cent of the variance of the 'improvement in designer construction knowledge' in the sample can be attributed to the linear combination of the proposed model. The Durbin Watson statistics of the overall model is 2.119 depicting that some multicollinearity is expected perhaps, due to the fact that some explanatory variables may be related linearly with one another.

Table 4.24
ANOVA (b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.083	5	.617	6.969	.000(a)
	Residual	3.185	36	.088		
	Total	6.268	41			

a Predictors: (Constant), RC – KPSS, RC – TDK, RC – KPO_MO, RC – KCB, RC – KOPP
b Dependent Variable: I_Design Knowledge (C1-D9)

The ANOVA table (Table 4.24) above shows that F=6.969, p=0.001 which is significant at 95% level of confidence. This indicates that the combination of the independent variables is able to predict the dependent variable, the improvement in designer construction knowledge accurately. The ANOVA tables for the other models, including for the overall model, are shown in Appendices F9.1 to F9.11.

The ANOVA Table 4.25 shows the F values and the level of significance of each model. In all cases (model 1-8) the p-values are p<0.0001 which show the models are significant at 95% level of confidence. Thus, this indicates that the combinations of the independent variables are able to predict the dependent variable, that is, the 'improvement in designer construction knowledge' accurately. The summary of the model coefficients are shown in Table 4.26.

Table 4.25
ANOVA (i) of the Overall Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.560	1	3.560	52.593	.000(a)
	Residual	2.708	40	.068		
	Total	6.268	41			
2	Regression	4.655	2	2.327	56.258	.000(b)
	Residual	1.613	39	.041		
	Total	6.268	41			
3	Regression	5.073	3	1.691	53.772	.000(c)
	Residual	1.195	38	.031		
	Total	6.268	41			
4	Regression	5.354	4	1.339	54.206	.000(d)
	Residual	.914	37	.025		
	Total	6.268	41			
5	Regression	5.601	5	1.120	60.485	.000(e)
	Residual	.667	36	.019		
	Total	6.268	41			
6	Regression	5.737	6	.956	63.025	.000(f)
	Residual	.531	35	.015		
	Total	6.268	41			
7	Regression	5.829	7	.833	64.503	.000(g)
	Residual	.439	34	.013		
	Total	6.268	41			
8	Regression	5.891	8	.736	64.437	.000(h)
	Residual	.377	33	.011		
	Total	6.268	41			

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB
g Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB
h Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB, BS - KPO_MO
i Dependent Variable: I_Design Knowledge (C1-D9)

Table 4.26
Summary of Multiple Regression Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	2.275	.205		11.088	.000			
	JR - KPO_MO	.403	.056	.754	7.252	.000	.754	.754	.754
2	(Constant)	1.434	.229		6.264	.000			
	JR - KPO_MO	.357	.044	.668	8.051	.000	.754	.790	.654
	RC - KOPP	.252	.049	.427	5.143	.000	.561	.636	.418
3	(Constant)	1.219	.208		5.856	.000			
	JR - KPO_MO	.283	.044	.529	6.464	.000	.754	.724	.458
	RC - KOPP	.223	.043	.378	5.133	.000	.561	.640	.364
	ITNET - KCB	.164	.045	.302	3.647	.001	.659	.509	.258
4	(Constant)	1.119	.187		5.987	.000			
	JR - KPO_MO	.237	.041	.444	5.791	.000	.754	.690	.363
	RC - KOPP	.206	.039	.350	5.323	.000	.561	.659	.334
	ITNET - KCB	.140	.040	.258	3.465	.001	.659	.495	.217
	EDF - KOPP	.119	.035	.245	3.375	.002	.625	.485	.212
5	(Constant)	.948	.168		5.626	.000			
	JR - KPO_MO	.214	.036	.401	5.939	.000	.754	.704	.323
	RC - KOPP	.169	.035	.287	4.829	.000	.561	.627	.263
	ITNET - KCB	.108	.036	.200	3.003	.005	.659	.448	.163
	EDF - KOPP	.138	.031	.283	4.442	.000	.625	.595	.241
	COP - KPSS	.118	.032	.226	3.651	.001	.539	.520	.198
6	(Constant)	.549	.203		2.711	.010			
	JR - KPO_MO	.189	.034	.353	5.598	.000	.754	.687	.275
	RC - KOPP	.141	.033	.240	4.274	.000	.561	.586	.210
	ITNET - KCB	.127	.033	.235	3.832	.001	.659	.544	.189
	EDF - KOPP	.159	.029	.328	5.505	.000	.625	.681	.271
	COP - KPSS	.093	.030	.180	3.083	.004	.539	.462	.152
	CS - KCB	.142	.048	.172	2.991	.005	.336	.451	.147
7	(Constant)	.384	.197		1.949	.060			
	JR - KPO_MO	.162	.033	.303	4.964	.000	.754	.648	.225
	RC - KOPP	.121	.031	.205	3.854	.000	.561	.551	.175
	ITNET - KCB	.133	.031	.245	4.324	.000	.659	.596	.196
	EDF - KOPP	.142	.027	.293	5.177	.000	.625	.664	.235
	COP - KPSS	.076	.029	.146	2.641	.012	.539	.413	.120
	CS - KCB	.147	.044	.178	3.349	.002	.336	.498	.152
	DBS - KCB	.106	.040	.156	2.670	.012	.663	.416	.121
8	(Constant)	.323	.187		1.729	.093			
	JR - KPO_MO	.152	.031	.284	4.889	.000	.754	.648	.209
	RC - KOPP	.091	.032	.154	2.799	.008	.561	.438	.120

	ITNET - KCB	.105	.031	.194	3.360	.002	.659	.505	.143
	EDF - KOPP	.124	.027	.256	4.605	.000	.625	.625	.197
	COP - KPSS	.083	.027	.160	3.065	.004	.539	.471	.131
	CS - KCB	.116	.044	.140	2.664	.012	.336	.421	.114
	DBS - KCB	.139	.040	.204	3.483	.001	.663	.518	.149
	BS - KPO_MO	.087	.037	.142	2.326	.026	.584	.375	.099

a Dependent Variable: I_Design Knowledge (C1-D9)

4.7 CONCLUSION

The main purpose of this chapter is to report the empirical findings of the study using SPSS to discover the answers to the research questions and to test the hypothesised relationships between the use or application of the various knowledge sharing tools and the approaches designated with the aim of improving the designers' construction knowledge in the Malaysian construction industry.

From the mail survey, 42 questionnaires were successfully collected and analysed. After coding and data entry, the data is subjected to editing and data cleaning. The data are then analysed using SPSS version 14 and the descriptive statistics for all main variables are produced as shown in Appendix F1 to F3. In measurement evaluation, reliability analysis in terms of Cronbach's alpha and factor analysis have been used.

To test the hypotheses in the study, correlation analysis was conducted to evaluate whether there exists a relationship between the dependent variable (improved designer construction knowledge) and the independent variables of interest. The study has shown favourable results with only three (3) hypotheses not supported or accepted based on the strength of the correlation, r.

Multiple regression was conducted by using the enter method in SPSS module by each of the knowledge sharing tools/approaches with respect to the dependent variable. The results all show significant relationship except model 8. The overall model using a stepwise regression method shows an adjusted R^2 of 0.925, which means that 92.5 per cent of the variances in the ‘improvement in designer construction knowledge’ are explained by the model. This shows the predictive strength of the model as very strong. The level of significance of the model is shown in the Appendix F9.

CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

5.1 INTRODUCTION

This concluding chapter discusses the findings of the study. The implications of knowledge sharing (KS) to the construction industry and practice in Malaysia are discussed. The chapter concludes with a discussion of study limitations and future research directions with respect to the Malaysian construction industry as a whole and its diverse industry players, in particular. This is particularly crucial amidst the stiff competitions brought about by the global financial uncertainty which badly affects the construction sector and the property markets as a whole.

5.2 OVERVIEW OF RESEARCH FINDINGS

This section summarizes the findings of the study and seeks to highlight the peculiarities or otherwise of the general practice of the Malaysian construction industry with regards to knowledge sharing.

Davenport (2000) stated that knowledge management (KM) is a process of refining knowledge and adding value to information. Knowledge sharing is still an uncharted territory in the Malaysian construction industry. While the concept of knowledge sharing is not new in other countries, it is still not widely adopted in the Malaysian scene. Literature on the knowledge sharing practice in Malaysia is limited and those pertaining to the construction sector are even scarcer. Thus, meaningful comparisons or discussions will be limited to those done in other countries, especially in the more developed economies.

It is imperative to note that a knowledge sharing culture is an environment where individuals are willing to disseminate information regardless of the size of the organization or company. In order to do so, individuals must adhere to the norms, values, attitudes and beliefs established by the organization as well as within the industry and community at large. When these aspects of the knowledge sharing are breached, information will not reach the intended audience and will thus cause a knowledge-transfer bottleneck. All in all, failures of knowledge sharing will have adverse consequences for years to come, especially in terms of low or slower adoption of new technology and knowledge integration, slow knowledge capture, poor usability, difficulty in managing knowledge contents and project management failure.

According to the KPMG consultant survey compiled by Cheng (2002), the causes of failure in a KMS as detailed in the report can be summarized as follows;

1. Inadequate communication channel
2. Unsuccessful integration of KM into daily working practices
3. The system was too complicated
4. Lack of orderly coordinated training
5. A common sentiment that there is an inadequate personal reward for the user.

Similarly, a survey by Fontain and Lesser (2002) compiled by IBM Institute for Knowledge-based Organisations, noted that sticky situations lead to the failures in adopting KM strategies. These include:

1. Unsuccessful alignment of knowledge management efforts with the
2. organisation strategic objectives

3. Overemphasis on KMS tools for sharing knowledge
4. Failure to address the need to manage contents
5. Failure to connect knowledge management activities into individual daily work activities
6. The strategies only focus on knowledge within the organization

In several writings on KS and KM, it was noted that the failure of knowledge sharing stems from the need to adopt a more open KS culture, in that trust and confidence among partners or parties involved must be present. Generally, people are also reluctant to share information especially in a culturally diverse society such as Malaysia. The maxim 'knowledge is power' is still strong and may become a bulwark towards the realization of a more open culture. This openness is crucial as knowledge sharing requires constant feedback and interaction among players. The feedback process is a vital element or component of knowledge sharing if it is to be beneficial to the parties or stakeholders involved. This will generate further discussions and thus further enhance the matter at hand on the material issues of concern to the industry players. Thus, it is envisaged that strong leadership is needed, in terms of coordination, actual implementation and monitoring.

In order to have individuals contribute to a culture that promotes knowledge sharing, they must be given the right tools to deliver data within the company. By listening to the needs of the knowledge workers, managers should be able to evaluate what is needed to transform their organisation. Once the tools are obtained and utilized by the intended users, managers must constantly evaluate the performance of the applications and make the necessary modifications to ensure that the organisation is not encountering any difficulties in distributing information.

If the situation should arise that individuals in the organisation are hindering the flow of data in the company, managers should have the power to replace the individuals. With substantiated claims, personnel can be repositioned within the organisation to ensure that the skilled individuals who are motivated to share are in the right place. Changing the sharers will breathe new life into the knowledge management unit and hopefully bring new ideas to the table.

As will be discussed later, there is a need to create a culture that is pro knowledge sharing; that encourages organizations to undertake initiatives to introduce effective knowledge management by embedding knowledge sharing practices in their work processes; and to implement strategies that are more knowledge friendly. By sharing knowledge, not only will there be less need to 'reinvent the wheel' but the duplication of effort in knowledge capturing, which may be attributed to lack of knowledge sharing practices being in place, may be avoided.

Neo (2002), in a study of knowledge sharing practices in a Singapore news company discovered that cultural factors have significant impact on an individual's decision to share or hoard knowledge. Neo's study revealed that lack of motivation, management support, trust and team spirit were considered as major barriers to knowledge sharing. Similarly the 'knowledge is power' mentality was a hindrance to promote a knowledge sharing culture in the company. He also found that incentives and reward mechanisms were considered favourable components of organizational culture for creating knowledge friendly environment. Ang (2002) also noted that the possession of specialized knowledge and technical skills were perceived as a source of power in the organization.

5.2.1 Research Questions

This study posits two important propositions for knowledge sharing in the Malaysian construction industry. Firstly, our concern is to test empirically whether there is any relationship between the applications of the various knowledge sharing tools and the improvement of designer construction knowledge. Secondly, the study also suggests identifying the most commonly used or applied knowledge sharing tools, in terms of frequency of usage or applications among the industry players. These research questions are posed in Chapter 1 of this study.

5.2.1.1 Research Question 1

Is there a positive relationship between the application of the various knowledge sharing tools and the improvement of designer construction knowledge?

There are nine (9) hypotheses to be tested empirically in order to validate the relationship for each of the knowledge sharing tools identified by the study. For research question 1, the findings from the correlation analysis are discussed with respect to the hypotheses developed.

Hypothesis 1

H1 There is a positive relationship between the application of research collaboration and 'improved designer construction knowledge'.

As summarised in Table 4.21, the five (5) relationships with respect to research collaboration all supported the hypothesis (H1) above. Research collaboration is a series of activities involving various parties in the construction project. This involved combined efforts undertaken by the affected parties or stakeholders to come together to undertake research, study or joint programmes such a project reviews in order to solve or troubleshoot problems arising on site or where business organisations have common or related problems, issues or concerns. From the study, the overall results of the analysis for H1 shows that for the research collaboration approach, there are strong positive correlations with the 'improved designer construction knowledge' in all the five (5) crucial construction knowledge areas. The r value ranges from a high of 0.568 for KCB to a medium value of 0.373 based on Cohen (1988) suggested guidelines for the interpretation of the value of Pearson Correlation (r).

Research collaboration is construed as a loose form of consultative knowledge sharing which is fairly common in the construction industry in Malaysia. It is a common practice among industry players for close consultation and collaboration in terms of problem solving whether it is done formally or otherwise. From the study results, research collaboration is tops amongst all the non-IT approaches in knowledge sharing within the industry. This form of social networking needs to be further formalized and entrenched in the industry as this will ultimately lead to 'creative sharing' for the common good of the industry over the long term. Thus, it can be concluded that respondents perceive that through research collaboration, there is an improvement in the designers' construction knowledge in all five (5) critical areas of knowledge sharing domain or areas identified in the study.

Notwithstanding the above, while the correlation between research collaboration and 'improved designer construction knowledge' with respect to technical domain knowledge is positive, it did show a lower r of .372 with p-value of 0.015 to indicate a weaker relationship. The closeness of relationship and the level of trust will determine the strength of the collaborative relationship, hence collaboration and KS in general. The relationship or ties are vital channels that determine what type of knowledge is shared and at what level or depth. Building strong collaborative ties is crucial to the success of KS. Similarly, the existence of authority structures is crucial for this to take place and that the role of organisational leader within the project team and stakeholders is critical for these collaborative efforts to materialize. The organisational environment must also be conducive to knowledge sharing to take place.

It is worth noting that the Malaysian Government through the Construction Industry Master Plan (CIDB, 2007) put forth as one of the strategic thrusts for the industry, the following:

1. innovate through R&D and adopt new construction methods. For this strategic thrust, the recommendations are to:
2. continuously innovate construction processes and techniques,
3. stimulate R&D activities through resource pooling amongst key players and provision of R&D infrastructure.

Hypothesis 2

H2 There is a positive relationship between the applications of conference and seminars and 'improved designer construction knowledge'.

The results of the analysis support the hypothesis that there is a positive relationship between the application of conferences and seminars and 'improved designer construction knowledge' in all five (5) knowledge areas. Nevertheless, it is highlighted that the scores indicate 'medium strength' relationships between conferences and seminars and 'improved designer construction knowledge' for the following knowledge areas:

1. Knowledge of a client's business and how to interpret business Requirement into technical specifications for construction team (KCB)

2. Technical/domain knowledge of design, materials, specification and technologies (TDK)

However, based on the correlations result, conferences and seminar are only useful for staff motivation (KP_MO) as conferences and seminars are viewed as an instrument or tool for knowledge enhancements and updating. Hence, the r value is much higher at 0.605 with a p-value of 0.001. It also scored very low in TDK at 0.301 indicating perhaps, that a good number of the conferences and seminars were really generic in nature and did not address the specific needs of the individuals or the construction industry at large, Thus, it is pertinent that the HR personnel clearly determine what type of conferences and seminars are needed by their staff so as to utilize the staff time and company's money properly if they want to ensure proper staff training and development over the long term.

Hypothesis 3

H3 There is a positive relationship between the application of brainstorming and 'improved designer construction knowledge.'

The correlation analysis results show only two of the five constructs, BS-PO_MO and BS-TDK having strong and positive relationships with the 'improved designer construction knowledge' domain. The perception amongst the respondents seems to indicate that brainstorming does not have a significant effect on improving the designers' construction knowledge in so far as knowledge of organizational processes and procedures (KOPP), knowledge of client's business (KCB), know-who knowledge of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors (KPSS). These three hypothesized relationships are not supported by the results of the correlation analysis. The use of brainstorming as a tool for knowledge sharing seems to show poor results among the nine (9) constructs tested. The lower level of engagement or participation in brainstorming may be due to the fact that more than half (see Table 4.7) of the respondents did not seem to possess academic credentials to undertake such an "intelligent" and sustained discussions on technical matters such as in the construction industry. The other reason could be cultural in nature such as avoidance of face to face or direct communication as this may cause uneasiness or discomfort when dealing with higher authorities in the organization.

Hypothesis 4

H_4 There is a positive relationship between the application of job rotation and observation and 'improved designer construction knowledge.'

Job rotation is an important element of training for the development of the competency of the staff. Through job rotation, the individual will be able to "try on" new jobs, learns new skills and develop competencies in the workplace. Similarly observation is not only observing how works are done but also to be instructed on problem solving through the 'learning by doing' process. From the results of the correlation analysis, this hypothesis is strongly supported by two of the five constructs, with JR-KP_MO and JR-KPSS having strong and positive relationships with the 'improved designer construction knowledge' domain. The perception amongst the respondents seems to indicate that job rotation and observation do have a significant effect on improving the designers' construction knowledge in as far as the five knowledge sharing domains is concerned.

Hypothesis 5

H5 There is a positive relationship between the application of communities of practice and 'improved design construction knowledge'

The "communities of practice" (CoP) was designed to explicitly recognize the importance of the less-formal knowledge sharing that occurs among peers, and within small groups (Wenger, 1998). CoP is an important tool for knowledge sharing for organizational benchmarking practices as we compare an organization with that of its peers in order to raise the bar of organizational performance. It has grown to be a crucial tool for knowledge sharing. The importance of CoP is hypothesized in the fifth hypothesis as above. The study results show strong positive correlations between the I_Design Knowledge with respect to all of the five (5) crucial construction knowledge areas and the use of 'communities of practice' (CoP), the strongest correlation being between the 'improved designer construction knowledge' (I_Design Knowledge) and COP-KPO_MO [$r = .565$, $n=42$, $p<.001$ at 2-tailed). 'Communities of practice' is perceived to be another venue for knowledge sharing among the practitioners in the construction industry in Malaysia. To what extent CoP is being utilized is not explicitly known but the general consensus indicated that this is a vital tool for the improvement of the skills of the designers in the construction industry in Malaysia in particular.

The diffusion of knowledge is considered to be one of the main challenges in the emerging knowledge society and hence knowledge economy. The emergence of internet-based information and communication technologies (ICT) provide a better leverage for knowledge diffusion and dissemination. They can easily connect distributed and loosely coupled 'pockets of innovation' and diffuse relevant information at high speed and at relatively low cost (Tuomi, 2000). The diffusion of knowledge in the construction industry in particular is a collective action that requires social organisation as it is an interactive process involving diverse parties in the industry. Generally, 'Communities of practice' or CoP stresses the importance of shared practice, repertoire, interests, knowledge, informality, and self-organising character of the community. The desire to advance the community may spur others to be involved in KS over the long haul. CoP is an important tool in the development of designer construction knowledge. For CoP to succeed there must be a felt need or a sense of urgency together with the emergence of social trust and bonding among the industry players.

Hypothesis 6

H_6 There is a positive relationship between the applications of Intranets and 'improved designer construction knowledge.'

In a project environment such as in the construction industry, it is essential that all team members collaborate, communicate effectively and openly contribute their knowledge to increase the chances of project success and increase the organizational value or reputation. The use of ICT in terms of database management, speedy retrieval and storage of data, faster transmission of critical data to those who need it in their workplace is critical. An increased usage of intranets for problem solving and to introduce new methods of performing work functions is envisaged to help reduce costs of construction projects.

From the study, the results show strong positive correlations between the I_Design Knowledge in all the five (5) crucial knowledge areas and the use of Intranets (ITNET). An intranet is widely regarded as an important tool for application in the building industry from database management and documentation system to office administration. Generally, intranet scored very high in terms of correlation coefficient, p. The strongest correlation is between the 'improved designer construction knowledge' (I_Design Knowledge) and ITNET-KCB [r = .659, n=42, p<.001 at 2- tailed). As the industry developed with more techno savvy managers and in line with the practices globally, it is envisaged that more Malaysian construction companies or other industry players will appreciate the intranet as an important tool not only for improving the designers' construction knowledge but also for sharing knowledge within the industry as a whole.

Hypothesis 7

H_7 There is a positive relationship between the applications of database systems and 'improved designer construction knowledge.'

The use of database systems enables the organization to have a proper record of their works or past projects which will provide a pool of experiences which can be accessed when required. Most managers in the construction industry appreciate the need to have good database systems which they can build up over the years to assist them in their business ventures. From the results of the correlation analysis, it is noted that there are strong positive correlations between the I_Design Knowledge with all five (5) crucial construction knowledge domain or areas in the database systems (DBS). The strongest correlation is between the 'improved designer construction knowledge' (I_Design Knowledge) and DBS_KCB [r = .663, n=42, p<.001 at 2-tailed). All the five (5) domains hypothesized show strong relationship with DBS KP_MO showing a medium strength correlation of r 0.453. The empirical test of the hypothesized relationship between the application of the database systems and improvement in designer construction knowledge is supported in this study.

Hypothesis 8

H_8 There is a positive relationship between the applications of document management systems and 'improved designer construction knowledge.'

Document management system and database system are two (2) very common IT related tools used in the operations of any business entity. One can regard them as two sides of the same coin and should form an integral part of the business operations plan. The results of the analysis support the hypothesis though the result is mixed ranging from a r value of a medium strength of 0.397 to a high of 0.501. With many of the organizations surveyed being small and medium sized companies (Table 4.9), one can surmise that the smaller organization may not fully adopt proper documentation systems, hence the result is as shown. Overall, there is a positive relationship between the application of document management system and 'improved designer construction knowledge' in all five (5) domains.

The strongest relationship between DMS and the 'improved designer construction knowledge' (I_Design Knowledge) is DMS-KPSS [$r = .501$, $n=42$, $p<.001$ at 2-tailed).

Hypothesis 9

H_9 There is a positive relationship between the applications of electronic discussion forum and 'improved designer construction knowledge.'

Electronic discussion forum is becoming an important tool of communication within the business organization and with other organizations in the industry. It comes in the form of discussion boards, blogs or newsletters internally generated within the organization or from other external sources. These sources increasingly form a vital source of information for business organizations. The study results show that there are strong positive correlations between all of the five variables in the electronic discussion forums (EDF) domain and the I_Design Knowledge variable. The strongest correlation between the 'improved designer construction knowledge' (I_Design Knowledge) and EDF-KPO_MO [r = .632, n=42, p<.001 at 2-tailed). It can be seen that EDF show high r values for all the five (5) domains tested.

Based on all the foregoing analyses, it appears that the respondents believe that applying the knowledge sharing tools will improve the construction knowledge of designers. However, the exception seems to be that they also specifically believe brainstorming would not significantly contribute to the improvement of the designers' construction knowledge in the following areas:

1. Knowledge of organizational processes and procedures, including statutory regulations and standards, management of interfaees between different stages of projects, in-house procedures and best practice guides (KOPP)
2. Knowledge of a client's business and how to inteprete business requirements into technical specifications for the construction team (KCB)
3. 'Know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors (KPSS)

5.2.1.2 Research Question 2

How often does sharing of crucial construction knowledge occur between designers and constructors through the different approaches?

Discussions and conclusions on Research Question 2 are derived from the findings of the analysis reported in Chapter 4 as Tables 4.18 and 4.19 as well as Figures 4.2 and 4.3. For the non-IT tools, ranking for frequency of use by the Malaysian construction industry players for locating and sharing knowledge is tabulated below (Table 5.1). For comparison, a similar ranking, based on the results of a study by Carrillo et al. (2004) is included in the same table.

Table 5.1
Comparative Rankings of Non-IT Tools of Knowledge Sharing

Ranking of Variables	This Research	Carrillo et. al (2004)
1	Research Collaboration	Conferences and Seminars
2	Brainstorming	Communities of Practice
3	Conferences and Seminars	Brainstorming
4	Communities of Practice	Research Collaboration
5	Job Rotation and Observation	Job Rotation and Observation

For the IT tools, the rankings comparison is as follows:

Table 5.2
Comparative Rankings of IT Tools of Knowledge Sharing

Ranking of Variables	This Research	Carrillo et. al (2004)
1	Database Systems	Intranet
2	Document Management Systems	Database Systems
3	Intranets	Document Management Systems
4	Electronic Discussion Forum	Electronic Discussion Forum

It must be noted that while this research covered Malaysian firms in the small firm category, Carrillo et al. (2004) included larger firms. Nevertheless, the following points pertaining to small firms are highlighted by them:

1. Small firms do not report using job rotation and observation
2. Few firms belong to research networks because of the perceived cost and relevance of such activities
3. Few small firms use communities of practice because they do not have a critical mass of people with a common interest

Taking these into consideration, small firms in both Malaysia and the UK seem to have a similar pattern for the choice of knowledge sharing tools, with a notable exception of the use of research collaboration.

5.3 CONCLUSIONS ON RESEARCH PROBLEM

The first part of the study was to test the relationships between the use of the knowledge-sharing tools identified by Carrillo et al. (2004) and the improvement of designer construction knowledge in terms of each of the 5 crucial knowledge areas suggested by Kamara et al. (2002). The results of the analysis confirmed positive relationships between the application of all the knowledge-sharing approaches (except brainstorming) and the designer construction knowledge as reported in Section 4.5.

That the positive relationships between the dependent and independent variables for the non-IT knowledge sharing tools) studied were confirmed supports the findings of studies carried out by researchers such as Bresnen et al. (2003) and Styhre, Josephson and Knauseder (2004). The findings, reported in Section 2.4.3, suggest that in the construction industry, knowledge sharing and learning depend heavily on the informal social processes and practices that lean towards a community approach.

However, the same cannot be said of the relationship between the use of the IT based knowledge sharing tools and the improvement of designer construction knowledge. Whilst respondents in this study perceive that there is a positive relationship between applying the IT based knowledge sharing tools and the improvement of designer construction knowledge, studies by various other researchers indicate otherwise. This may be best summed up by Newell (2004) who concluded that the ICT-based approach to sharing of project knowledge has not been very effective.

We note here that while the respondents perceive the knowledge sharing tools as positively contributing to the improved designer construction knowledge, more than 50% reported that they almost never, rarely or sometimes apply or use each of these tools in their practices.

This would indeed appear contradictory. Nevertheless, these perceptions have been influenced by the various initiatives by the government in encouraging industry players to adopt tools and methods to share and disseminate relevant knowledge as part of the bigger agenda towards the creation of a knowledge based economy. The initiatives, in turn, have been arrived at with input from the same industry players. Having said that, the majority of these players are small companies with limited capacity and resources which prohibit them from being able to fulfil what they desire.

At this juncture, it should be highlighted that one important strategic thrust put forth by the Malaysian government under its Construction Industry Master Plan (CIDB, 2007) is to leverage on ICT in the construction industry, with specific recommendation under this strategic thrust to;

1. Encourage knowledge sharing for continuous improvement

2. Develop local construction software industry.

Since the Master Plan has been developed with input from the construction industry players, the positive perception with regards to the use of ICT based tools must have long been in their minds.

In as far as the results for Research Question 2, the rankings for the choice of knowledge sharing tools indicate a similar pattern as those arrived at in a UK study by Carillo et. al (2004), except for research collaboration.

That research collaboration ranks higher in the Malaysian context may be explained in terms of another strategic thrust of the Construction Industry Master Plan which calls for innovation through R&D and adoption of new construction methods. For this strategic thrust, it is recommended to a continuously innovate construction processes and technologies, to stimulate R&D activities through resource pooling initiatives amongst key players as well as to provide R&D infrastructure.

Based on the answers to the open ended questions, respondents generally favour the practical or hands-on approaches whereby construction knowledge may be gained through human processes and interactions. These include accepting critical feedback from project stakeholders, having field exposure as well as carrying out constructability reviews whereby site personnel provide input into design processes. Respondents also suggested education and training delivered by practitioners. This was seen to be more practical and useful, as opposed to being an academic exercise. Provisions for continuous professional development and training, which are paid for by the employers, are also suggested.

Suffice to say that whilst respondents agree that embracing the various knowledge sharing approaches studied would improve the designer construction knowledge, this has not been matched in reality. Hopefully, with the government's encouragement through incentives and grants and guidance via the strategic thrusts of its master plans, this mismatch between perceptions and reality may soon be corrected.

5.4 RESEARCH IMPLICATIONS FOR THEORY

The paucity of research and data on knowledge sharing generally in the Malaysian scenario means that the ideas and findings from this study provide an early indicator of the typical attribute or attitude of the Malaysian firms with respect to knowledge sharing. Comparative data and or analyses are not widely available such as to provide in depth appraisal in knowledge management and knowledge sharing in Malaysia. It is therefore expected that, with the data and results presented through this study, further study or research into this important issue of knowledge sharing will be diligently taken up in the hope that this will help improve the level of competitiveness among industry players and enable them to compete against international companies in the international arena.

This thesis adds to the growing literature on knowledge and knowledge sharing. This study helps set the cultural (Malaysian) and environmental context of knowledge sharing and the tools widely adopted by Malaysian companies / organisations in the sharing of knowledge across the construction industry. The study adds to findings of several other studies on knowledge sharing and will definitely enhance our understanding of the cultural and social behaviours of Malaysian entrepreneurs in the construction industry with respect to knowledge management and sharing an the widely used tools for the purpose of continuous learning.

5.5 RESEARCH IMPLICATIONS FOR POLICY AND PRACTICE

5.5.1 Private Sector Managers

A construction project normally involves multiple organisations. This means that the transfer of knowledge from one stage to the next is dependent on the kind of procurement strategy or contract type adopted for the project (McCarthy, et al., 2000 cited in Kamara et al., 2002). The success of a project generally depends on the effective sharing of key information and knowledge about the project's goals. This sharing is through collaboration between designers and constructors at the various designer / constructor interfaces throughout the project. Types of construction contracts where collaboration is an integral part of the process include partnering arrangements, alliances, design and build and managed projects (McCarthy, et al., 2000).

Since there is a general consensus amongst industry players that applying the identified knowledge sharing tools will lead to an improvement in the designer construction knowledge, it is imperative that they show willingness to invest in these various tools, regardless of whether they are designers or constructors.

For private sector projects where decisions are in the hands of private sector managers, it would be expected that their choice would be for more collaborative types of contract strategies as highlighted above.

5.5.2 Public Sector Policymakers

Construction industry stakeholders among the public sector policymakers in Malaysia are all for construction knowledge sharing through research and development as well as through leveraging on ICT. This is evident from the strategic thrusts no. 5 and 6 of the Construction Industry Master Plan and the specific recommendations pertaining to these strategic thrusts. This being so, construction project implementers in the public sector should be opting for contract strategies which are collaborative in nature so that the sharing of knowledge between the designers and constructors may be maximized through research collaboration and applying suitable ICT tools.

5.6 LIMITATIONS OF THE RESEARCH

This study is an exploratory study of the Malaysian construction industry in respect of knowledge sharing and the various approached adopted by the industry players to enhance their knowledge of the industry as a whole.

This study, like any other research work, is not without limitations especially in the evaluation of its results. First and foremost, the paucity of literature on the subject matter under investigation, especially in the Malaysian context, limits the scope and depth of the inquiry. There are very few studies or work done especially in the construction industry in knowledge sharing. Thus, comparisons can only be made with the developed or western countries where the culture and practices may be incongruous to the Malaysian or Asian context of doing business.

The study did not discriminate between male or female decision makers (the gender issue) but instead is organizational based. The gender question is excluded from the study and hence, we are not able to study the differences, if any, adopted by male or female superior or decision maker in respect of knowledge sharing openness and its methods.

The third issue is that the study sample size of forty-two (42) is small indeed, even though it captured all the different categories of the industry players and size of firms or organization. Due to the small number of respondents, it may not be appropriate to generalize the findings to cover the industry as a whole. Thus, it is suggested that future studies should take this into account. Moreover, face to face interviews were not conducted to provide an alternative feedback to the researcher on the practices adopted by the industry players in terms of knowledge sharing. Although various measures have been undertaken to increase the response rate, the number of willing respondents did not increase as might be expected.

The fourth issue relates to the willingness of the respondents to disclose confidential data which may limit the depth of the analyses. Both the third and fourth issues may also contain elements related to the "knowledge is power" matter.

The fifth problem relates to the difficulty to obtain objective measures of knowledge sharing behaviours. The survey instrument relied on self-reported measures where the findings are dependent entirely upon the knowledge worker's (in this instance the managers) responses regarding their knowledge sharing behaviours rather than actual observed situations. This may subject the findings to elements of bias and inaccuracy.

The research design uses cross-sectional data, rather than longitudinal data. As such the element of causality cannot be correctly inferred by a one off survey design method and a single set of respondents.

5.7 IMPLICATIONS FOR FURTHER RESEARCH

Knowledge sharing is increasingly an important tool in the dissemination and enhancement of knowledge in the K-economy. The success of the knowledge sharing practices among users and practitioners is usually centred on several stipulations, firstly the degree of trust and confidence in the information that one share with others and secondly, the ability to effectively communicate the knowledge to users or stakeholders. The unwillingness to

share knowledge is what is generally regarded as 'knowledge hoarding'. Several reasons were given by experts in the field of knowledge management (KM) with regard to knowledge hoarding. Primary among them is the need to maintain secrecy especially trade secrets, privacy compliance with government policies and procedures, ignorance, lack of self-confidence about one's contribution, the need to hoard information as 'knowledge is power' and perhaps an assumption that others already have this knowledge.
Thus, it is worthwhile considering the various barriers that may impinge of the knowledge sharing efforts or knowledge strategy. According to Szulanski (1996), the barriers are divided into three categories; the individual, organisational and technological. As far as individual is concerned, Szulanski (1996) posits several barriers and among those mentioned are, apprehension or fear that sharing may reduce or jeopardise people's job security, lack of social network, differences in educational and experiences levels, lack of trust in people because they misuse knowledge or take unjust credit for it, and use of strong hierarchy, position-based status and formal power where subordinates need to 'pull rank'.

On the organisational or firm level, the barriers to knowledge sharing that have been identified are, among others; that integration of KM strategy and sharing initiatives into the company's goals and strategic approach is missing or unclear; lack of leadership and managerial direction in terms of clearly communicating the benefits and values of knowledge sharing practices; lack of transparent reward and recognition systems that would motivate people to share their knowledge; prohibitive corporate culture that disallows knowledge sharing especially outside the organisation, size of business unit may be too big and unmanageable to enhance contact and facilitate ease of knowledge sharing. Physical work environment and the layout of work areas may restrict effect sharing practices.

On the technological front, several barriers have been cited and among the most common ones are; the lack of integration of IT systems and processes impedes on the way people do things; lack of technical support, lack of compatibility between the various IT systems and processes; reluctance to use IT systems due to lack of familiarity and experience with their use and lack of training regarding employee familiarisation and experience with new IT system and processes.

The findings of this research have shed light on what the Malaysian construction industry community believes would be a positive impact resulting from the application of the various knowledge tools; at the same time they also reveal the rather contradictory low level of commitment and willingness of the same players in investing in these tools. This divergence between perception and reality should be investigated further, as an extension to this research, to pinpoint the reasons for its occurrence. Other research extension areas may include examining the reasons behind the apparent lack of interest in the use of intranets, discussion forums and the issue of social trust in the construction industry in Malaysia. The results of these extensions to this research may well help shape new policies and guidelines or refine existing ones with respect to the government's desire to create a construction industry community that is knowledge based.

Research in this field may also be developed further to compare different industry sectors, for example, between the building and the oil and gas sectors.

This research has also not taken into consideration the potential gender and racial make- up differences so that extension of the research along these lines may yet yield results that would contribute further towards the government's aims of enhancing the construction industry sector in this country.

5.8 CONCLUSION

Knowledge sharing has been accepted as the key enabler of knowledge management (KM). Thus to support the knowledge explosion and to be able to use this to the benefit of the organisation, various tools have been adopted in order to support and leverage knowledge sharing. This study attempts to explore the knowledge sharing approaches adopted by the construction industry in Malaysia. Whilst the study has come up with several findings on the most common tools used, in general it can be said that their level of use is still very low, especially the IT-based tools. The reason for this apparently low usage may be attributed to lack of trust, knowledge and also the closed 'Asian-type' culture which prevent or limit the outflow or dissemination of knowledge to others, as everybody else is a competitor and hence, all company knowledge is "secrets" which are closely guarded to the hearts. The need for more knowledge sharing among and across industries and community-wide will mean that the future industry will be more robust, and innovative rather than every boy reinventing the wheel when similar problems arise in the future. Thus said, more needs to be done to 'open-up' the construction industry so that it is able to compete for more innovative ideas, more openness and greater knowledge sharing than the current situation permits, as shown in this exploratory study.

This exploratory study is an attempt to fill the void in the knowledge sharing literature in the Malaysian context and in the construction industry specifically. Based on the study findings, the study discussed theoretical and practical implications for sharing knowledge in the work context.

REFERENCES

Akinci, B., Kiziltas, S., Ergen, E., Karaesmen, I. Z. and Keceli, F. (2006). "Modelling and Analyzing the Impact of Technology on Data Capture and Transfer Processes at Construction Sites: A Case Study," *Journal of Construction Engineering and Management,* Vol. 132, Issue 11, pp. 1148 – 1157.

Alarcon, L. F. and Mardones, D. (1998)."Improving the Design – Construction Interface." Proceedings of the sixth nnual Conference of the International Group for Lean Construction (IGLC – 6) Guaraja, Brazil.

Alavi, M. and Leidner, D. E. (2001). "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quarterly,* Vol.25, Iss.1 pages107-136.

Al-Ghassani, A.M, Kamara, J.M., Amumba ,C.J. and Carrillo, P.M. (2004). "An Innovative Approach To Identifying Knowledge Management Problems." Engineering Construction and Architectural Management. *ABI/INFORM Global.* pg 349.

Ang, H.(2002). " 'Knowledge is Power' as a Barrier to Knowledge Sharing." Master's Thesis, Nanyang Technological University, Singapore.

Argote, L., Beckman, S. and Epple, D. (1990). "The Persistence and Transfer of Learning in Industrial Settings." *Management Science.* Vol. 36, pages 1750-1763.

Argyris, C. (1999). "On Organizational Learning." Blackwell Publishers, Cambridge, Oxford.

Bartlett, M. S. (1954). "A Note on Multiplying Factors for Various Chi-Squared Approximations," *JRSSB* 16: 296-298.

Bourke, L. B. and Fielder, E. P. (1993). "How to Conduct Self-Administered and Mail Surveys." Thousand Oaks, CA: Sage Publications.

Bowen, H.K., Clark, K.B., Holloway, C.A., and Wheelwright, S.C. (1994). "The Perceptual Enterprise Machine—Seven Keys to Corporate Renewal through Successful Product and Process Development," Oxford University Press, New York.

Bresnen, M., Edelman, L., Newell, S., Scarbrough, H. and Swan, J. (2003). "Social Practices and the Management of Knowledge in Project Environments," *International Journal of Project Management,* Vol. 21, Iss. 3, pages157-166.

Briggs, S. R. and Cheek, J. M. (1986). " The Role of Factor Analysis in the Development of Personality Scales." *Journal of Personality.*

Bryman, A. and Bell, E. (2003). "Business Research Methods," Oxford University Press, New York.

Carrillo, P. and Chinowsky, P. (2006). "Exploiting Knowledge Management: The Engineering and Construction Perspective," *Journal of Management in Engineering*, Vol. 22, Issue 1, pp. 2 – 10.

Carrillo, P., Robinson, H., Al-Ghasani, A. and Anumba, C. (2004). "Knowledge Management in UK Construction: Strategies, Resources and Barriers," *Project Management Journal*, Vol. 35, No. 1, pages 46-56.

Carson, D., Gilmore, A., Perry, C. and Gronhaug, K. (2001). "Qualitative Marketing Research." Sage Publications, London.

Cavana, R. Y., Delahaye, B. L. and Sekaran, U. (2001). "Applied Business Research: Qualitative and Quantitative Methods." John Wiley and Sons Australia Ltd., Milton, Qld.

Chase, R. (1997). "Knowledge Management Benchmarks". *Journal of Knowledge Management*, Vol.1 No. 1, pp. 83-92.

Cheng, M. Y.(2002)." Socialising Knowledge Management: The Influence of the Opinion Leader." *Journal of Knowledge Management Practice*, December, 2002.

Chinowsky, P. and Carrillo, P. (2007). "Knowledge Management to Learning Organization Connection." *Journal of Management in Engineering*, Vol. 23, Issue 3, pp. 122 -130.

Churchill, G. A. and Iacobucci, D. (2002). "Marketing Research Methodological Foundations." South Western, Mason, Ohio.

Construction Industry Development Board (CIDB) (2007). "Construction Industry Master Plan Malaysia 2006 – 2015." CIDB Publication.

Construction Industry Institute (CII) (1986). " Constructability, a Primer," CII Publication.

Cohen, W. M. and Levinthal, D. A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly*,35:128-152.

Cohen, J. W. (1998). " Statistical Power Analysis for the Behavioural Sciences," 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates.

Cooke-Davis, T. (2002). "The 'Real' Success Factors on Projects," *International Journal of Project Management,* Vol.20 Iss. 3 pages 185–190.

Creswell, J. W. (1994). "Research Design: qualitative and Quantitative Approaches." Thousand Oaks, CA: Sage Publications.

Damm, D. and Schindler, M. (2002). "Security Aspects of an Enterprise Knowledge Medium for Distributed Project Work," *International Journal of Project Management*, Vol.20 Iss.1, pages 37–47.

Darr, E. D., Argote, L. and Epple, D. (1995). "The Acquisition, Transfer and Depreciation of Knowledge in Service Organizations: Productivity in Franchises," *Management Science*, Vol. 40, Iss. 11, page 1750.

Davenport, T. H. and Prusak, L. (1997). "Working Knowledge: How Organizations Manage What They Know," Harvard Business school Press, Cambridge, MA.

Demsetz, H. (1991). "The Theory of the Firm Revisited," in The Nature of the Firm, J. Williamson and S. Winter (eds.), Oxford University Press, New York, pages 159-178.

Diener, E. and Crandall, R. (1978), "Ethics in Social and Behavioral Record." Chicago: University of Chicago Press.

Dillon, W.R., Madden, T. J. and Firtle, N. H. (1997). "Marketing Research in a Marketing Environment," 3rd ed. Burr Ridge, Illinois, Irwin.

Disterer, G., (2002). "Management of Project Knowledge and Experience," *Journal of Knowledge Management*, Vol. 6, No. 5, Pages 512-520.

Drucker, P. F. (1993). "The Post-Capitalist Society." New York: Harper Business.

Dunn, S. C. (2001). "Motivation by Project and Functional Managers in Matrix Organizations," *Engineering Management Journal*, Vol. 13, Iss. 2, pages 3-9.

Easterby – Smith, M., Thorpe, R. and Lowe, A. (2003). " Management Research – An Introduction," 2nd ed. Sage Publications, London.

El Sawy, O. A., Gomes, G. M. and Gonzalez, M. V. (1996). "Preserving Institutional Memory: The Management of History as an Organizational Resource," *Academy of Management Best Paper Proceedings*, Vol. 37, pages 118-122.

Emory, C. W. and Cooper, D. R. (1991). "Business Research Methods," 4th ed. Richard D. Irwin, Boston, MA.

Fiksel, J. and Hayes-Roth, F. (1989), "Knowledge Systems for Planning Support," *IEEE Expert*, Vol. 4 No. 3, pages 16-23.

Fischer, M. and Tatum, C. B. (1997), "Characteristics of Design Relevant Constructability Knowledge," *Journal of Construction Engineering and Management*, Vol. 123, Issue 3, pp. 253 – 260.

Fong, P.S.W. (2005). "Aspects of Learning and Knowledge in Construction Projects," in Proceedings of the Construction Research Congress, I. D. Tommelein (ed.) held on April 5-7, 2005 in San Diego, California.

Fong, P. S. and Chu, L. (2006), "Exploratory Study of Knowledge Sharing in Contracting Companies: A Sociotechnical Perspective," *Journal of Construction Engineering and Management*, Vol. 132, Issue 9, pp. 928 – 939.

Fontain, M. and Lesser, E. (2002). " Challenges in Managing Organizational Knowledge." IBM Institute for Knowledge – based Organization Publication.

Garrety, K., Robertson, P. L. and Badham, R. (2004). "Integrating Communities of Practice in Technology Development Projects," *International Journal of Project Management*, Vol.22, pages 351-358.

Gibson Jr., G. E., McGinnis, C. I., Flanigan, W. S. and Wood, J. E. (1996). "Constructability in Public Sector," *Journal of Construction Engineering and Management*, Vol. 122, No. 3, pp 274-280.

Glavinich, T. E. (1995). "Improving Constructability during Design Phase," *Journal of Architectural Engineering*, Vol. 1, No. 2, pp 73-76.

Grace, D. (1999). "Critical Variables in Child Care Services Switching: Contrasting Consumer and Staff Perceptions." Unpublished Honours Thesis, Griffith University.

Gransberg, D. D. and Douglass III, E. E. (2005). "Implementing Project Constructability," *AAEC International Transactions*, 2005, ABI/INFORM Global, pp PM.01.1-PM.01.4

Grant, R. M. (1996b). "Toward a Knowledge-based Theory of the Firm." *Strategic Management Journal*, Winter Special Issue, Vol. 17, pages 109-122.

Guba, E. G. (1990). " The Paradigm Dialogue." Sage Publications, Newbury Park.

Gyampoh-Vidogah, R., Moreton, R. and Proverbs, D. (2003). "Implementing Information Management in Construction: Establishing Problems, Concepts and Practice," *Construction Innovation*, Vol. 3, pages 157-173.

Hair, J., Anderson, R., Tatman, R. and Black, W. (1998). "Multivariate Data Analysis," 5th ed. Prentice Hall, New Jersey.

Hansen, M.T., Nohria, N. and Tierney, T. (1999). " What's Your Strategy for Managing Knowledge?" *Harvard Business Review*, March- April:106-16.

Hastings, C. (1993). "Organizational Forms." Heinemann.

Hjertzen , E and Toll, J. (1999). "Measuring Knowledge Management at cap." Gemini.

A.B' MSc Dissertation, available at http://94emahj.island./in.se/therm/paper.html, Linkoping University, Sweden.

Holtham, C. and Courtney, N. "The Executive Learning Ladder: A Knowledge Creation Process Grounded in the Strategic Information Systems Domain," in Proceedings of the Fourth Americas Conference on Information Systems, E. Hoadley and I. Benbasat (eds.), Baltimore, MD, pages 594-597.

Howard, H. C. (1991). "Project – Specific Knowledge Bases in AEC Industry," *Journal of Computing in Civil Engineering*, Vol. 5, Issue 1, pp.25 – 41.

Huber, G.P. (1991). "Organizational Learning : The Contributing Processes and the Literatures." *Organization Science*, Vol. 2, Iss.1, pages 88–115.

Hussey, J. and Hussey, R. (1997). "Business Research – A Practical Guide for Undergraduate and Post Graduate Students." Palgrave, New York, USA.

Johnson, J. (1995). "Chaos: The Dollar Drain of IT Project Failures," *Application Development Trends*, January, pages 41-47.

Juran, J.M. (1988), "Juran on Planning for Quality," The Free Press, New York, NY.

Kaiser, H. F. (1970). "A Second Generation Little Jiffy." *Psychometrika*, 35, 401-415.

Kamara, J. M., Augenbroe, G., Anumba, C. J. and Carrillo, P. M. (2002). "Knowledge Management in the Architecture, Engineering and Construction Industry," *Construction Innovation*, Vol. 2, pages 53-67.

Kanter, R.M. (1996). "When a thousand flowers bloom: Sructural, Collective, and Social Conditions for Innovation in Organizations," in Myers, P.S., (ed)., "Knowledge Management and Organizational Design." Butterworth-Heinemann, Boston, pages 93–131.

Kasvi, J. J. J., Vartiainen, M. and Hailikari, M. (2003). "Managing Knowledge and Knowledge Competences in Projects and Project Organizations," International Journal of Project Management, Vol. 21, Iss. 8, pages 571-582.

Kerlinger, F. N. (2000). "Foundation of Behavioral Research," in Chapter 24, Survey Research, Harcourt Grove, Fortworth.

Kofman, F.and Senge, P.(1993), "Communities and Commitment: the Heart of Learning Organizations". *Organizational Dynamics*, 22(2):5-22.

Koskinen, K. U. (2004). "Knowledge Management to Improve Project Communication and Implementation," *Project Management Journal*, Vol. 35, No. 1, pages 13-19.

Kotnour, T. (2000). "Organizational Learning Practices in the Project Management Environment," *Organizational Learning*, Vol. 17, Nos. 4/5, pages 393-406.

Leech, N.L, Barrett, K.C and Morgan, G.A. (2005), "SPSS for Intermediate Statistics: Use and Interpretation." Lawrence Erlbaum Associates Inc.

Leininger, M. M. (1985). "Qualitative Research Methods in Nursing." WB Saunders Company.

Leseure, M. J. and Brookes N. J. (2004). "Knowledge Management Benchmarks for Project Management", *Journal of Knowledge Management*, Vol. 8, No. 1, pages 103-116.

Liebowitz J. and Megbolugbe, I. (2003). "A Set of Frameworks to Aid the Project Manager in Conceptualizing and Implementing Knowledge Management Initiatives," *International Journal of Project Management*, Vol. 21, Iss. 3, pages 189-198.

Lin, Y., Wang, L. and Tserng, H. P. (2006). "Enhancing Knowledge Exchange through Web Map – Based Knowledge Management System in Construction: Lessons Learned in Taiwan," *Automation in Construction*, Vol. 15, Issue 6, pp. 693 – 705.

Liu, P.L, Chen, W.C. and Tsai, C.H .(2004)." An empirical study on the correlation between knowledge management capability and competitiveness in Taiwan's Industries," *Technovation* 24 (2004) pp971-977.

Lundin, R.A. and Midler, C. (1998). "Emerging Convergences or Debates", in Lundin, R.A. and Midler, C., (ed), "Projects as arenas for renewal and learning processes," Kluwer Academic Publishers; Boston, pages 231–41.

Mangione, T. W. (1995). "Mail Surveys: Improving the Quality." Thousand Oaks, CA: Sage.

McCarthy, T. J., Kahn, H. J., Elhag, T. M. S., Williams, A. R., Milburn, R. and Patel,M. B. (2000). "Knowledge Management in the Designer/Constructor Interface," in Proceedings of the 8th International Conference on Computing in Civil and Building Engineering," held on August 14-17 at Stanford.

Neo, J. (2000). "Cultural Factors Affecting Knowledge Sharing Behaviour." Masters Thesis. Nanyang Technological University Singapore.

Newell S. (2004). "Enhaneing Cross-Project Learning," *Engineering Management Journal*, Vol. 16, No. 1, pages 12-20.

Newell, S., Robertson, M., Scarbrough, H. and Swan, J. (2002). "Managing Knowledge Work." Palgrave Macmillan, Basingstoke, Hampshire.

Nima, M.A., Kadir, M. R. A., Jaafar, M. S. and Alghulami, R. G. (2001). "Constructability Implementation: A Survey in the Malaysian Construction Industry." *Construction Management and Economics*, Vol. 19. Iss. 8, pp 819-829.

Nima, M.A., Kadir, M. R. A., Jaafar, M. S. and Alghulami, R. G. (2002). "Constructability Concepts in Wesport Highway in Malaysia," *Journal of Construction Engineering and Management,* Vol. 128. Iss.4, pp 308, 356.

Niwa, K. (1990), "Toward Successful Implementation of Knowledge-based Systems: Expert Systems versus Knowledge Sharing Systems," *IEEE Transactions on Engineering Management*, Vol. 37 No. 4, pages 277-83.

Nonaka, I. (1994). "A Dynamic Theory of Organizational Knowledge Creation," *Organizational Science*, Vol. 5, Iss. 1, pages 14-37.

Pallant, J. (2004). "SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS 11." London: Open university Press.

Pavitt, K. (1984). "Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory," *Research Policy*, Vol. 13, Iss.6, pages 343–373.

Pentland, B. T. (1995). "Information Systems and Organizational Learning: The Social Epistemology of Organizational Knowledge Systems." *Accounting, Management and Information Technologies*, Vol. 5, Iss. 1, pages 1-21.

Project Management Institute (PMI) (2004). " A Guide to the Project Management Body of Knowledge (PMBOK Guide)," Upper Darby (PA). Project Management Institute.

Prusak, I. (1997). "Knowledge in Organizations." Butterworth-Heinemann.

Puddicombe, M. S. (2006). "The Limitations of Planning: The Importance of Learning." *Journal of Construction Engineering and Management*, Vol. 132, Issue 9, pp. 949 – 955.

Pulaski, M. H. and Horman, M. J.(2005). "Organizing Constructability Knowledge for Design." *Journal of Construction Engineering and Management*, Vol. 131, Issue 8, pp. 911 – 919.

Robinson, H.S., Carrillo, P.M., Anumba, C.J. and Al-Ghassani, A.M. (2001), "Linking Knowledge Management Strategy to Business Performance in

Construction Organizations." Proceedings of the ARCOM 2001 conference, 5-7 September, Salford, pp 577-86.

Rubery, J., Farnshaw, J., Marchington, M., Cooke, F. L. and Vincent, S. (2002). "Changing Organizational Forms and the Employment Relationship," *The Journal of Management Studies*, Vol. 39, Iss. 5, pages 645-672.

Sambamurthy, V., Bharadwaj, A. and Grover, V. (2003). "Shaping Agility through Digital Options: Reconceptualizing the Role of Information Technology in Firms," *MIS Quarterly*, Vol. 27, Iss. 2, pages 237-263.

Sambamurthy, V. and Subramani, M. (2005). "Special Issue on information Technologies and Knowledge Management," *MIS Quarterly*, Vol.29, No. 1, pages 1-7.

Scarbrough, H. and Swan, J.(1999). "Case Studies in Knowledge Management." *Institute of Personal Development* (IPD), London.

Schindler, M. and Eppler, M. J. (2003). "Harvesting Project Knowledge: A Review of Project Learning Methods and Success Factors," *International Journal of Project Management*, Vol. 21, Iss. 3, pages 219-228.

Shane, B. and Schumacher, T. (1996), ``Capturing Intellectual Assets in a Project Management Organization," *Project Management Journal,* Vol.27 No. 4, pages 3-11.

Shankar, R., Singh, M. D., Gupta, A. and Narain, R. (2003). "Strategic Planning for Knowledge Management Implementation in Engineering Firms," *Work Study*, Vol. 52, Iss. 4/5, pages 190-200.

Sidell, S.A. (1993), "Lessons Learned: It's the right thing to do," 47th Annual ASQC Quality Congress Transactions, May 24-26, pages 167-73.

Siemieniuch, C.E., Sinclair, M.A. (1999). "Organisational Aspects of Knowledge Life Cycle Management in Manufacturing," *International Journal of Human-Computer Studies*, Vol. 51, Iss. 3, pages 517–47.

Skyrme, D.J. and Amidon, D.A. (1999)."A Report on: Creating the knowledge-Based Business." Business Intelligent Limited, London, UK.

Smith, B. and Dodds, B. (1997). "Developing Managers in the Project-orientated Organization," *Journal of European Industrial Training*, Vol. 21, Iss.5, pages 165–170.

Smith, G.F. (1994), "Quality Problem Solving: Scope and Prospects,' *Quality Management Journal*, Vol. 2 No. 1, pages 25-40.

Snowden, D. (1999). "Liberating Knowledge." In Reeves, J. (Ed), Liberating Knowledge. London: Caspian Publishing, 36 – 42.

Stein, E. W. and Zwass, V. (1995). "Actualizing Organizational Memory and Information systems." *Information Systems Research*, Vol. 6, Iss. 2, pages 85-117.

Strauss, A. and Corbin, J. (1990). "Basics of Qualitative Research: techniques and Procedures for Developing Grounded Theory." Thousand Oakks, CA: Sage.

Styrhe, A., Josephson, P. E. and Knauseder, I. (2004). "Learning Capabilities in Organizations: Case Studies of Six Construction Projects," *Construction Management And Economics*, Vol. 22, pages 957-966.

Sullivan, C.H. and Yates, C.E. (1988), ``Reasoning by Analogy : A Tool for Business Planning,', *Sloan Management Review*, Vol. 29 No. 3, pages 55-60.

Szulanski, G. (1996). " Exploring Internal Stickiness: Impediments to the Transfer of Best Practices within the Firm." *Strategic Management Journal*, 17:27-43.

Tan, S. S., Teo, H. H., Tan B. C. and Wei, K. K. (1998). "Developing a Preliminary Framework for Knowledge Management in Organizations," in Proceedings of the Fourth Americas Conference on Information Systems, E. Hoadley and I. Benbasat (eds.), Baltimore, MD, pages 629-631.

Tiwana, A. (2002). "The Knowledge Management Toolkit: Orchestrating IT, Strategy and Knowledge Platforms," Pearson Education, Singapore.

Tsai, T-F, (2000). "The Framework of Knowledge Management in Consulting Company,' Masters thesis, Da-Yeh University, Chang Hua, Taiwan ROC.

Tull, D. S. and Hawkins, D. I. (1990). " Marketing Research; Measurement and Method. AText with Cases." Macmillan.

Tuomi, I. (2002). "Networks of Innovation: Change and Meaning in the Age of the Internet." Oxford: Oxford university Press.

Turner, J.R., Keegan, A. and Crawford, L. (2000)."Learning by Experience in the Project-based Organization," in Proceedings of the PMI Research Conference, Paris 2000. Upper Darby (PA) Project Management Institute.

van Aken, E.M., Monetta, D.J. and Sink, D.S. (1994), "Affinity Groups: The Missing Link in Employee Involvement." *Organizational Dynamics*, Spring.

von Krogh, G. (1998). "Care in Knowledge Creation," *California Management Review*, Vol. 40, Iss. 3, pages 133-153.

von Krogh, G., Nonaka, I. and Aben, M. (2001). "Making the Most of Your Company's Knowledge: A Strategic Framework," *Long Range Planning*, Vol. 34, pages 421-439.

Walsh, J. P. and Ungson, G. R. (1991). "Organizational Memory," Academy of Management Review, Vol. 16, Iss. 1, pages 57-91.

Webb, S.P. (1998). "Knowledge Management: Linchpin of Change." The Association for Information Management (ASLIB), London.

Wheelright, S. and Clark, K. B. (1992). "Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency and Quality," Free Press.

Williams, T. (2004). "Identifying the Hard lessons from Projects-easily," *International Journal of Project Management*, Vol.22, pages 273-279.

Williams, T. M. (2003). "Learning from Projects," *Journal of Operational Research Society,* Vol. 54, Iss.5, pages 443-451.

Williams, T. M., Eden, C., Ackermann, F. and Howick, S. (2001). "The Use of Project Post-Mortems," PMI 2001, Project Management Institute Annual Symposium, Nashville, Tennessee USA.

Wong, K. Y. and Aspinwall, E. (2004). "Knowledge Management Implementation Frameworks: A Review." *Knowledge and Process Management*, Vol. 11, No. 2, pages 93-104.

Yates, J. K. and Battersby, L. C. (2003). "Master Builder Project Delivery System and Designer Construction Knowledge," *Journal of Construction Engineering and Management*, Vol. 129, No. 6, pp635-644.

Zikmund, W. G. (2003). "Business Researeh Methods," 7th ed. Thomson South Western, Mason, Ohio.

APPENDIX A

MAIL SURVEY QUESTIONNAIRE

Research Topic: Knowledge Sharing in the Malaysian Construction Industry

Section A: Respondent's Background

1. Please indicate your professional background and training (Architect, Engineer, quantity surveyor etc.)

   ____

2. Please indicate the number of years of experience in the construction industry

   - Less than 5 years ☐
   - 5 - 10 years ☐
   - 11 - 15 years ☐
   - 16 -20 years ☐
   - more than 20 years ☐

3. Please indicate the number of years as a project manager

   - Less than 5 years ☐
   - 5 - 10 years ☐
   - 11 - 15 years ☐
   - 16 -20 years ☐
   - more than 20 years ☐

4. Do you have any formal project management qualification?

Yes ☐

No ☐

5. If yes, please indicate the type of qualification

- certificate ☐
- diploma ☐
- degree ☐
- professional membership ☐

Section B: Organizational Background

1. Size of organization (No. of employees)

- Less than 10 ☐
- 10 - 100 ☐
- 101 - 1000 ☐
- 1001 – 10,000 ☐

2. Organization Type

- Design Consultancy: Architecture ☐
- Design Consultancy: Engineering ☐
- Contractor ☐

3. What is the average yearly value of projects undertaken by the organization?

- RM ____________

4. Is the organization certified to ISO 9001:2000?

Yes ☐

No ☐

5. Does the organization have any formal procedures or guidelines for project knowledge sharing?

Yes ☐

No ☐

6. If yes, please specify the type of knowledge sharing procedures and guidelines used.

____

Section C

Please indicate your response to the following statements by circling the appropriate indicator on the 5 – point Likert scale as follows:

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

There is a positive relationship between the application of research collaboration and improved designer construction knowledge in terms of:

1. knowledge of organizational processes and procedures

1 2 3 4 5

2. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

3. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

4. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

5. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of conferences and seminars and improved designer construction knowledge in terms of:

6. knowledge of organizational processes and procedures

1 2 3 4 5

7. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

8. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

9. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

10. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of brainstorming and improved designer construction knowledge in terms of:

11. knowledge of organizational processes and procedures

1 2 3 4 5

12. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

13. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

14. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

15. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of job rotation and observation and improved designer construction knowledge in terms of:

16. knowledge of organizational processes and procedures

1 2 3 4 5

17. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

18. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

19. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

20. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of communities of practice and improved designer construction knowledge in terms of:

21. knowledge of organizational processes and procedures

1 2 3 4 5

22. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

23. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

24. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

25. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of intranets and improved designer construction knowledge in terms of:

26. knowledge of organizational processes and procedures

1 2 3 4 5

27. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

28. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

29. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

30. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of database systems and improved designer construction knowledge in terms of:

31. knowledge of organizational processes and procedures

1 2 3 4 5

32. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

33. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

34. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

35. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of document management systems and improved designer construction knowledge in terms of:

36. knowledge of organizational processes and procedures

1 2 3 4 5

37. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

38. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

39. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

40. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

There is a positive relationship between the application of electronic discussion forums and improved designer construction knowledge in terms of:

41. knowledge of organizational processes and procedures

1 2 3 4 5

42. knowledge of client's business and how to interpret business requirements into technical specifications for the construction team

1 2 3 4 5

43. knowledge of how to predict outcomes, manage teams, focus on clients and how to motivate others

1 2 3 4 5

44. technical/domain knowledge of design, materials, specifications and technologies

1 2 3 4 5

45. 'know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

1 2 3 4 5

Section D

Please indicate your response to the following statements by circling the appropriate indicator on the 5-point Likert scale as follows:

1	2	3	4	5
Almost Never	Rarely	Sometimes	Quite Often	Always

Based on your experience and involvement in the implementation of construction projects, how frequently does sharing of crucial construction knowledge occur between designers and constructors through the following approaches?

1. Research Collaboration

1 2 3 4 5

2. Conferences and Seminars

1 2 3 4 5

3. Brainstorming

1 2 3 4 5

4. Job Rotation and Observation

1 2 3 4 5

5. Communities of Practice

1 2 3 4 5

6. Intranets

1 2 3 4 5

7. Database Systems

1 2 3 4 5

8. Document Management Systems

1 2 3 4 5

9. Electronic Discussion Forums

1 2 3 4 5

Based on your experience, kindly provide comments on any other approaches that you feel are applicable to help enhance the designer's construction knowledge within the construction industry in Malaysia.

....

....

....

....

....

....

....

....

....

....

....

....

....

Thank you for taking your time in assisting with this survey by completing this questionnaire.

APPENDIX B

Guidance Notes

1. Sample definitions of Knowledge Management:
   - A systematic process of capturing, transferring and sharing knowledge to add competitive value and to improve performance (Al-Ghassani et al., 2004)
   - In its simplest form, knowledge management is about encouraging people to share knowledge and ideas to create value-adding products and services (Chase, 1997).

   Hence, in the context of this study, knowledge sharing is taken as one of the processes of knowledge management.

2. The independent variables used in this study are the knowledge sharing tool/approaches borrowed from Carrillo et al. (2004). These are:

   Non-IT approaches
   - Research Collaboration
   - Conferences and seminars
   - Brainstorming
   - Job Rotation and Observation
   - Communities of Practice (Groups in which knowledge is created as a result of social interaction and learning among members).

   IT approaches
   - Intranets
   - Database systems
   - Document Management systems
   - Electronic Discussion Forums

3. The dependent variable is the 'Improved Designer Construction Knowledge'. The supporting dependent variables are the crucial knowledge as suggested from the findings of the research by Kamara et al. (2002, p 58) as follows:
   - Knowledge of organizational processes and procedures, including statutory regulations and standards, management of interfaces between different stages of projects, in-house procedures and best practice guides
   - Knowledge of a client's business and how to interpret business requirements into technical specifications for the construction team
   - Knowledge of how to predict outcomes, manage teams, focus on clients and motivate others
   - Technical/domain knowledge of design, materials, specifications and technologies
   - 'Know-who knowledge' of people with the skills for a specific task and knowledge of the abilities of suppliers and subcontractors

c

APPENDIX C

The UNIVERSITY of NEWCASTLE
AUSTRALIA

The University of Newcastle
Faculty of Business and Law

University Drive
Callaghan NSW Australia 2308

For further information:
Supervisor Name: Dr. Andrew Dempster
Tel/Fax: 61 2 4921 5799
Email: Andrew.Dempster@newcastle.edu.au

23rd July, 2006

KNOWLEDGE SHARING IN THE MALAYSIAN CONSTRUCTION INDUSTRY
SURVEY INFORMATION SHEET

Dear Potential Participant,

I am Abang Hatta Abang Taha, a student in the Newcastle Graduate School of Business, SEGi Malaysia, at the University of Newcastle, Australia, undertaking a Doctorate of Business Administration. As part of my studies, I am conducting a research project titled Knowledge Sharing in the Malaysian Construction Industry. You are invited to take part in this research project which examines the relationship between the use of project knowledge sharing approaches and the improvement of designer construction knowledge in Malaysia.

The first objective of this research is to test the relationships between the application of knowledge sharing approaches and the improvement of designer construction knowledge in the Malaysian construction industry. In the process, the researcher will identify which of the knowledge sharing approaches contribute significantly to the knowledge areas that are considered crucial to the designers This will help construction organizations focus on developing the positively contributing processes to further improve the construction knowledge of project designers.

The second objective is to investigate and determine the relative frequency with which the sharing of construction knowledge between designers and constructors occurs through the different approaches.

You are invited to participate in this research. If you consent to participate, this will involve:

- Completing an anonymous survey which will take approximately 20 minutes of your time.
- Returning the survey to the researcher in the enclosed self-addressed and stamped envelope. *This will be taken as your informed consent to participate.*

I would then appreciate if you could complete the attached questionnaire and return it in the self-addressed and stamped envelope enclosed, on or before **31st August, 2006.**

Your company has been selected at random from the list of all construction firms registered with Construction Industry Development Board (CIDB), architectural and engineering consultancy firms registered with the respective boards.

Participation is **entirely voluntary.** You can withdraw at any time and there will be no disadvantage if you decide not to complete the survey. All information collected will be confidential. All information gathered from the survey will be stored securely and once the information has been analysed all questionnaires will be destroyed. At no time will any individual be identified in any reports resulting from this study.

If you have any concerns or would like to know the outcome of this project, please contact my supervisor, Dr. Andrew Dempster at the above address.

Thank you for your interest,

Yours sincerely,

Abang Hatta Abang Taha

Complaints Clause:
This project has been approved by the University's Human Research Ethics Committee, Approval No.Bus-Law /SEGi/3-4/6:06A.

The University requires that should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, telephone (02 49216333, email HumanEthics@newcastle.edu.au)

D

APPENDIX D

Lembaga Pembangunan Industri Pembinaan Malaysia
CONSTRUCTION INDUSTRY DEVELOPMENT BOARD MALAYSIA

Bersama Kita Memajukan Industri Pembinaan Malaysia Ke Arah Dayasaing Global

Our Ref. : LPIPM:PEB/USB/01/1.2 (37)
Date : 1st August 2006

TO WHOM IT MAY CONCERN

Dear Sir / Madam,

A Survey on Knowledge Sharing in the Malaysian Construction Industry

I am pleased to inform you that Abang Hatta Abang Taha is a student pursuing a Doctorate of Business Administration at the Newcastle Graduate School of Business, University of Newcastle, Australia. He is currently conducting a research entitled Knowledge Sharing in the Malaysian Construction Industry.

The objective of this research is to test the relationships between the application of knowledge sharing approaches and the improvement of designer construction knowledge in the Malaysian construction industry. This will help construction organizations focus on developing the positively contributing processes to further improve the construction knowledge of project designers.

CIDB Malaysia is fully supportive of this research. As such, we hope you will be able to provide full cooperation to Abang Hatta Abang Taha to complete the survey.

We thank you in anticipation of your support.

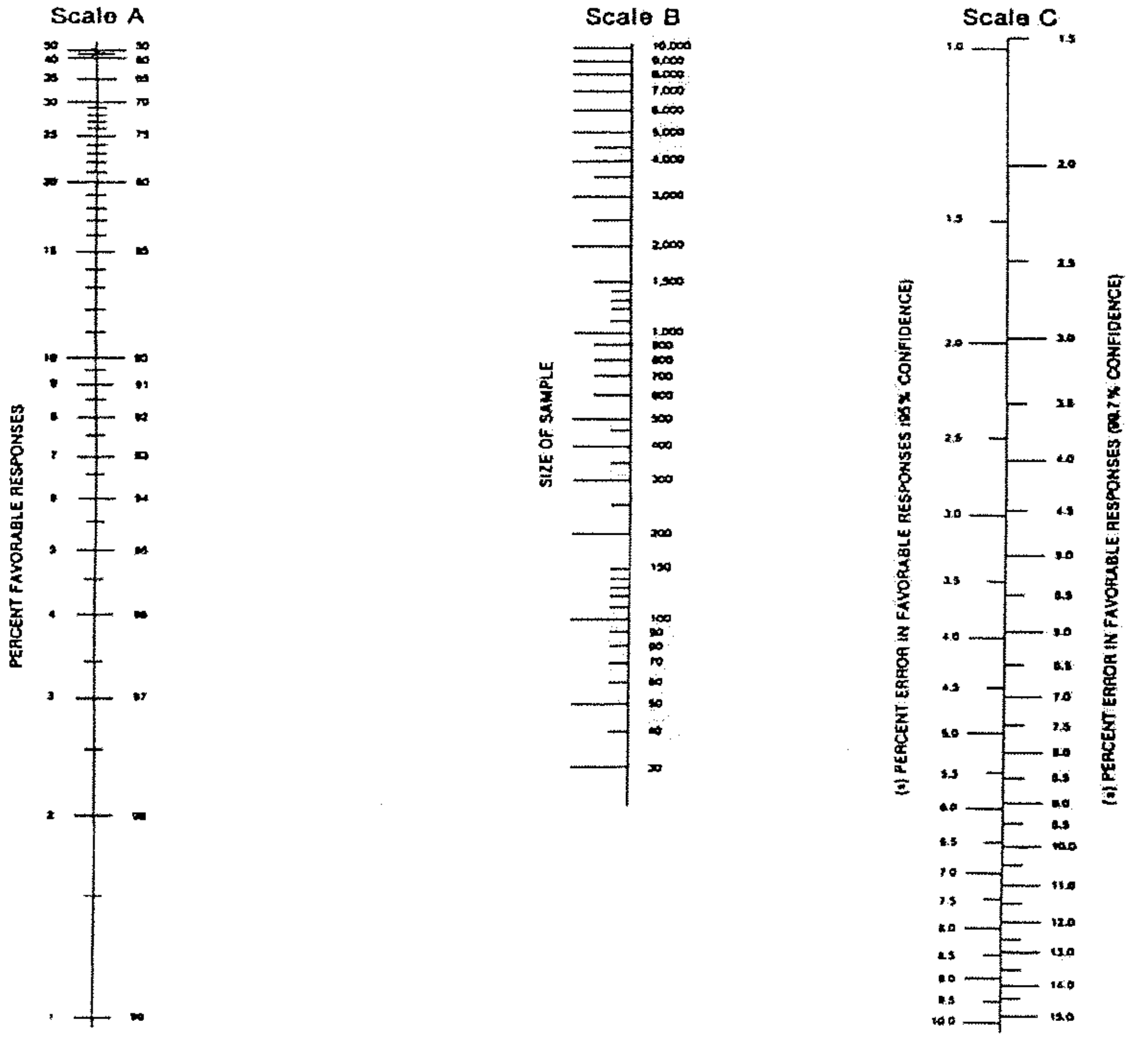
"BUILD PERFECT"

(DATUK IR. HAMZAH HASAN)
Chief Executive
Construction Industry Development Board Malaysia

SAMPLE SIZE CALCULATOR

An easy method of obtaining approximate answers to a variety of sampling problems.

To use the chart, lay a straightedge to connect known values on any two of the scales. Read the unknown value where the straightedge intersects the third scale.



Kennedy Research, Inc., Waters Building, Grand Rapids, Michigan 49503 616/458-1461

KENNEDY RESEARCH

Source: Dillon, Madden and Firtle (1994, p 253)

Appendix F1: Descriptive Statistics for Variables of Sections A and B

Variables	N		Minimum	Maximum	Mean	Std. Dev.	Variance	Skewness	Kurtosis
	Valid	Missing							
Prof. Background	42	0	1	4	2.33	1.074	1.154	.518	-.978
Years of Experience in Construction Industry	42	0	1	5	3.36	1.358	1.845	-.143	-1.189
No. of Years as Project Manager	42	0	1	5	2.12	1.173	1.376	.901	.007
Formal Project Management Qualification	42	0	1	2	1.64	.485	.235	-.619	-1.701
Type of Qualification	42	0	1	5	4.10	1.185	1.405	-1.022	-.199
Size of Organisation (Employees)	42	0	1	3	2.05	.439	.193	.262	2.637
Type of Organisation	42	0	1	3	2.24	.821	.674	-.477	-1.349
Average Yearly Project value	37	0	500,000	800,000,000	99,527,027.0	192,515,365.4	37062165,915,915,920.0	2.827	7.351
ISO 9001:2000 Certified	42	0	1	2	1.64	.485	.235	-.619	-1.701
Formal Procedures or Guidelines for Project Knowledge Sharing	42	0	1	2	1.69	.468	.219	-.855	-1.335
Valid N (listwise)	37	5							

Note: Std. Dev = Standard Deviation

\

Appendix F2: Descriptive Statistics for Scale Variables of Sections C and D

Variables	N		Minimum	Maximum	Mean	Std. Dev	Variance	Skewness	Kurtosis
	Valid	Missing							
RC - KOPP	42	0	3	5	4.00	.663	.439	.000	-.596
RC - KCB	42	0	3	5	4.14	.566	.321	.035	.129
RC - KPO_MO	42	0	1	5	4.00	.796	.634	-1.521	4.491
RC - TDK	42	0	4	5	4.40	.497	.247	.403	-1.932
RC - KPSS	42	0	3	5	4.14	.608	.369	-.070	-.236
CS - KOPP	42	0	2	5	3.74	.701	.491	-.480	.494
CS - KCB	42	0	3	5	3.86	.472	.223	-.476	1.164
CS - KPO_MO	42	0	2	5	3.90	.692	.479	-.337	.377
CS - TDK..	42	0	2	5	3.90	.726	.527	-.655	.940
CS - KPSS.	42	0	2	5	3.86	.872	.760	-.872	.452
BS - KOPP	42	0	2	5	3.86	.783	.613	-.699	.628
BS - KCB	42	0	2	5	3.98	.680	.463	-.459	.774
BS - KPO_MO	42	0	2	5	3.93	.640	.409	-.527	1.307
BS - TDK	42	0	2	5	3.93	.712	.507	-.321	.181
BS - KPSS	42	0	1	5	3.83	.794	.630	-1.530	3.790
JR - KOPP	42	0	2	5	3.71	.708	.502	-.388	.299
JR - KCB	42	0	2	5	3.69	.643	.414	-1.345	1.632
JR - KPO_MO	42	0	2	5	3.62	.731	.534	-.436	.123
JR - TDK	42	0	2	5	3.88	.670	.449	-.882	1.881
JR - KPSS	42	0	2	5	3.74	.701	.491	-.480	.494
COP - KOPP	42	0	2	5	3.86	.751	.564	-.118	-.394
COP - KCB	42	0	2	5	3.76	.726	.527	-.401	.302
COP - KPO_MO	42	0	2	5	3.67	.786	.618	-.269	-.143
COP - TDK	42	0	2	5	3.79	.717	.514	-.072	-.217
COP - KPSS	42	0	2	5	3.86	.751	.564	-.481	.365
Valid N (listwise)	42	0							

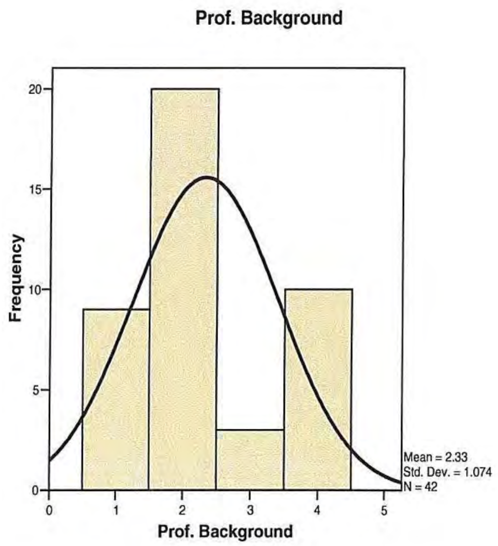
Note: Std. Dev = Standard Deviation

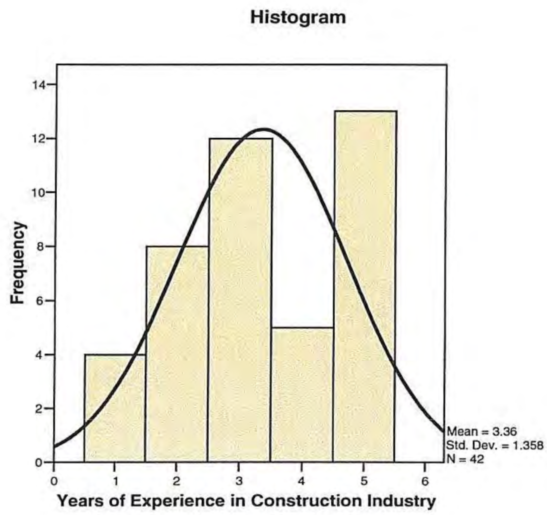
Appendix F3: Descriptive Statistics for Scale Variables of Sections C and D (Continued)

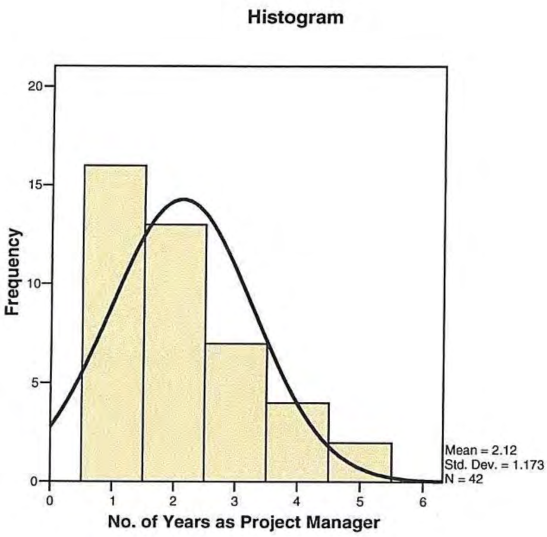
Variables	N Valid	N Missing	Minimum	Maximum	Mean	Std. Dev	Variance	Skewness	Kurtosis
ITNET - KOPP	42	0	2	5	3.88	.803	.644	-.372	-.157
ITNET - KCB	42	0	2	5	3.67	.721	.520	-1.031	.846
ITNET- KPO_MO	42	0	2	5	3.74	.734	.539	-.315	.124
ITNET - TDK	42	0	2	5	3.88	.705	.498	-.266	.133
ITNET- KPSS	42	0	2	5	3.74	.701	.491	-.033	-.176
DBS - KOPP	42	0	2	5	3.90	.656	.430	-.448	.920
DBS - KCB	42	0	3	5	4.10	.576	.332	.010	.152
DBS - KPO_MO	42	0	2	5	3.95	.661	.437	-.483	1.020
DBS - TDK	42	0	3	5	4.05	.539	.290	.048	.713
DBS- KPSS	42	0	2	5	3.95	.731	.534	-.319	.010
DMS - KOPP	42	0	2	5	4.02	.643	.414	-.597	1.632
DMS - KCB	42	0	2	5	3.93	.677	.458	-.905	2.052
DMS - KPO_MO	42	0	2	5	3.93	.745	.556	-.624	.736
DMS - TDK	42	0	2	5	3.95	.731	.534	-.713	1.084
DM,S- KPSS	42	0	2	5	3.86	.683	.467	-.295	.334
EDF - KOPP	42	0	2	5	3.50	.804	.646	-.296	-.352
EDF - KCB	42	0	2	5	3.55	.772	.595	-.334	-.170
EDF - KPO_MO	42	0	2	5	3.55	.916	.839	-.347	-.661
EDF - TDK	42	0	2	5	3.71	.805	.648	-.601	.177
EDF- KPSS	42	0	2	5	3.52	.833	.695	-.212	-.424
FKS - RC	42	0	1	5	3.24	1.055	1.113	-.374	-.206
FKS - CS	42	0	1	5	3.19	1.087	1.182	-.518	-.340
FKS - BS	42	0	1	5	3.29	1.019	1.038	-.326	-.293
FKS - JR&O	42	0	1	5	2.98	1.000	.999	-.258	-.748
FKS - COPs	42	0	1	5	3.26	.885	.783	-.332	-.150
FKS - Intranets	42	0	1	5	3.00	1.036	1.073	-.415	-.683
FKS - DBS	42	0	1	5	3.19	1.110	1.231	-.509	-.520
FKS - DMS	42	0	1	5	3.36	1.100	1.211	-.540	-.296
FKS - EDF	42	0	1	4	2.64	1.055	1.113	-.135	-1.170
I_Design Knowledge (C1-C45)	42	0	3.1	4.9	3.854	.3715	.138	.357	.056
I_Design Knowledge (D1-D9)	42	0	1.4	4.4	3.127	.8074	.652	-.451	-.642
I_Design Knowledge (C1-D9)	42	0	2.9	4.7	3.734	.3910	.153	-.009	-.373
Valid N (listwise)	42								

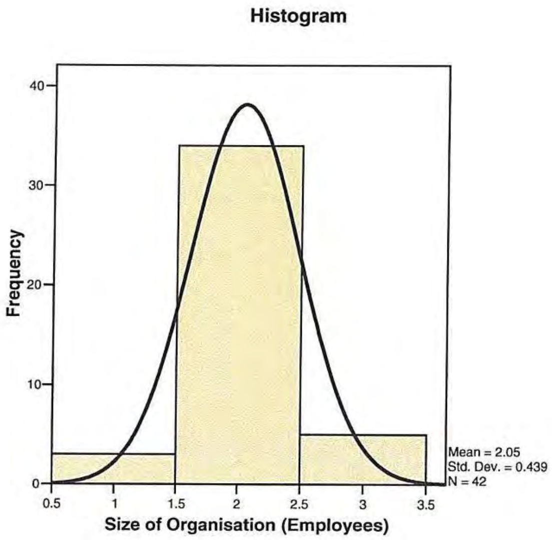
Note: Std. Dev = Standard Deviation

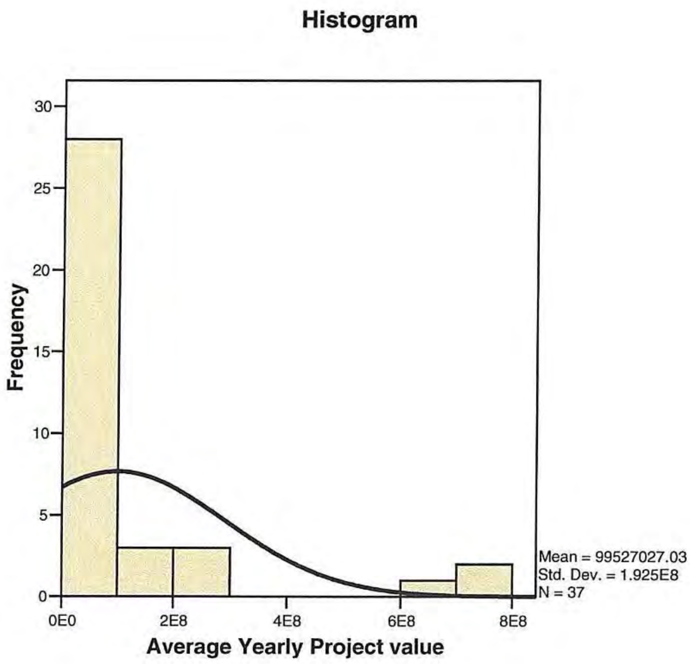
APPENDIX F4.1: Histograms with Normal Curves for Descriptive Statistics for Demographic Variables in Section A and B.



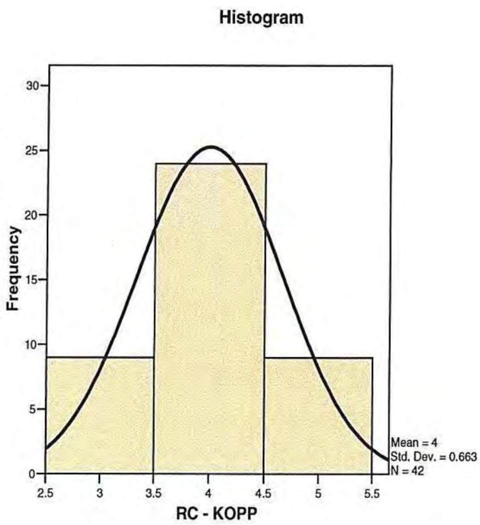


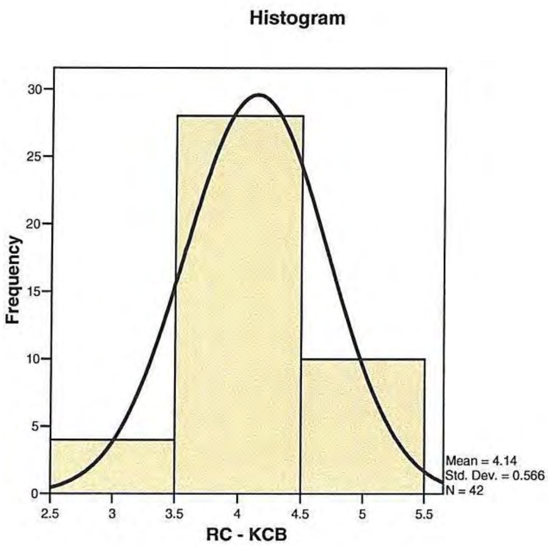

Histogram
20
15
10
5
0
Frequency
0
1
2
3
4
5
6
No. of Years as Project Manager
Mean = 2.12
Std. Dev. = 1.173
N = 42


Histogram
40
30
20
10
0
Frequency
0.5
1
1.5
2
2.5
3
3.5
Size of Organisation (Employees)
Mean = 2.05
Std. Dev. = 0.439
N = 42

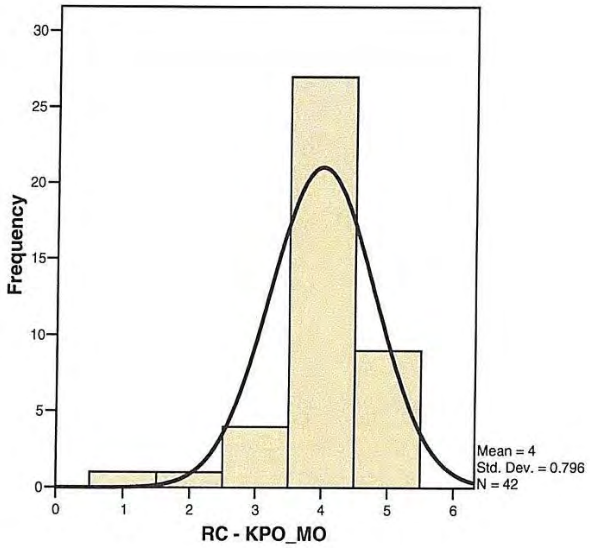

Histogram
Frequency
30
25
20
15
10
5
0
0E0
2E8
4E8
6E8
8E8
Average Yearly Project value
Mean = 99527027.03
Std. Dev. = 1.925E8
N = 37

APPENDIX F4.2: Histograms with Normal Curves for Descriptive Statistics forScale Variables in Section C and D.

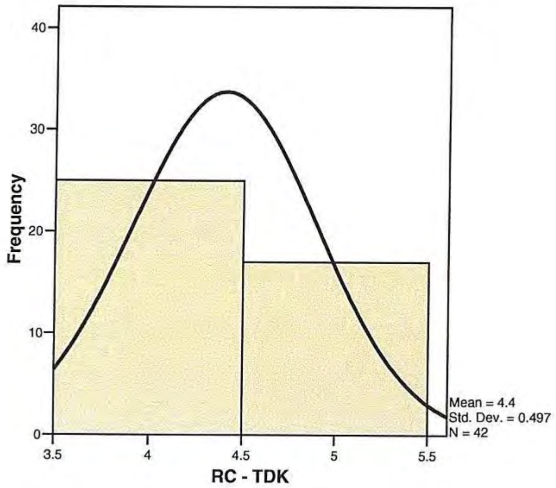




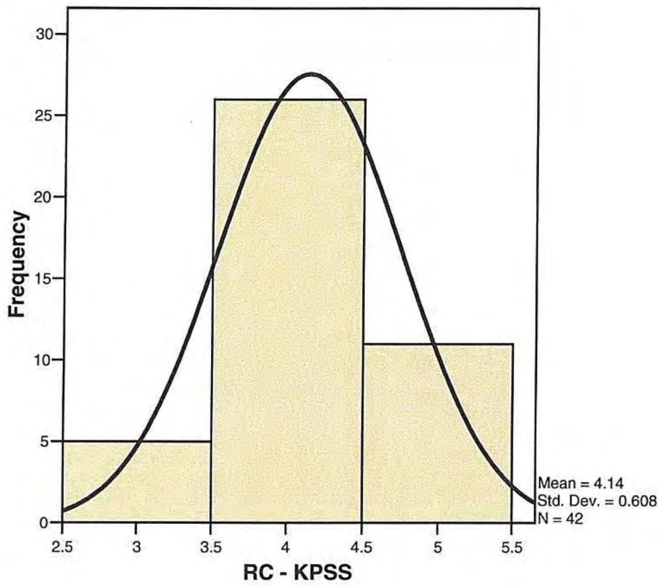
Histogram



Histogram

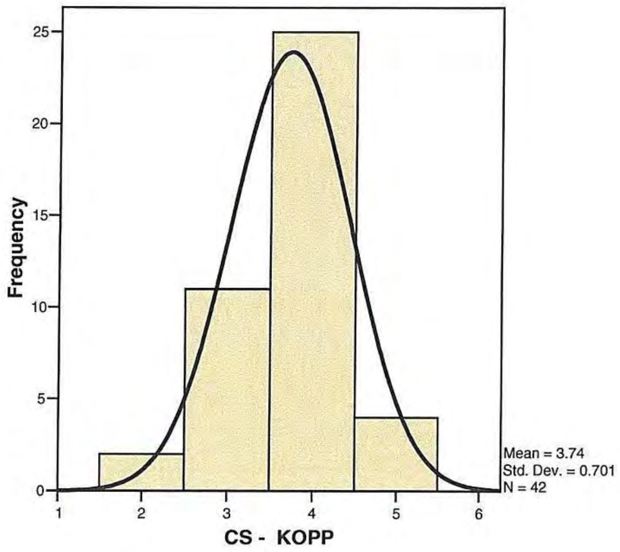


Histogram

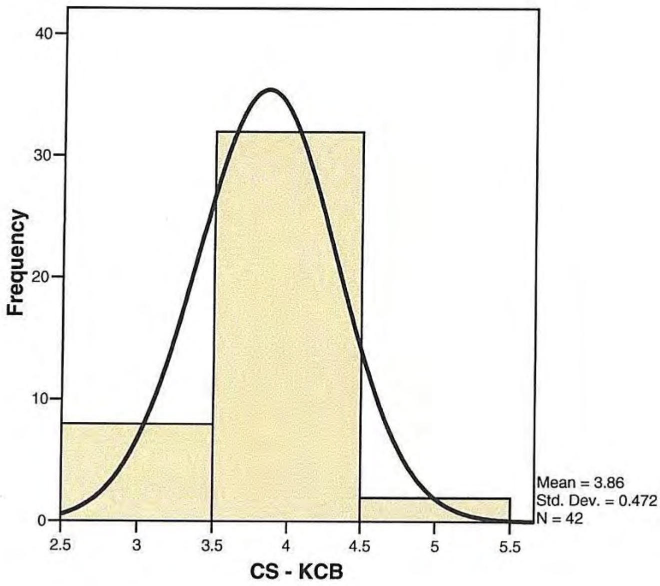


30
25
20
15
10
5
0
Frequency
2.5
3
3.5
4
4.5
5
5.5
RC - KPSS
Mean = 4.14
Std. Dev. = 0.608
N = 42

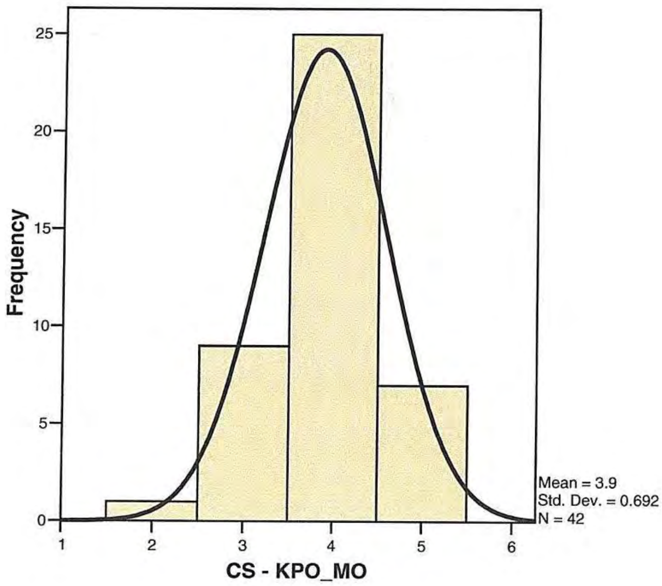
Histogram


25
20
15
10
5
0
Frequency
1
2
3
4
5
6
CS - KOPP
Mean = 3.74
Std. Dev. = 0.701
N = 42

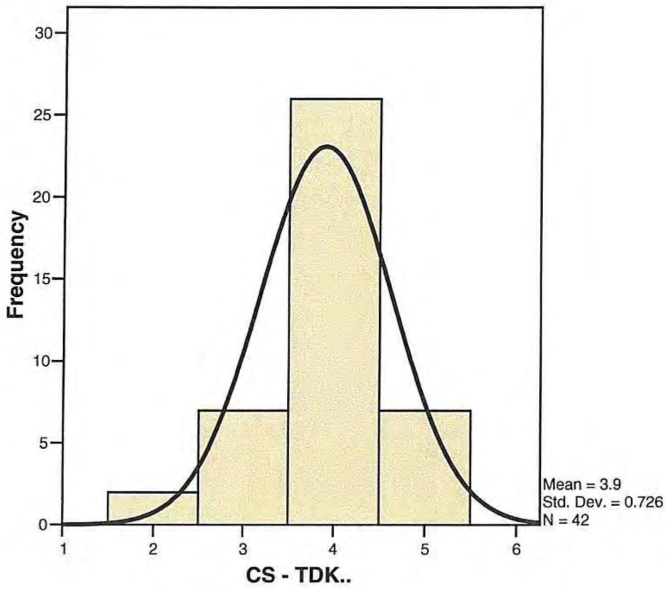
Histogram



Histogram

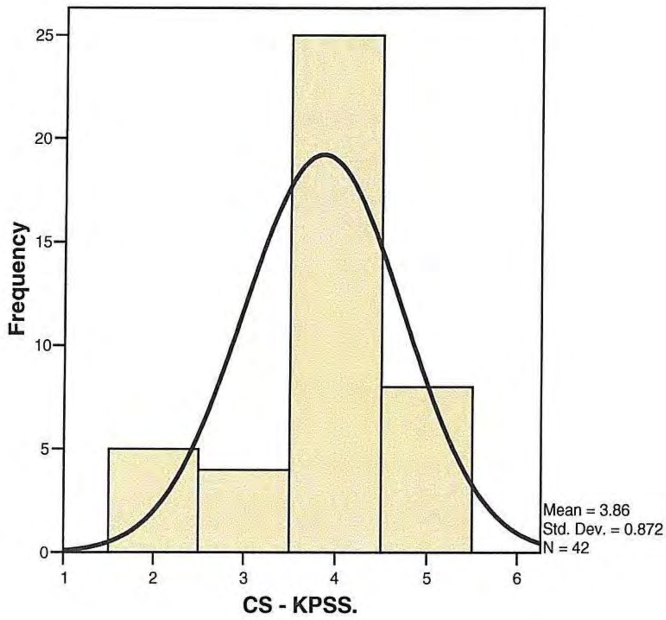


Histogram



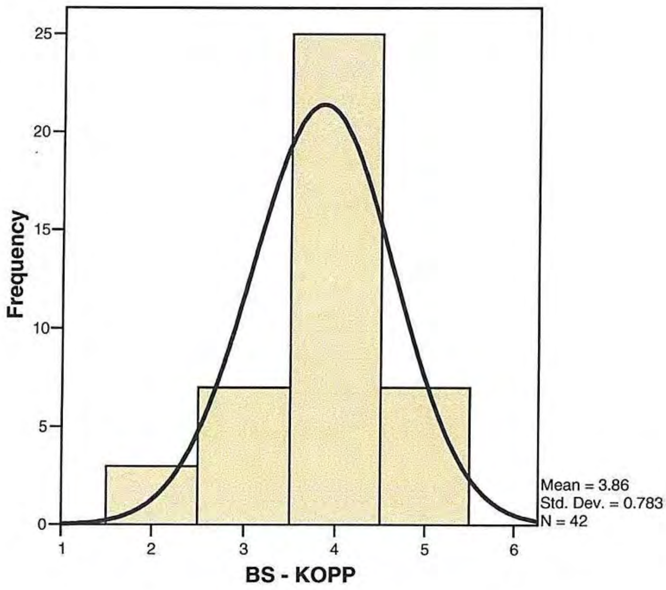
30
25
20
15
10
5
0
Frequency
1
2
3
4
5
6
CS - TDK..
Mean = 3.9
Std. Dev. = 0.726
N = 42

Histogram

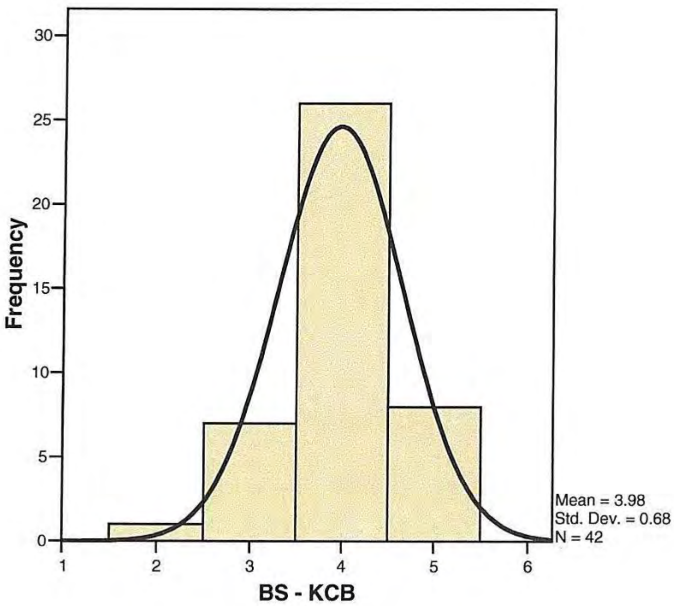


25
20
15
10
5
0
Frequency
1
2
3
4
5
6
CS - KPSS.
Mean = 3.86
Std. Dev. = 0.872
N = 42

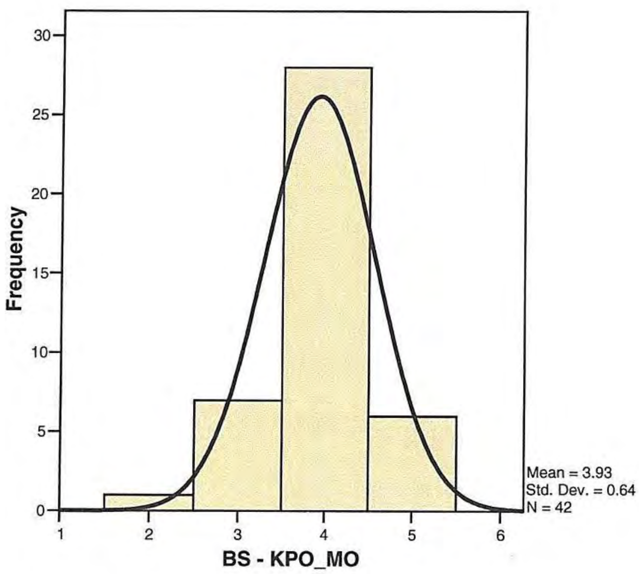
Histogram


25
20
15
10
5
0
Frequency
1
2
3
4
5
6
BS - KOPP
Mean = 3.86
Std. Dev. = 0.783
N = 42

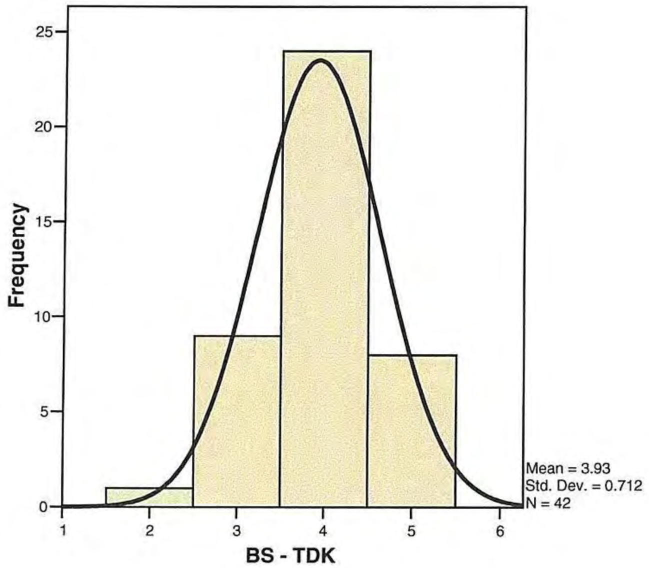
Histogram



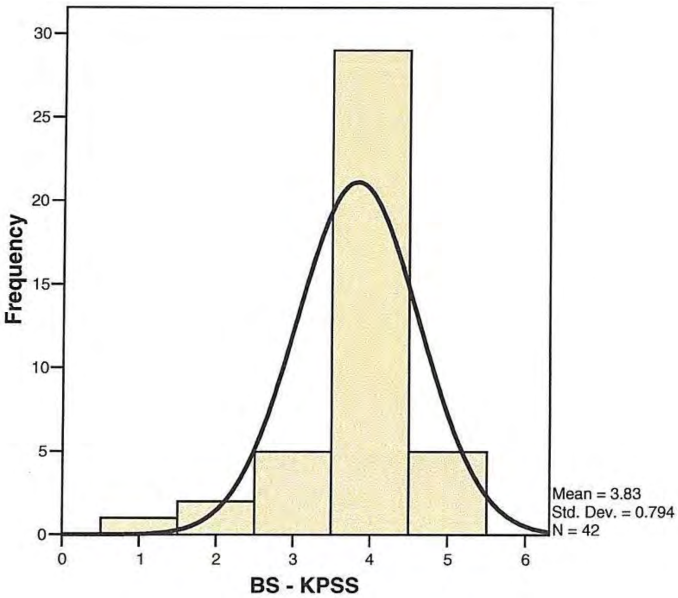
Histogram

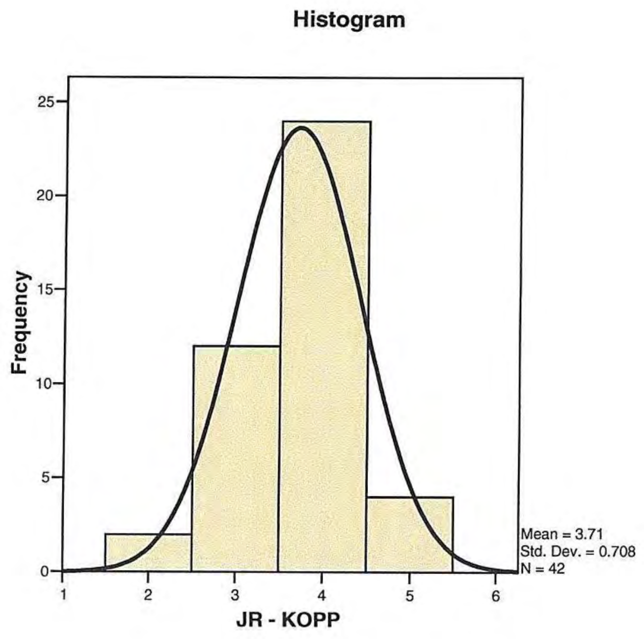


Histogram

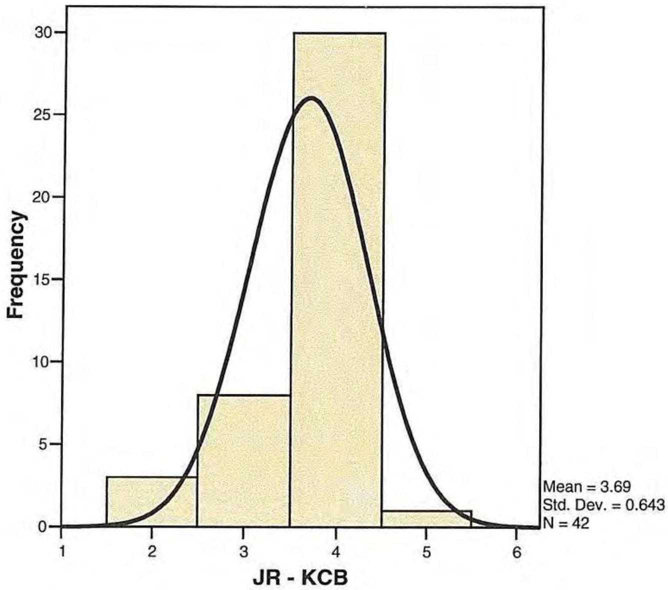


Histogram

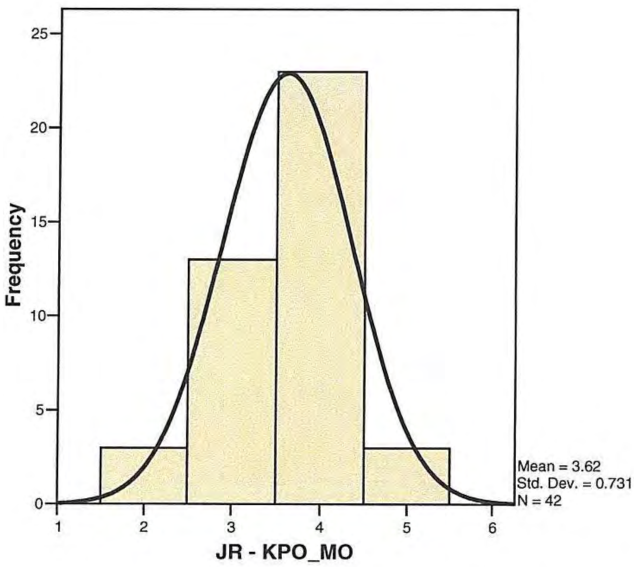



Histogram
25
20
15
10
5
0
Frequency
1
2
3
4
5
6
JR - KOPP
Mean = 3.71
Std. Dev. = 0.708
N = 42

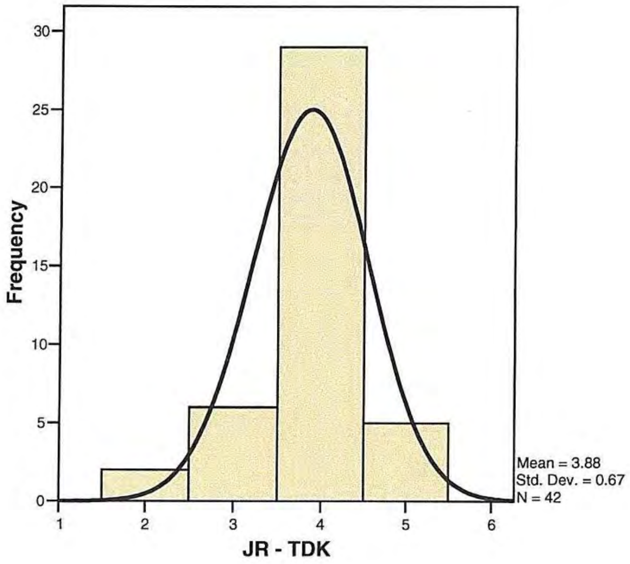
Histogram



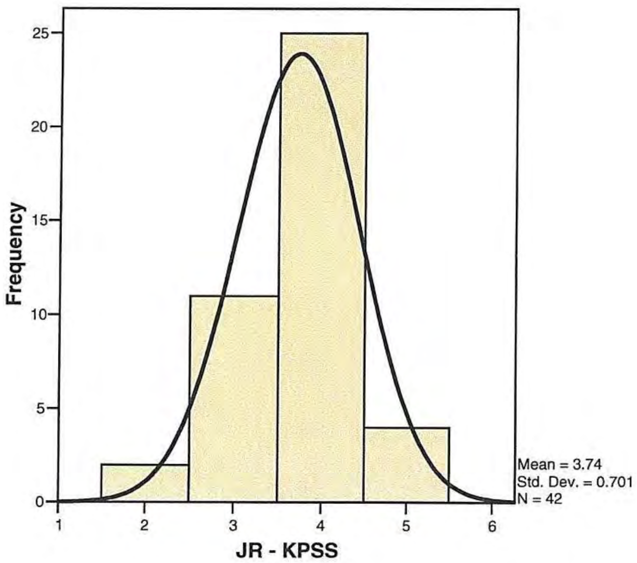
Histogram



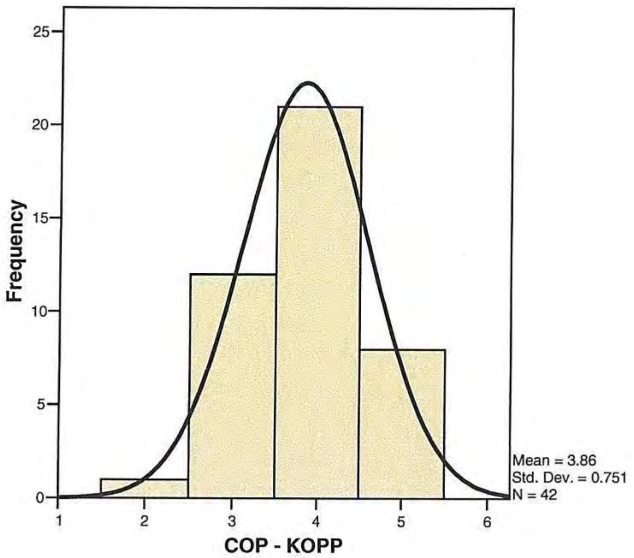
Histogram



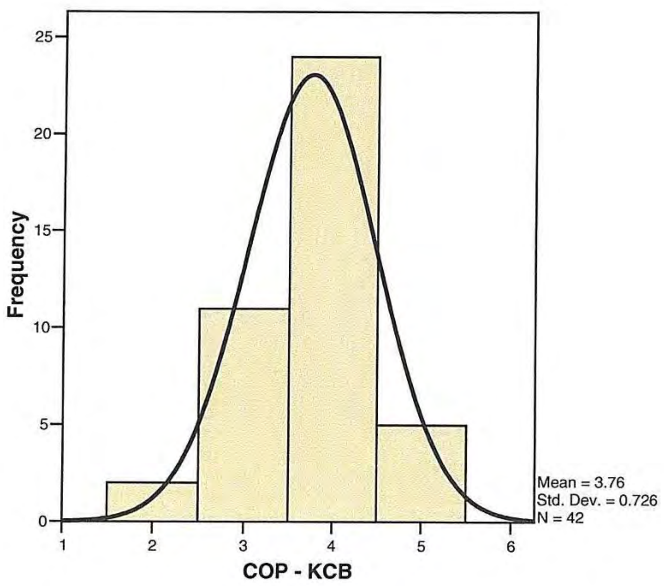
Histogram



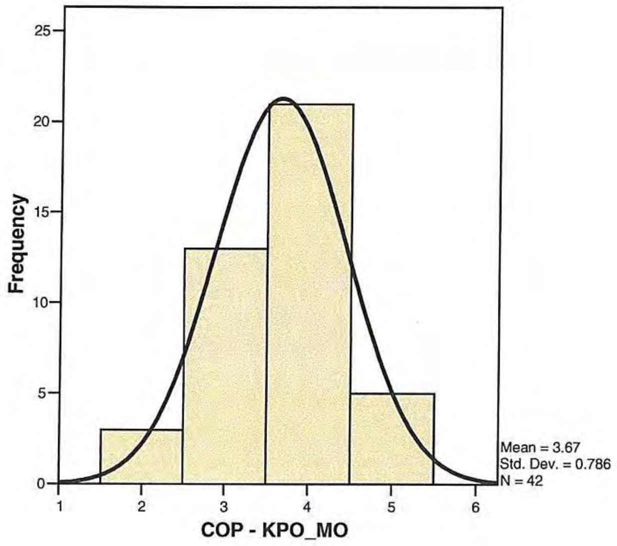
Histogram



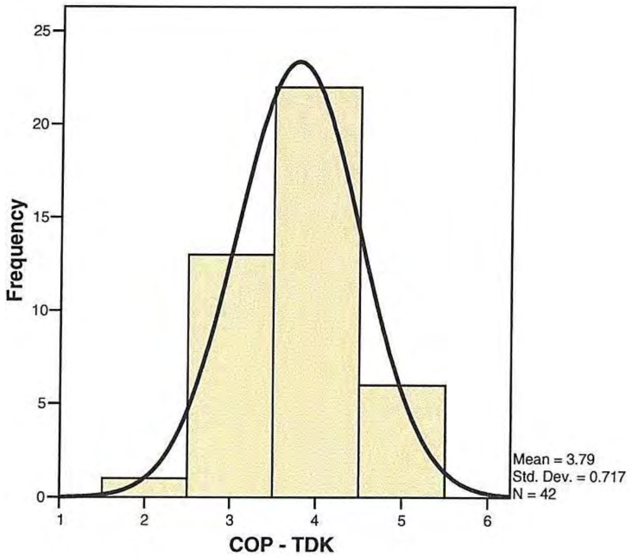
Histogram



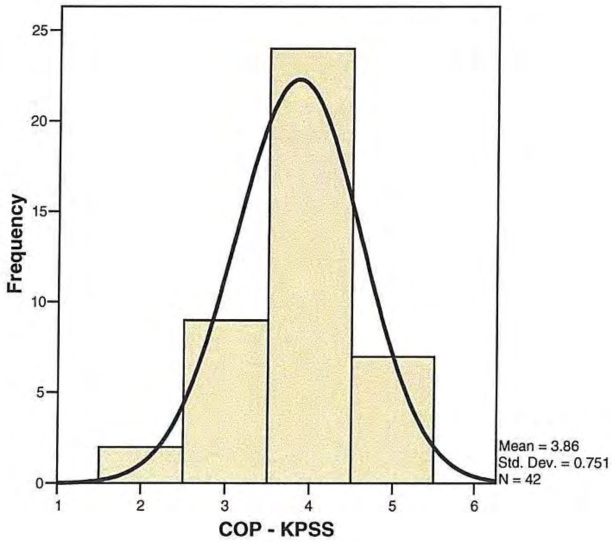
Histogram



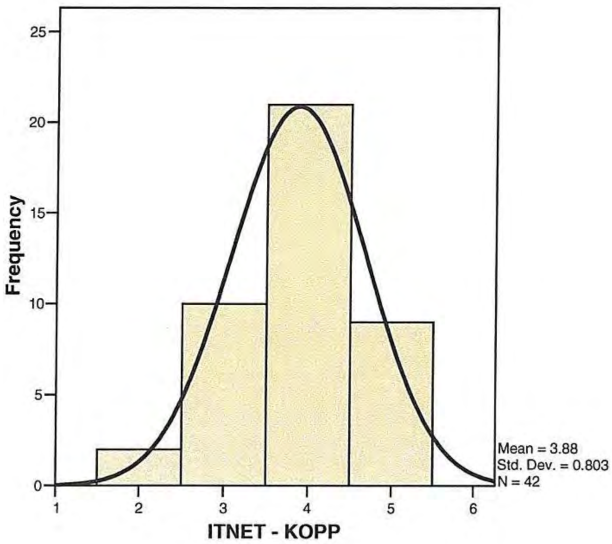
Histogram



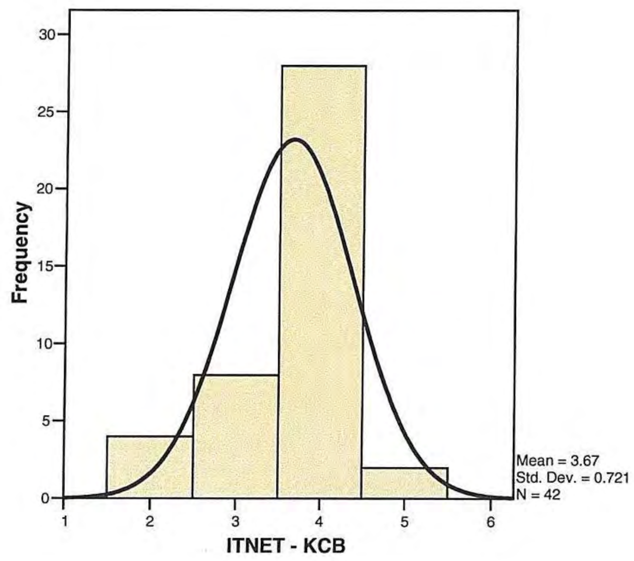
Histogram



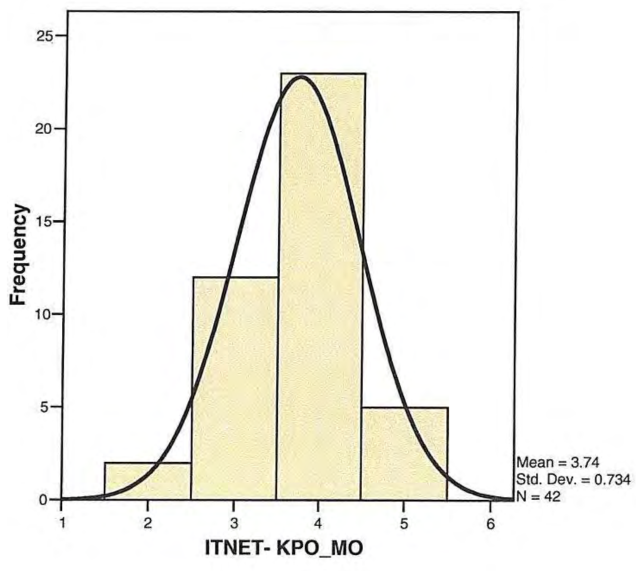
Histogram



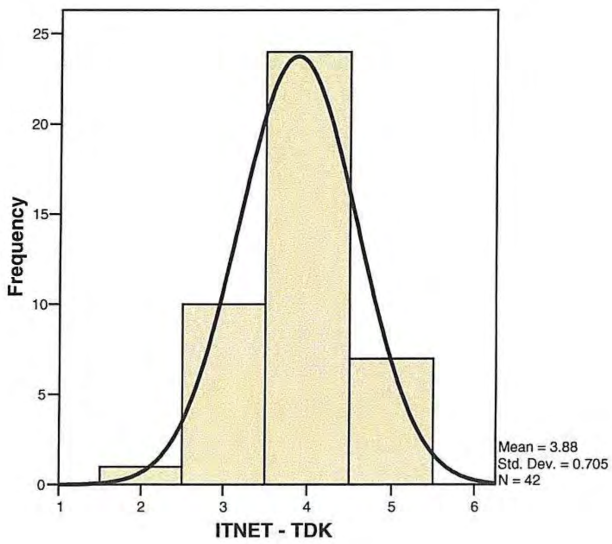
Histogram



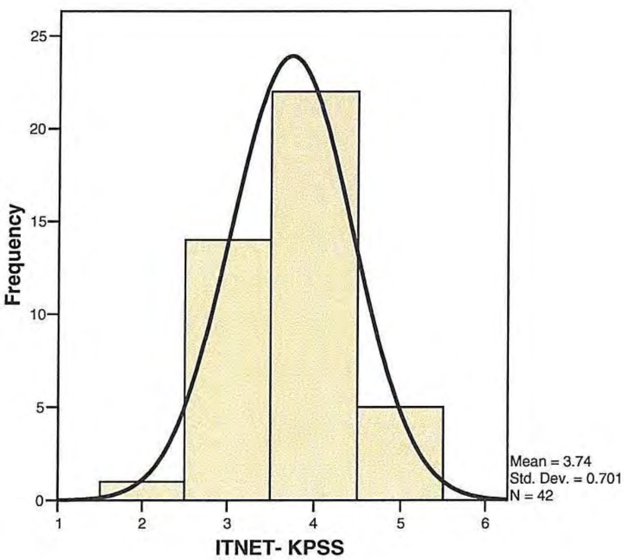
Histogram



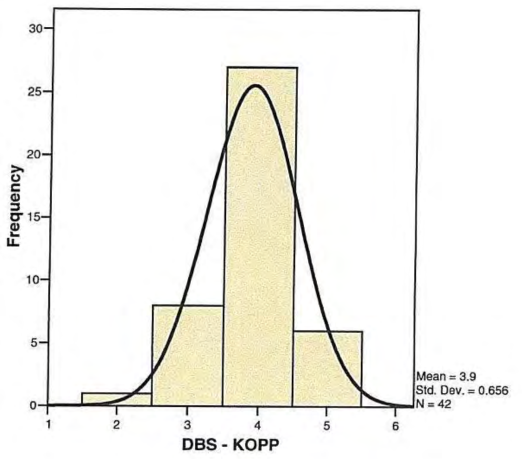
Histogram



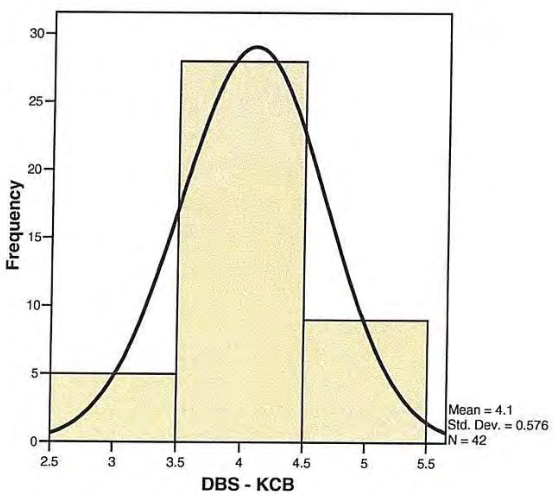
Histogram



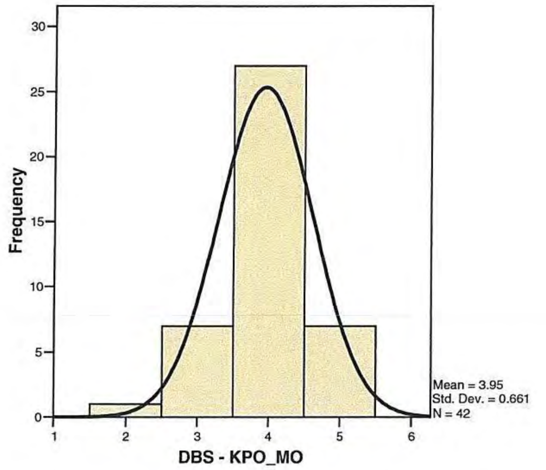
Histogram



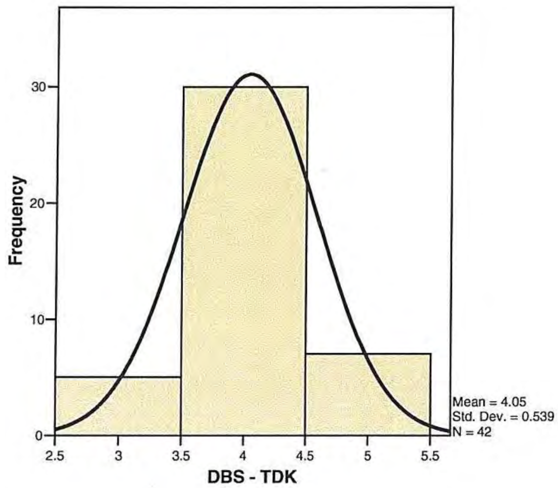
Histogram



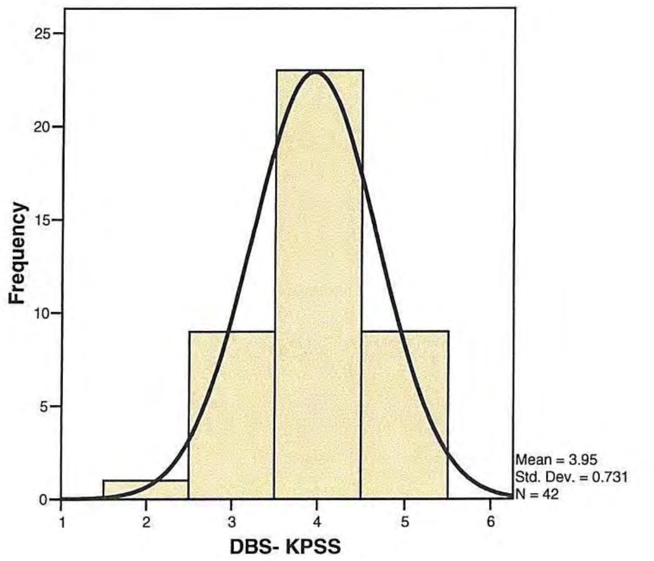
Histogram



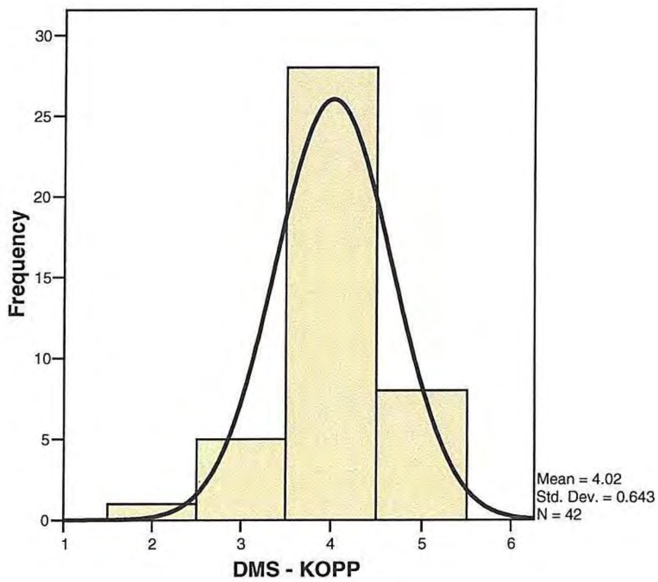
Histogram



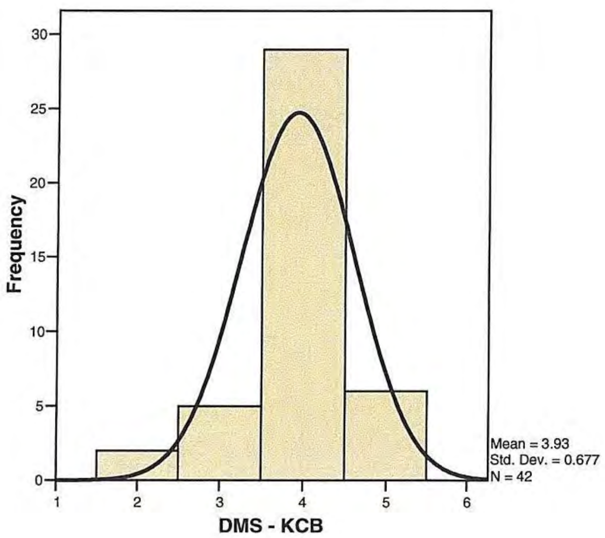
Histogram



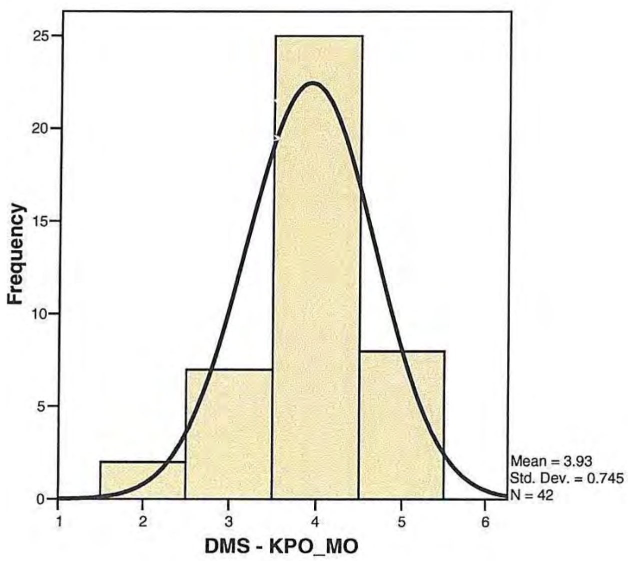
Histogram

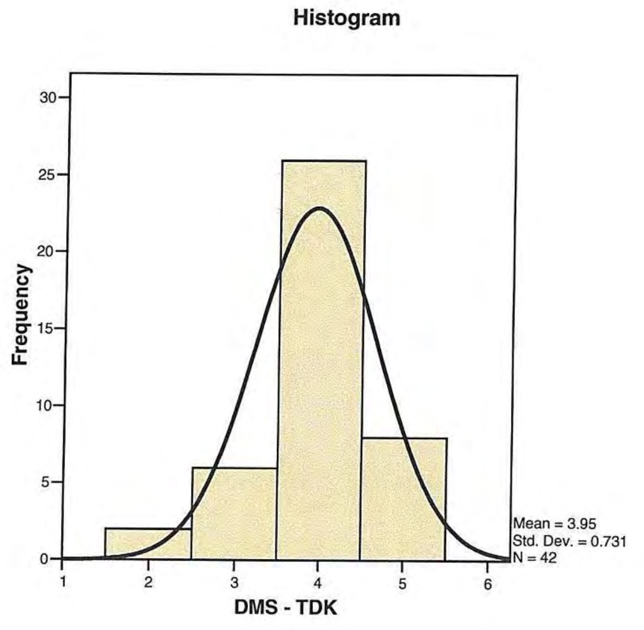


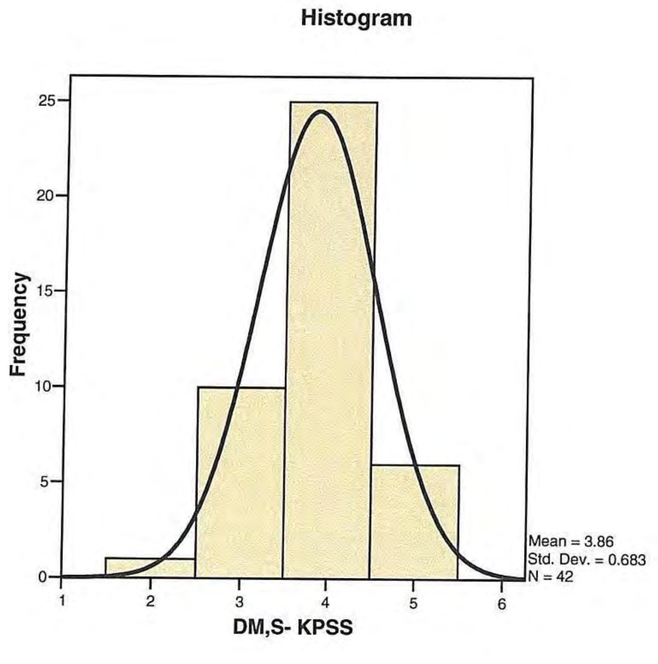
Histogram

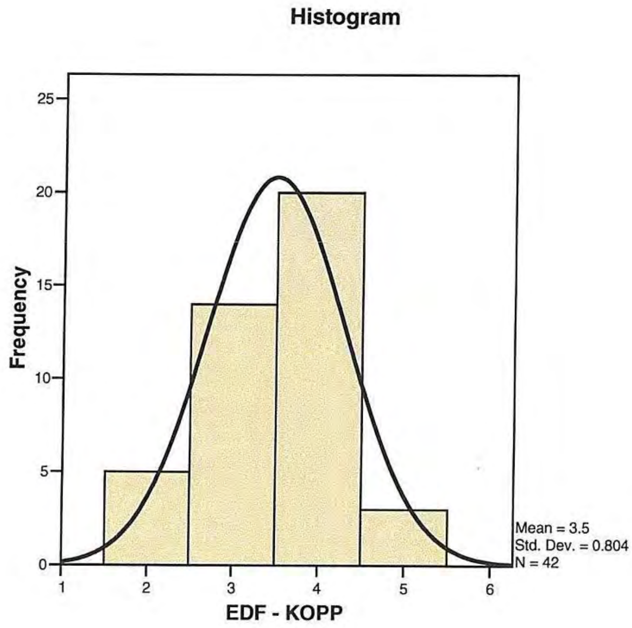


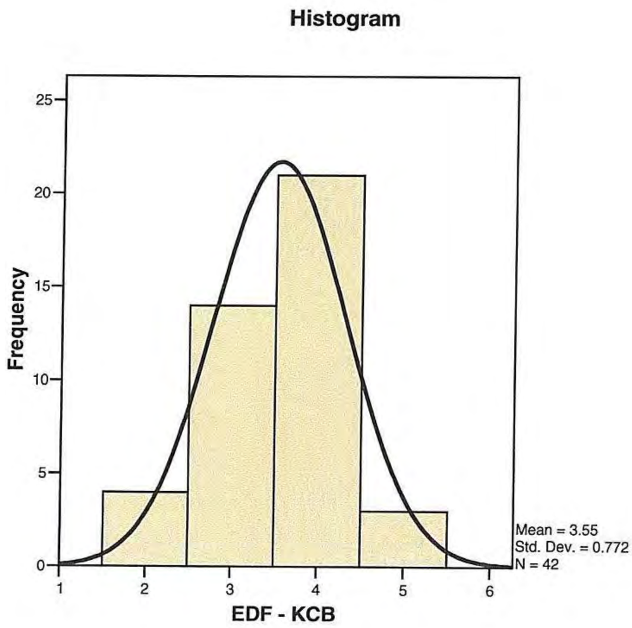
Histogram



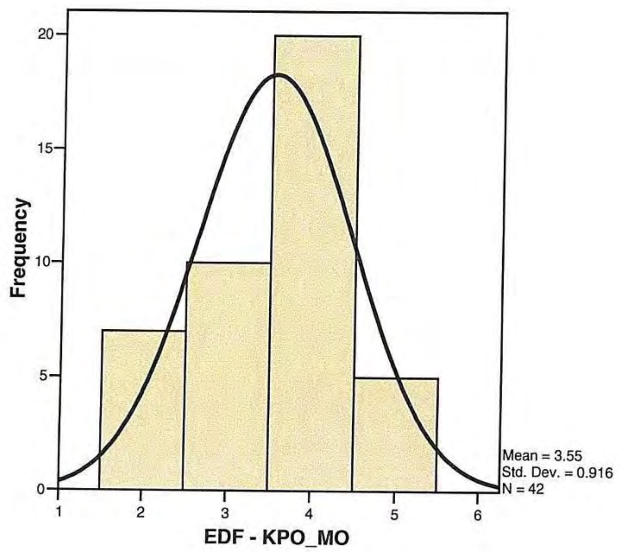

Histogram
Frequency
30
25
20
15
10
5
0
1
2
3
4
5
6
DMS - TDK
Mean = 3.95
Std. Dev. = 0.731
N = 42


Histogram
Frequency
25
20
15
10
5
0
1
2
3
4
5
6
DM,S- KPSS
Mean = 3.86
Std. Dev. = 0.683
N = 42

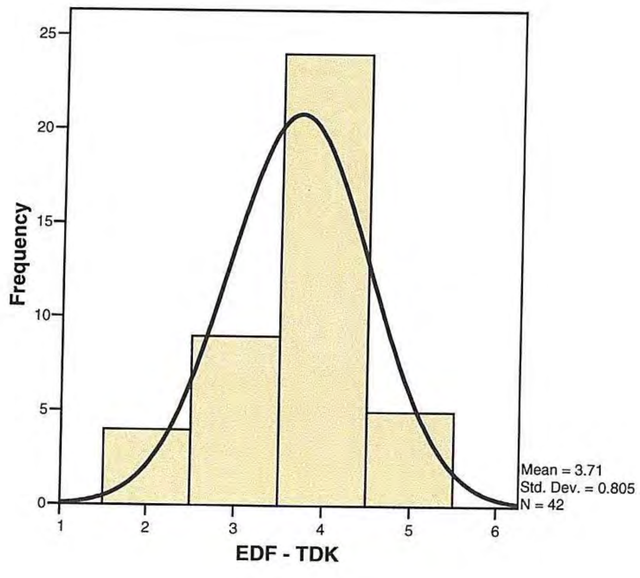

Histogram
Frequency
25
20
15
10
5
0
1
2
3
4
5
6
EDF - KOPP
Mean = 3.5
Std. Dev. = 0.804
N = 42

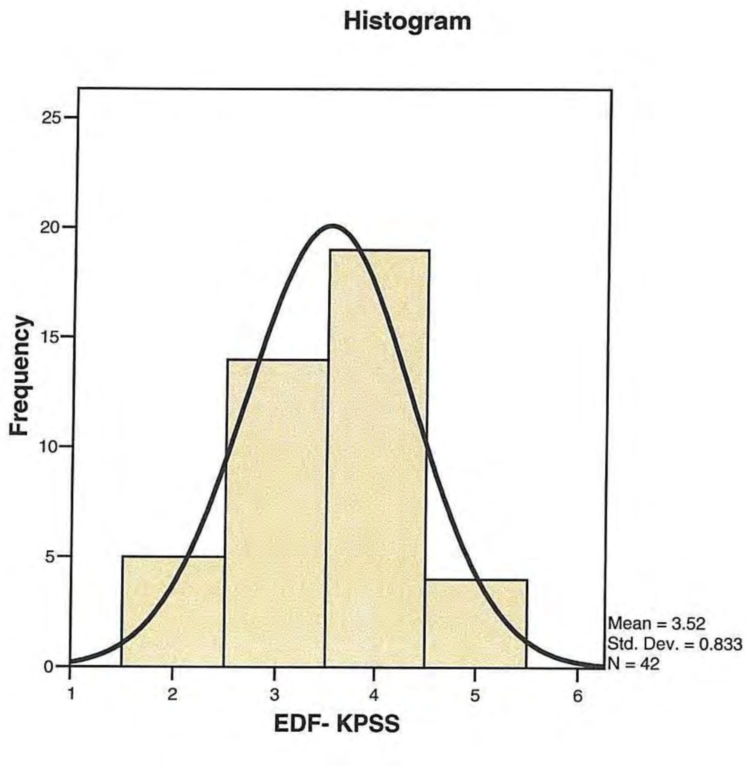

Histogram
Frequency
25
20
15
10
5
0
1
2
3
4
5
6
EDF - KCB
Mean = 3.55
Std. Dev. = 0.772
N = 42

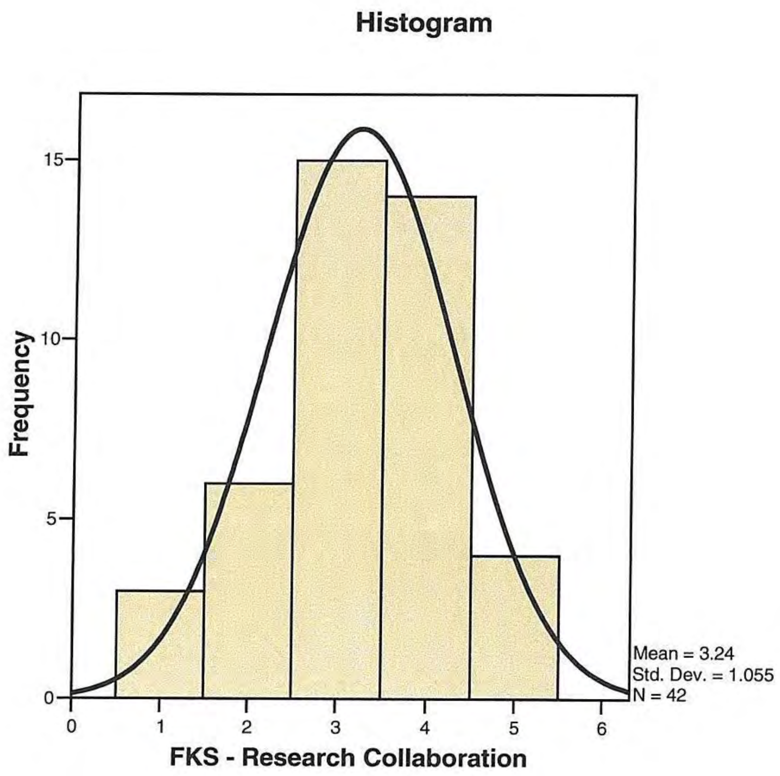
Histogram



Histogram

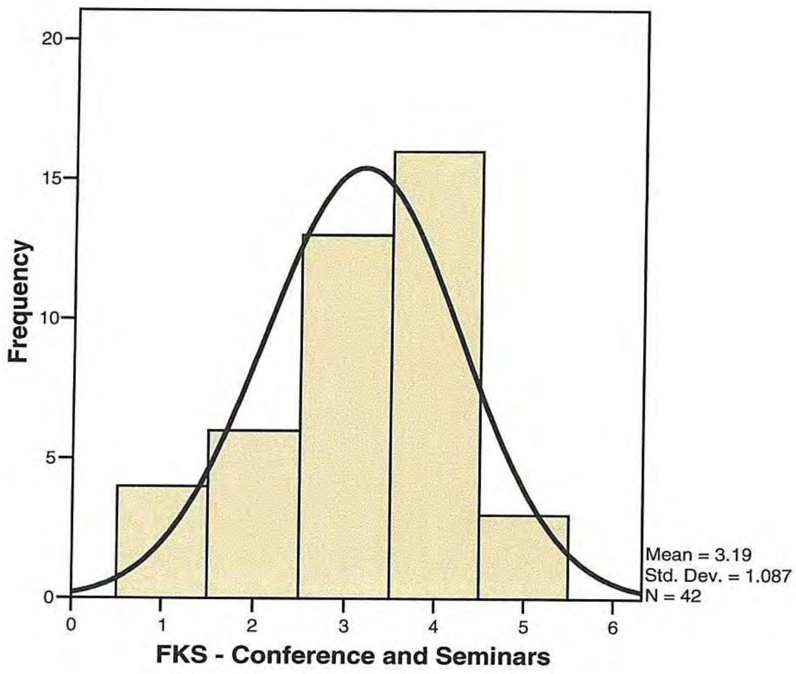



Histogram
Frequency
25
20
15
10
5
0
1
2
3
4
5
6
EDF- KPSS
Mean = 3.52
Std. Dev. = 0.833
N = 42

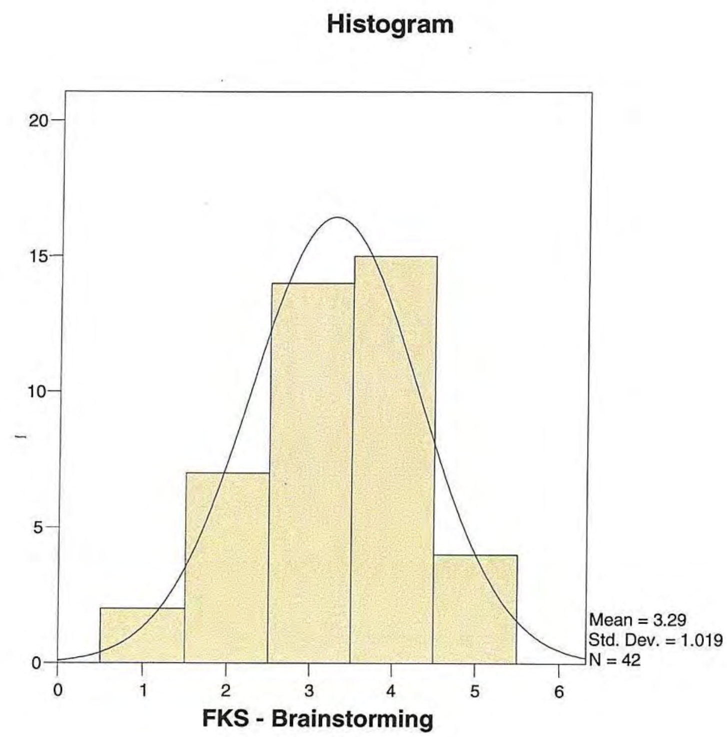


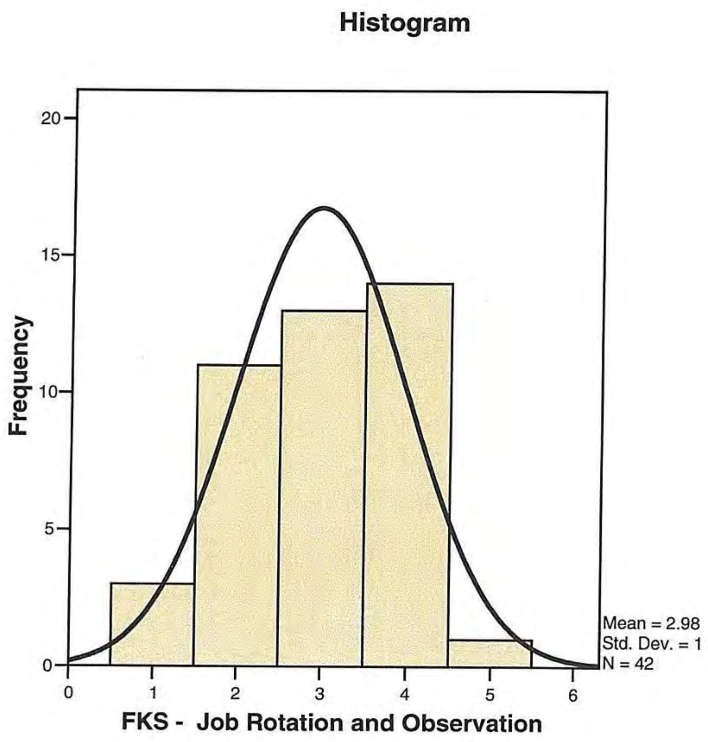
Histogram
15
10
5
0
Frequency
0
1
2
3
4
5
6
Mean = 3.24
Std. Dev. = 1.055
N = 42
FKS - Research Collaboration

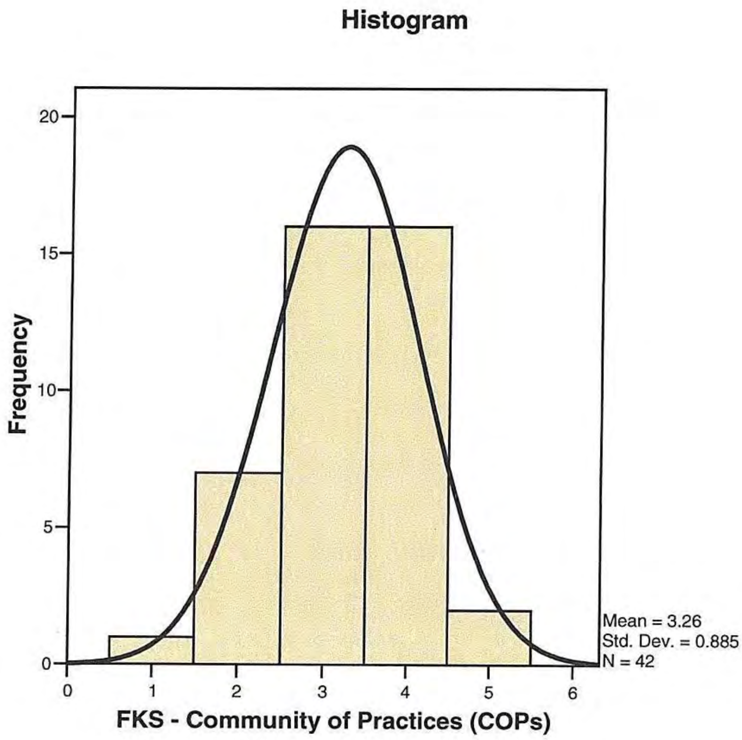
Histogram



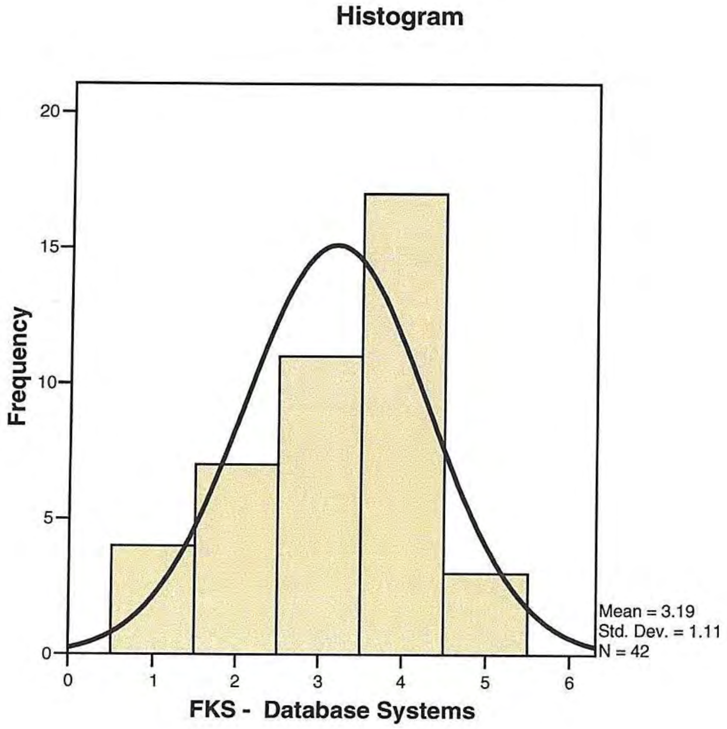
Frequency
20
15
10
5
0
0
1
2
3
4
5
6
Mean = 3.19
Std. Dev. = 1.087
N = 42
FKS - Conference and Seminars

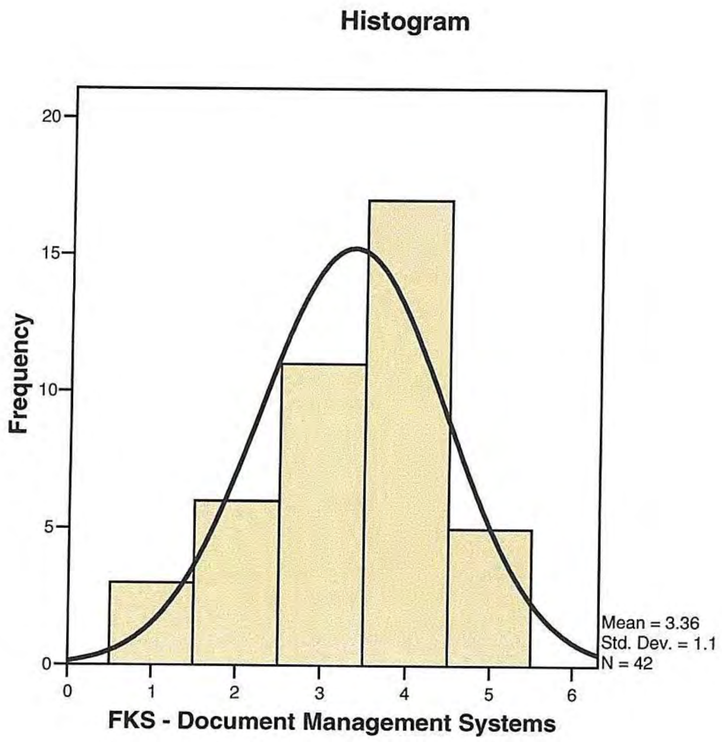

Histogram
20
15
10
5
0
0
1
2
3
4
5
6
FKS - Brainstorming
Mean = 3.29
Std. Dev. = 1.019
N = 42

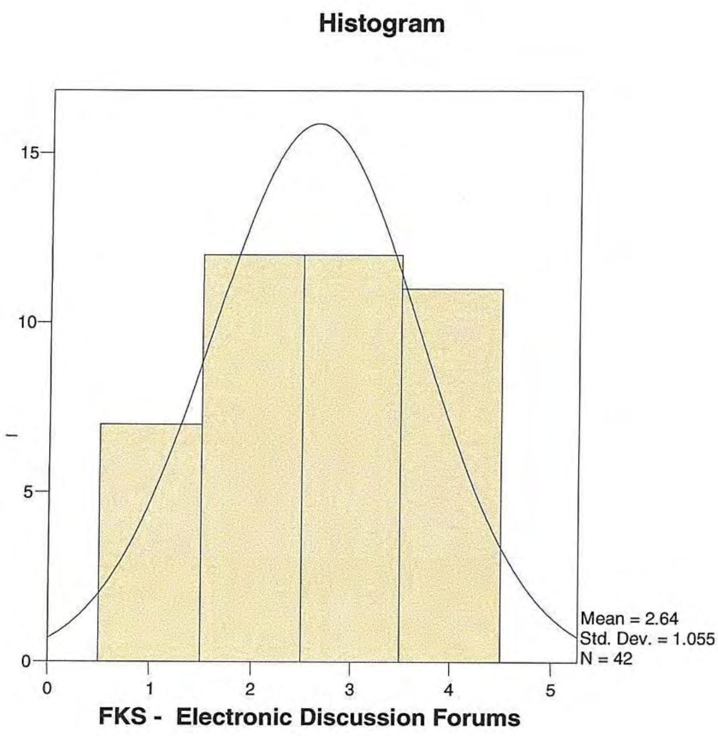

Histogram
Frequency
20
15
10
5
0
0
1
2
3
4
5
6
Mean = 2.98
Std. Dev. = 1
N = 42
FKS - Job Rotation and Observation



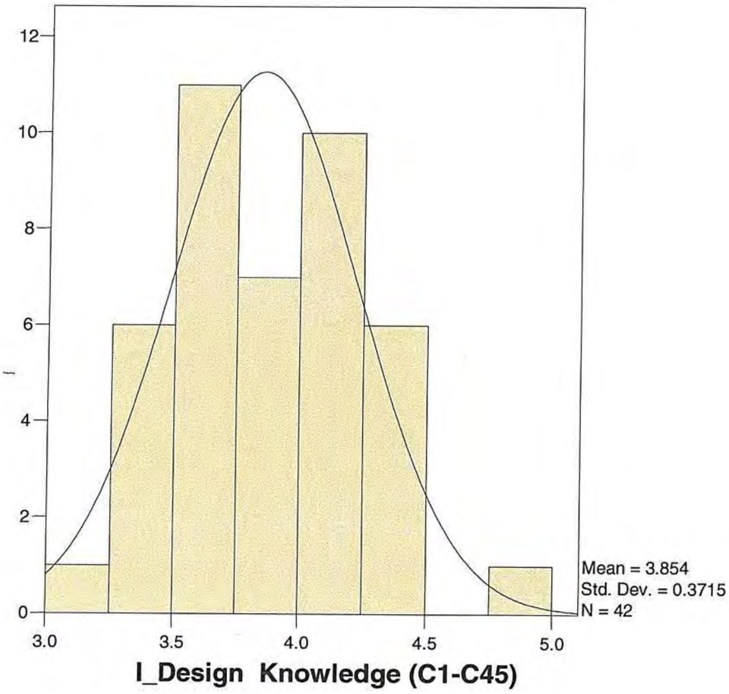
Histogram
20
15
10
5
0
Frequency
0
1
2
3
4
5
6
FKS - Community of Practices (COPs)
Mean = 3.26
Std. Dev. = 0.885
N = 42


Histogram
20
15
10
5
0
Frequency
0
1
2
3
4
5
6
FKS - Database Systems
Mean = 3.19
Std. Dev. = 1.11
N = 42

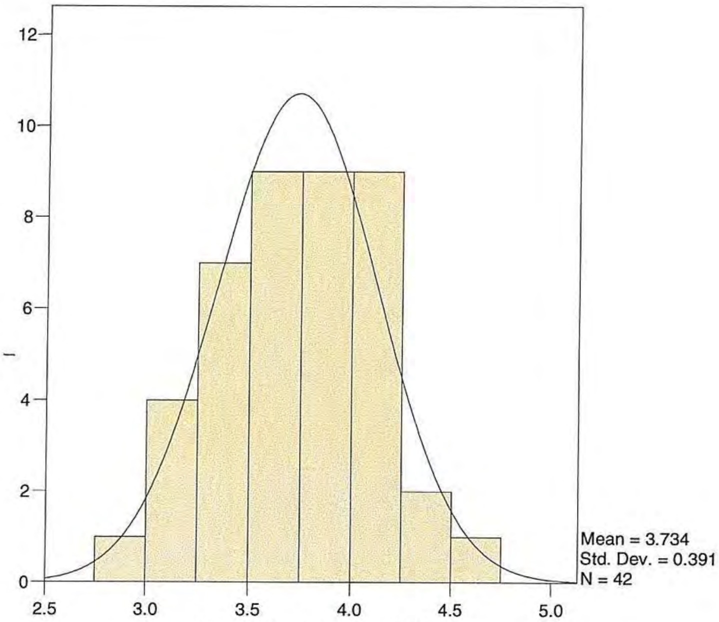

Histogram
Frequency
20
15
10
5
0
0
1
2
3
4
5
6
Mean = 3.36
Std. Dev. = 1.1
N = 42
FKS - Document Management Systems


Histogram
15
10
5
0
0
1
2
3
4
5
Mean = 2.64
Std. Dev. = 1.055
N = 42
FKS - Electronic Discussion Forums

Histogram


12
10
8
6
4
2
0
3.0
3.5
4.0
4.5
5.0
Mean = 3.854
Std. Dev. = 0.3715
N = 42
I_Design Knowledge (C1-C45)

Histogram



I_Design Knowledge (C1-D9)

APPENDIX F5

APPENDIX F5: SUMMARY OF CROSS TABULATIONS

Table 5.1
Positive relationship between application of Research Collaboration (RC) and improvement in the identified knowledge areas

No.	Variables	Response Scales					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agrec	
1.	RC – KOPP	-	-	9[1] (21.4)[2]	24 (57.1)	9 (21.4)	42 (100.0)
2.	RC – KCB	-	-	4 (9.5)	28 (66.7)	10 (23.8)	42 (100.0)
3.	RC - KPO_MO	1 (2.4)	1 (2.4)	4 (9.5)	27 (64.3)	9 (21.4)	42 (100.0)
4.	RC – TDK	-	-	-	25 (59.5)	17 (40.5)	42 (100.0)
5.	RC-KPSS	-	-	5 (11.9)	26 (61.9)	11 (26.2)	42 (100.0)

Notes: - No Response
1 Figures in brackets ( ) denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

RC – KOPP *Knowledge of Organisational Processes and Procedures*
RC – KCB *Knowledge of Client Business*
RC - KPO_MO *Knowledge to Predict Outcomes.. and Motivates Others*
RC – TDK *Technical or Domain Knowledge of design*
RC-KPSS *Knowledge of People with Skills for Specific tasks*

The above notation is used for all the subsequent tables.

Table 5.2
Positive relationship between application of Conference and Seminars (CS) and improvement in the identified knowledge areas

No.	Parameters	Response Scales					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	CS-KOPP	-	2 (4.8)	11 (26.2)	25 (59.5)	4 (9.5)	42 100.0
2.	CS-KCB	-	-	8[1] (19.0)[2]	32 (76.2)	2 (4.8)	42 100.0
3.	CS-KPO_MO	-	1 (2.4)	9 (21.4)	25 (59.5)	7 (16.7)	42 100.0
4.	CS-TDK	-	2 (4.8)	7 (16.7)	26 (61.9)	7 (16.7)	42 100.0
5.	CS-KPSS-	-	5 (11.9)	4 (9.5)	25 (59.5)	8 (19.0)	42 100.0

Notes: - No Response

1 Figures in brackets ( ) denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

Table 5.3
Positive relationship between application of Brainstorming (BS) and improvement in the identified knowledge areas

No.	Parameters	Response Scales					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	BS-KOPP	-	3[1] (7.1)[2]	7 (16.7)	25 (59.5)	7 (16.7)	42 (100.0)
2.	BS-KCB	-	1 (2.4)	7 (16.7)	25 (61.9)	8 (19.0)	42 (100.0)
3.	BS-KPO_MO	-	1 (2.4)	7 (19.0)	28 (85.7)	6 (14.3)	42 (100.0)
4.	BS-TDK	-	1 (2.4)	9 (21.4)	24 (57.1)	8 (19.0)	42 (100.0)
5.	BS-KPSS	1 (2.4)	2 (4.8)	5 (11.9)	29 (69.0)	5 (11.9)	42 (100.0)

Notes: - No Response
1 Figures in brackets ( ) denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

Table 5.4
Positive relationship between application of Job Rotation and Observation (JR) and improvement in the identified knowledge areas

No.	Parameters	Response Scale					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	JR-KOPP	-	2[1] (4.8)[2]	12 (28.6)	24 (57.1)	4 (9.5)	42 (100.0)
2.	JR-KCB	-	3 (7.1)	8 (19.0)	30 (71.4)	1 (2.4)	42 (100.0)
3.	JR-KPO_MO	-	3 (7.1)	13 (31.0)	23 (54.8)	3 (7.1)	42 (100.0)
4.	JR-TDK	-	2 (4.8)	6 (14.3)	29 (69.0)	5 (1.9)	42 (100.0)
5.	JR-KPSS	-	2 (4.8)	11 (26.2)	25 (59.5)	4 (9.5)	42 (100.0)

Notes: - No Response

1 Figures in brackets () denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale

Table 5.5
Positive relationship between application of Community of Practice (COPs) and improvement in the identified knowledge areas

No.	Parameters	Response Scales					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	COPs-KOPP	-	1[1] (2.4)[2]	12 (28.6)	21 (50.0)	8 (19.0)	42 (100.0)
2.	COPs -KCB	-	2 (4.8)	11 (26.2)	24 (57.1)	5 (11.9)	42 (100.0)
3.	COPs -KPO_MO	-	3 (7.1)	13 (31.0)	21 (50.0)	5 (11.9)	42 (100.0)
4.	COPs -TDK	-	1 (2.4)	13 (31.0)	22 (52.4)	6 (14.2)	42 (100.0)
5.	COPs -KPSS	-	2 (4.8)	9 (21.4)	24 (57.1)	7 (16.7)	42 (100.0)

Notes: - No Response

1 Figures in brackets () denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

Table 5.6
Positive relationship between application of Intranets (ITNET) and improvement in the identified knowledge areas

No.	Parameters	Response Scales					
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	Total
1.	ITNET -KOPP	-	2[1] (4.8)[2]	10 23.8	21 50.0	9 21.4	42 (100.0)
2.	ITNET -KCB	-	4 9.5	8 19.0	28 66.7	2 4.8	42 (100.0)
3.	ITNET -KPO_MO	-	2 4.8	12 28.6	23 54.8	5 11.9	42 (100.0)
4.	ITNET -TDK	-	1 2.4	10 23.8	24 57.1	7 16.7	42 (100.0)
5.	ITNET -KPSS	-	1 2.4	14 33.3	22 52.4	5 11.9	42 (100.0)

Notes: - No Response

1 Figures in brackets ( ) denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

Table 5.7
Positive relationship between application of Database Systems (DBS) and improvement in the identified knowledge areas

No.	Variables	Response Scale					
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	Total
1.	DBS -KOPP	-	1[1] (2.4)[2]	8 19.0	27 64.3	6 14.3	42 (100.0)
2.	DBS -KCB	-	-	5 11.9	28 66.7	9 21.4	42 (100.0)
3.	DBS - KPO_MO	-	1 (2.4)	7 16.7	27 64.3	7 16.7	42 (100.0)
4.	DBS -TDK	--	-	5 11.9	30 71.4	7 16.7	42 (100.0)
5.	DBS -KPSS	-	1 (2.4)	9 (21.4)	23 (54.8)	9 (21.4)	42 (100.0)

Notes: - No Response

1 Figures in brackets ( ) denotes the percentage of the response to the total number
2 The number refers to the frequency of responses for the particular scale.

Table 5.8

Positive relationship between application of Document Management Systems (DMS) and improvement in the identified knowledge areas

No.	Variables	Response Scales					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	DMS -KOPP	-	1[1] (2.4)[2]	5 11.9	28 66.7	8 19.0	42 (100.0)
2.	DMS -KCB	-	2 4.8	5 11.9	29 69.0	6 14.3	42 (100.0)
3.	DMS - KPO_MO	-	2 4.8	7 16.7	25 59.5	8 19.0	42 (100.0)
4.	DMS -TDK	-	2 4.8	6 14.3	26 61.9	8 19.0	42 (100.0)
5.	DMS -KPSS	-	1 2.4	10 23.8	25 59.5	6 14.3	42 (100.0)

Notes: - No Response

1 Figures in brackets ( ) denotes the percentage of the response to the total number

2 The number refers to the frequency of responses for the particular scale.

Table 5.9

Positive relationship between application of Electronic Discussion Forums (EDF) and improvement in the identified knowledge areas

No.	Variables	Response Scale					Total
		[1] Strongly Disagree	[2] Disagree	[3] Nether Agree nor Disagree	[4] Agree	[5]Strongly Agree	
1.	EDF -KOPP	-	5[1] (11.9)[2]	14 33.3	20 47.6	3 7.1	42 (100.0)
2.	EDF -KCB	-	4 9.5	14 33.3	21 50.0	3 7.1	42 (100.0)
3.	EDF - KPO_MO	-	7 16.7	10 23.8	20 47.6	5 11.9	42 (100.0)
4.	EDF -TDK	-	4 9.5	9 21.4	24 57.1	5 11.9	42 (100.0)
5.	EDF -KPSS	-	5 11.9	14 33.3	19 45.2	4 9.5	42 (100.0)

Notes: - No Response

1 Figures in brackets ( ) denotes the percentage of the response to the total number

2 The number refers to the frequency of responses for the particular scale.

APPENDIX F6

Appendix F6.1: Cronbach's alpha for Application of Research collaboration (RC)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.766	.768	5

Item Statistics

	Mean	Std. Deviation	N
RC - KOPP	4.00	.663	42
RC - KCB	4.14	.566	42
RC - KPO_MO	4.00	.796	42
RC - TDK	4.40	.497	42
RC - KPSS	4.14	.608	42

Inter-Item Correlation Matrix

	RC - KOPP	RC - KCB	RC - KPO_MO	RC - TDK	RC - KPSS
RC - KOPP	1.000	.520	.601	.370	.363
RC - KCB	.520	1.000	.433	.223	.577
RC - KPO_MO	.601	.433	1.000	.308	.302
RC - TDK	.370	.223	.308	1.000	.289
RC - KPSS	.363	.577	.302	.289	1.000

The covariance matrix is calculated and used in the analysis.

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.138	4.000	4.405	.405	1.101	.027	5
Inter-Item Correlations	.399	.223	.601	.378	2.695	.016	5

The covariance matrix is calculated and used in the analysis.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.69	5.195	2.279	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RC - KOPP	16.69	3.195	.659	.472	.678
RC - KCB	16.55	3.571	.609	.458	.703
RC - KPO_MO	16.69	2.999	.566	.389	.722
RC - TDK	16.29	4.160	.389	.177	.768
RC - KPSS	16.55	3.668	.497	.361	.737

Appendix F6.2: Cronbach's alpha for Application of Conferences and Seminars (CS)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.750	.758	5

Item Statistics

	Mean	Std. Deviation	N
CS - KOPP	3.74	.701	42
CS - KCB	3.86	.472	42
CS - KPO_MO	3.90	.692	42
CS - TDK..	3.90	.726	42
CS - KPSS.	3.86	.872	42

Inter-Item Correlation Matrix

	CS - KOPP	CS - KCB	CS - KPO_MO	CS - TDK..	CS - KPSS.
CS - KOPP	1.000	.400	.400	.190	.297
CS - KCB	.400	1.000	.405	.244	.483
CS - KPO_MO	.400	.405	1.000	.419	.503
CS - TDK..	.190	.244	.419	1.000	.518
CS - KPSS.	.297	.483	.503	.518	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
CS - KOPP	15.52	4.499	.406	.228	.744
CS - KCB	15.40	4.881	.524	.320	.717
CS - KPO_MO	15.36	4.040	.604	.365	.673
CS - TDK..	15.36	4.235	.480	.304	.719
CS - KPSS.	15.40	3.418	.627	.444	.662

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
19.26	6.198	2.490	5

Appendix F6.3: Cronbach's alpha for Application of Brainstorming (BS)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.831	.834	5

Item Statistics

	Mean	Std. Deviation	N
BS - KOPP	3.86	.783	42
BS - KCB	3.98	.680	42
BS - KPO_MO	3.93	.640	42
BS - TDK	3.93	.712	42
BS - KPSS	3.83	.794	42

Inter-Item Correlation Matrix

	BS - KOPP	BS - KCB	BS - KPO_MO	BS - TDK	BS - KPSS
BS - KOPP	1.000	.497	.466	.506	.549
BS - KCB	.497	1.000	.612	.500	.534
BS - KPO_MO	.466	.612	1.000	.470	.600
BS - TDK	.506	.500	.470	1.000	.281
BS - KPSS	.549	.534	.600	.281	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
BS - KOPP	15.67	4.959	.643	.445	.793
BS - KCB	15.55	5.229	.683	.483	.783
BS - KPO_MO	15.60	5.369	.687	.513	.784
BS - TDK	15.60	5.515	.537	.387	.822
BS - KPSS	15.69	4.999	.616	.492	.802

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
19.52	7.816	2.796	5

Appendix F6.4: Cronbach's alpha for Application of Job Rotation and Observation(JR)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.876	.877	5

Item Statistics

	Mean	Std. Deviation	N
JR - KOPP	3.71	.708	42
JR - KCB	3.69	.643	42
JR - KPO_MO	3.62	.731	42
JR - TDK	3.88	.670	42
JR - KPSS	3.74	.701	42

Inter-Item Correlation Matrix

	JR - KOPP	JR - KCB	JR - KPO_MO	JR - TDK	JR - KPSS
JR - KOPP	1.000	.497	.491	.595	.583
JR - KCB	.497	1.000	.625	.648	.627
JR - KPO_MO	.491	.625	1.000	.553	.610
JR - TDK	.595	.648	.553	1.000	.659
JR - KPSS	.583	.627	.610	.659	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
JR - KOPP	14.93	5.385	.640	.430	.866
JR - KCB	14.95	5.412	.723	.546	.847
JR - KPO_MO	15.02	5.195	.679	.483	.857
JR - TDK	14.76	5.259	.743	.568	.841
JR - KPSS	14.90	5.113	.754	.570	.838

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
18.64	7.991	2.827	5

Appendix F6.5: Cronbach's alpha for Application of Community of Practice (COP)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.932	.932	5

Item Statistics

	Mean	Std. Deviation	N
COP - KOPP	3.86	.751	42
COP - KCB	3.76	.726	42
COP - KPO_MO	3.67	.786	42
COP - TDK	3.79	.717	42
COP - KPSS	3.86	.751	42

Inter-Item Correlation Matrix

	COP - KOPP	COP - KCB	COP - KPO_MO	COP - TDK	COP - KPSS
COP - KOPP	1.000	.786	.619	.757	.654
COP - KCB	.786	1.000	.840	.790	.741
COP - KPO_MO	.619	.840	1.000	.779	.661
COP - TDK	.757	.790	.779	1.000	.712
COP - KPSS	.654	.741	.661	.712	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
COP - KOPP	15.07	7.239	.777	.695	.924
COP - KCB	15.17	6.972	.899	.834	.901
COP - KPO_MO	15.26	6.979	.807	.762	.919
COP - TDK	15.14	7.150	.856	.746	.909
COP - KPSS	15.07	7.287	.763	.594	.927

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
18.93	10.946	3.308	5

Appendix F6.6: Cronbach's alpha for Application of Intranet (ITNET)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.853	.854	5

Item Statistics

	Mean	Std. Deviation	N
ITNET - KOPP	3.88	.803	42
ITNET - KCB	3.67	.721	42
ITNET- KPO_MO	3.74	.734	42
ITNET - TDK	3.88	.705	42
ITNET- KPSS	3.74	.701	42

Inter-Item Correlation Matrix

	ITNET - KOPP	ITNET - KCB	ITNET- KPO_MO	ITNET - TDK	ITNET- KPSS
ITNET - KOPP	1.000	.562	.649	.448	.420
ITNET - KCB	.562	1.000	.706	.399	.644
ITNET- KPO_MO	.649	.706	1.000	.409	.717
ITNET - TDK	.448	.399	.409	1.000	.429
ITNET- KPSS	.420	.644	.717	.429	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ITNET - KOPP	15.02	5.438	.640	.495	.831
ITNET - KCB	15.24	5.503	.726	.562	.807
ITNET- KPO_MO	15.17	5.264	.794	.692	.788
ITNET - TDK	15.02	6.219	.501	.274	.863
ITNET- KPSS	15.17	5.703	.683	.582	.819

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
18.90	8.479	2.912	5

Appendix F6.7: Cronbach's alpha for Application of Database Systems (DBS)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.895	.898	5

Item Statistics

	Mean	Std. Deviation	N
DBS - KOPP	3.90	.656	42
DBS - KCB	4.10	.576	42
DBS - KPO_MO	3.95	.661	42
DBS - TDK	4.05	.539	42
DBS- KPSS	3.95	.731	42

Inter-Item Correlation Matrix

	DBS - KOPP	DBS - KCB	DBS - KPO_MO	DBS - TDK	DBS- KPSS
DBS - KOPP	1.000	.735	.552	.566	.601
DBS - KCB	.735	1.000	.781	.613	.648
DBS - KPO_MO	.552	.781	1.000	.554	.652
DBS - TDK	.566	.613	.554	1.000	.687
DBS- KPSS	.601	.648	.652	.687	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DBS - KOPP	16.05	4.681	.708	.580	.879
DBS - KCB	15.86	4.711	.830	.750	.855
DBS - KPO_MO	16.00	4.585	.741	.653	.872
DBS - TDK	15.90	5.113	.704	.527	.881
DBS- KPSS	16.00	4.293	.757	.602	.871

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
19.95	7.120	2.668	5

Appendix F6.8: Cronbach's alpha for Application of Document Management Systems (DMS)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.899	.901	5

Item Statistics

	Mean	Std. Deviation	N
DMS - KOPP	4.02	.643	42
DMS - KCB	3.93	.677	42
DMS - KPO_MO	3.93	.745	42
DMS - TDK	3.95	.731	42
DMS- KPSS	3.86	.683	42

Inter-Item Correlation Matrix

	DMS - KOPP	DMS - KCB	DMS - KPO_MO	DMS - TDK	DM,S- KPSS
DMS - KOPP	1.000	.676	.614	.677	.618
DMS - KCB	.676	1.000	.763	.683	.716
DMS - KPO_MO	.614	.763	1.000	.486	.554
DMS - TDK	.677	.683	.486	1.000	.670
DM,S- KPSS	.618	.716	.554	.670	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DMS - KOPP	15.67	5.886	.755	.581	.877
DMS - KCB	15.76	5.503	.849	.747	.856
DMS - KPO_MO	15.76	5.649	.692	.612	.891
DMS - TDK	15.74	5.613	.725	.600	.883
DM,S- KPSS	15.83	5.752	.744	.582	.878

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
19.69	8.658	2.942	5

Appendix F6.9: Cronbach's alpha for Application of Electronic Discussion Forum (EDF)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.923	.924	5

Item Statistics

	Mean	Std. Deviation	N
EDF - KOPP	3.50	.804	42
EDF - KCB	3.55	.772	42
EDF - KPO_MO	3.55	.916	42
EDF - TDK	3.71	.805	42
EDF- KPSS	3.52	.833	42

Inter-Item Correlation Matrix

	EDF - KOPP	EDF - KCB	EDF - KPO_MO	EDF - TDK	EDF- KPSS
EDF - KOPP	1.000	.609	.646	.754	.728
EDF - KCB	.609	1.000	.601	.690	.757
EDF - KPO_MO	.646	.601	1.000	.780	.733
EDF - TDK	.754	.690	.780	1.000	.774
EDF- KPSS	.728	.757	.733	.774	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EDF - KOPP	14.33	8.764	.769	.621	.911
EDF - KCB	14.29	9.038	.741	.600	.916
EDF - KPO_MO	14.29	8.160	.778	.650	.911
EDF - TDK	14.12	8.400	.862	.751	.893
EDF- KPSS	14.31	8.268	.857	.743	.893

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
17.83	13.069	3.615	5

Appendix F6.10: Cronbach's alpha for Frequency of Knowledge Sharing (FKS)

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.918	.925	10

Item Statistics

	Mean	Std. Deviation	N
FKS - RC	3.2381	1.05483	42
FKS - CS	3.1905	1.08736	42
FKS - BS	3.2857	1.01898	42
FKS - JR	2.9762	.99971	42
FKS - COP	3.2619	.88509	42
FKS - ITNET	3.0000	1.03594	42
FKS - DBS	3.1905	1.10956	42
FKS - DMS	3.3571	1.10036	42
FKS - EDF	2.6429	1.05510	42
I_Design Knowledge (C1-D9)	3.7338	.39100	42

Inter-Item Correlation Matrix

	FKS – RC	FKS – CS	FKS – BS	FKS - JR	FKS – COPs	FKS – ITNET	FKS - DBS	FKS - DMS	FKS - EDF	I_Design Knowledge (C1-D9)
FKS – RC	1.000	.683	.480	.561	.376	.536	.544	.387	.648	.520
FKS – CS	.683	1.000	.654	.588	.454	.498	.636	.614	.507	.523
FKS – BS	.480	.654	1.000	.581	.267	.439	.512	.646	.369	.527
FKS - JR	.561	.588	.581	1.000	.531	.636	.686	.562	.500	.615
FKS – COPs	.376	.454	.267	.531	1.000	.559	.619	.528	.416	.469
FKS – ITNET	.536	.498	.439	.636	.559	1.000	.806	.578	.580	.576
FKS - DBS	.544	.636	.512	.686	.619	.806	1.000	.802	.622	.626
FKS – DMS	.387	.614	.646	.562	.528	.578	.802	1.000	.428	.619
FKS - EDF	.648	.507	.369	.500	.416	.580	.622	.428	1.000	.531
I_Design Knowledge (C1-D9)	.520	.523	.527	.615	.469	.576	.626	.619	.531	1.000

The covariance matrix is calculated and used in the analysis.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
FKS - RC	28.639	46.282	.675	.632	.911
FKS - CS	28.686	45.005	.747	.668	.907
FKS - BS	28.591	47.157	.636	.624	.914
FKS - JR	28.900	45.894	.753	.618	.907
FKS - COP	28.615	48.942	.595	.459	.916
FKS - ITNET	28.877	45.550	.748	.702	.907
FKS - DBS	28.686	43.346	.856	.860	.900
FKS - DMS	28.520	44.995	.737	.779	.908
FKS - EDF	29.234	46.587	.652	.546	.913
I_Design Knowlesge (C1-D9)	28.143	52.857	.718	.545	.918

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
31.877	57.090	7.5558	10

ANOVA with Friedman's Test and Tukey's Test for Nonadditivity

			Sum of Squares	df	Mean Square	Friedman's Chi-Square	Sig
Between People			234.069	41	5.709		
Within People	Between Items		30.300	9	3.367	7.234	.000
	Residual	Nonadditivity	4.401[a]	1	4.401	9.679	.002
		Balance	167.322	368	.455		
		Total	171.723	369	.465		
	Total		202.024	378	.534		
Total			436.092	419	1.041		

Grand Mean = 3.188

a. Tukey's estimate of power to which observations must be raised to achieve additivity = 2.627.

b. The covariance matrix is calculated and used in the analysis.

Hotelling's T-Squared Test

Hotelling's T-Squared	F	df1	df2	Sig
95.853	8.572	9	33	.000

The covariance matrix is calculated and used in the analysis.

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.530[b]	.414	.659	12.268	41.0	369	.000
Average Measures	.918[c]	.876	.951	12.268	41.0	369	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Appendix F6.11: Cronbach's alpha for Overall Construct

Case Processing Summary

		N	%
Cases	Valid	42	100.0
	Excluded[a]	0	.0
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.946	.950	55

Inter-Item Correlation Matrix - not shown as the Table is very large

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RC - KOPP	201.305	447.613	.541	.	.945
RC - KCB	201.162	449.701	.550	.	.945
RC - KPO_MO	201.305	444.926	.526	.	.945
RC - TDK	200.900	455.504	.352	.	.946
RC - KPSS	201.162	452.135	.415	.	.946
CS - KOPP	201.567	451.128	.390	.	.946
CS - KCB	201.448	456.616	.316	.	.946
CS - KPO_MO	201.400	445.748	.582	.	.945
CS - TDK..	201.400	454.095	.278	.	.947
CS - KPSS.	201.448	447.613	.403	.	.946
BS - KOPP	201.448	453.926	.260	.	.947
BS - KCB	201.329	455.209	.260	.	.947
BS - KPO_MO	201.377	447.547	.564	.	.945
BS - TDK	201.377	449.930	.423	.	.946
BS - KPSS	201.472	455.604	.206	.	.947
JR - KOPP	201.591	448.577	.471	.	.946
JR - KCB	201.615	449.255	.497	.	.946
JR - KPO_MO	201.686	440.049	.738	.	.944
JR - TDK	201.424	451.753	.387	.	.946
JR - KPSS	201.567	447.700	.507	.	.945
COP - KOPP	201.448	448.461	.446	.	.946
COP - KCB	201.543	446.324	.534	.	.945
COP - KPO_MO	201.639	444.711	.540	.	.945
COP - TDK	201.520	447.978	.485	.	.946
COP - KPSS	201.448	446.326	.514	.	.945
ITNET - KOPP	201.424	446.284	.481	.	.946
ITNET - KCB	201.639	443.272	.640	.	.945
ITNET- KPO_MO	201.567	444.518	.586	.	.945
ITNET - TDK	201.424	451.205	.384	.	.946
ITNET- KPSS	201.567	446.308	.555	.	.945
DBS - KOPP	201.400	446.347	.594	.	.945
DBS - KCB	201.210	447.122	.647	.	.945
DBS - KPO_MO	201.353	450.782	.428	.	.946
DBS - TDK	201.258	450.302	.552	.	.945
DBS- KPSS	201.353	446.259	.532	.	.945
DMS - KOPP	201.281	452.037	.394	.	.946
DMS - KCB	201.377	449.185	.473	.	.946
DMS - KPO_MO	201.377	450.972	.369	.	.946
DMS - TDK	201.353	451.277	.367	.	.946
DM,S- KPSS	201.448	448.960	.476	.	.946
EDF - KOPP	201.805	442.254	.601	.	.945
EDF - KCB	201.758	448.372	.436	.	.946
EDF - KPO_MO	201.758	439.126	.606	.	.945
EDF - TDK	201.591	444.749	.525	.	.945
EDF- KPSS	201.781	445.015	.498	.	.945
FKS - Research Collaboration	202.067	440.769	.482	.	.946
FKS - Conference and Seminars	202.115	439.937	.485	.	.946
FKS - Brainstrorming	202.020	441.149	.491	.	.946
FKS - Job Rotation and Observation	202.329	437.711	.586	.	.945
FKS - Community of Practices (COPs)	202.043	446.084	.437	.	.946
FKS - Intranets	202.305	438.608	.542	.	.945
FKS - Database Systems	202.115	434.571	.593	.	.945
FKS - Document Management Systems	201.948	435.147	.585	.	.945
FKS - Ellectronic Discussion Forums	202.662	440.160	.496	.	.946
I_Design Knowlasge (C1-D9)	201.571	446.544	1.000	.	.944

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
205.305	463.221	21.5226	55

ANOVA with Friedman's Test and Tukey's Test for Nonadditivity(b)

			Sum of Squares	df	Mean Square	Friedman's Chi-Square	Sig
Between People			345.310	41	8.422		
Within People	Between Items		241.413	54	4.471	9.921	.000
	Residual	Nonadditivity	19.649(a)	1	19.649	44.462	.000
		Balance	977.976	2213	.442		
		Total	997.625	2214	.451		
	Total		1239.037	2268	.546		
Total			1584.347	2309	.686		

Grand Mean = 3.7328

a Tukey's estimate of power to which observations must be raised to achieve additivity = 3.754.

b The covariance matrix is calculated and used in the analysis.

Hotelling's T-Squared Test

Hotelling's T-Squared	F	df1	df2	Sig
.000[a]	.	.	.	.

The covariance matrix is calculated and used in the analysis.

a. There are not enough cases to compute Hotelling's T-Squared.

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.243[b]	.174	.349	18.691	41.0	2214	.000
Average Measures	.946[c]	.921	.967	18.691	41.0	2214	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

APPENDIX F7:

FACTOR ANALYSIS: – The Principal Component Analysis of the Knowledge Sharing Tools (SPSS OUTPUTS)

Note: The correlation output is omitted due to its size.

Table 1. Communalities

	Initial	Extraction
RC - KOPP	1.000	.770
RC - KCB	1.000	.736
RC - KPO_MO	1.000	.759
RC - TDK	1.000	.825
RC - KPSS	1.000	.683
CS - KOPP	1.000	.762
CS - KCB	1.000	.816
CS - KPO_MO	1.000	.779
CS - TDK..	1.000	.870
CS - KPSS.	1.000	.869
BS - KOPP	1.000	.749
BS - KCB	1.000	.748
BS - KPO_MO	1.000	.885
BS - TDK	1.000	.895
BS - KPSS	1.000	.839
JR - KOPP	1.000	.811
JR - KCB	1.000	.904
JR - KPO_MO	1.000	.924
JR - TDK	1.000	.835
JR - KPSS	1.000	.918
COP - KOPP	1.000	.840
COP - KCB	1.000	.902
COP - KPO_MO	1.000	.878
COP - TDK	1.000	.924
COP - KPSS	1.000	.839
ITNET - KOPP	1.000	.829
ITNET - KCB	1.000	.719
ITNET- KPO_MO	1.000	.822
ITNET - TDK	1.000	.834
ITNET- KPSS	1.000	.850
DBS - KOPP	1.000	.781
DBS - KCB	1.000	.834
DBS - KPO_MO	1.000	.838
DBS - TDK	1.000	.784
DBS- KPSS	1.000	.799
DMS - KOPP	1.000	.864
DMS - KCB	1.000	.939
DMS - KPO_MO	1.000	.833
DMS - TDK	1.000	.877
DM,S- KPSS	1.000	.771
EDF - KOPP	1.000	.877
EDF - KCB	1.000	.896
EOF - KPO_MO	1.000	.877
EDF - TDK	1.000	.915
EDF- KPSS	1.000	.873
FKS - RC	1.000	.828
FKS - CS	1.000	.849
FKS - BS	1.000	.798
FKS - JR	1.000	.743
FKS - COP	1.000	.846
FKS - ITNET	1.000	.830
FKS - DBS	1.000	.881
FKS - DMS	1.000	.862
FKS - EDF	1.000	.800
I_Design Knowledge (C1-D9)	1.000	.999

Extraction Method: Principal Component Analysis.

Table 2: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	15.690	28.528	28.528	15.690	28.528	28.528	6.806	12.374	12.374
2	6.389	11.617	40.145	6.389	11.617	40.145	5.590	10.163	22.538
3	4.468	8.123	48.268	4.468	8.123	48.268	5.530	10.054	32.592
4	3.900	7.090	55.358	3.900	7.090	55.358	5.412	9.840	42.431
5	2.943	5.350	60.708	2.943	5.350	60.708	4.655	8.464	50.895
6	2.557	4.649	65.357	2.557	4.649	65.357	4.601	8.366	59.261
7	2.504	4.553	69.910	2.504	4.553	69.910	3.300	6.001	65.262
8	2.041	3.710	73.620	2.041	3.710	73.620	2.833	5.151	70.413
9	1.593	2.896	76.516	1.593	2.896	76.516	2.160	3.928	74.341
10	1.495	2.718	79.233	1.495	2.718	79.233	2.134	3.880	78.221
11	1.241	2.256	81.490	1.241	2.256	81.490	1.630	2.964	81.185
12	1.193	2.169	83.658	1.193	2.169	83.658	1.360	2.473	83.658
13	.864	1.570	85.229						
14	.836	1.520	86.749						
15	.773	1.406	88.156						
16	.728	1.324	89.479						
17	.650	1.183	90.662						
18	.619	1.126	91.787						
19	.542	.985	92.772						
20	.478	.870	93.642						
21	.433	.788	94.430						
22	.361	.656	95.086						
23	.325	.592	95.677						
24	.306	.557	96.234						
25	.303	.551	96.785						
26	.274	.499	97.284						
27	.265	.482	97.765						
28	.206	.374	98.139						
29	.194	.354	98.493						
30	.159	.290	98.782						
31	.128	.232	99.014						
32	.122	.222	99.236						
33	.090	.164	99.400						
34	.083	.151	99.552						
35	.061	.111	99.663						
36	.055	.100	99.763						
37	.048	.086	99.849						
38	.034	.062	99.911						
39	.031	.056	99.967						
40	.013	.024	99.991						
41	.005	.009	100.000						
42	.000	.000	100.000						
43	.000	.000	100.000						
44	.000	.000	100.000						
45	.000	.000	100.000						
46	.000	.000	100.000						
47	.000	.000	100.000						
48	.000	.000	100.000						
49	.000	.000	100.000						
50	.000	.000	100.000						
51	.000	.000	100.000						
52	.000	.000	100.000						
53	.000	.000	100.000						
54	.000	.000	100.000						
55	.000	.000	100.000						

Extraction Method: Principal Component Analysis.

Scree Plot

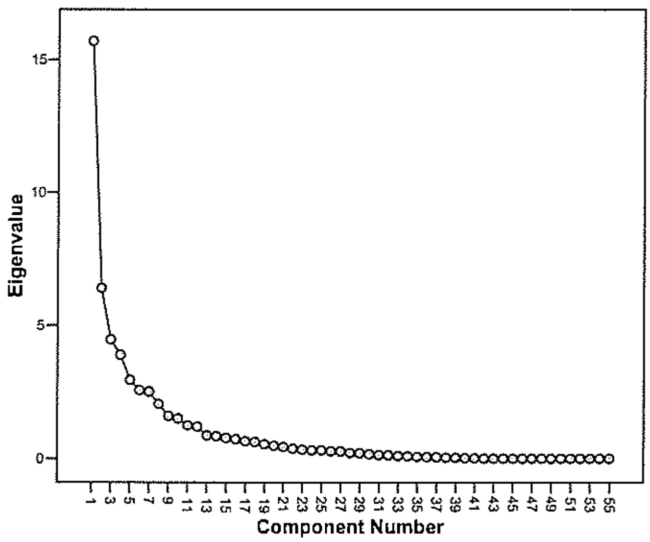


Table 3:Component Matrix(a)

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
I_Design Knowledge (C1-D9)	.992	.098	.063	.004	.011	-.004	.011	-.005	-.012	-.015	.011	.006
JR - KPO_MO	.764	-.056	.012	.191	.070	-.384	.117	-.101	-.026	.186	-.124	-.270
DBS - KCB	.706	-.192	-.214	-.401	.038	-.011	-.242	.101	-.025	.060	.098	-.090
ITNET - KCB	.674	-.156	.175	.072	-.267	.090	.259	.044	-.230	-.004	.063	-.010
EDF - KOPP	.659	-.396	.010	.158	.321	.106	.055	-.037	.085	-.311	-.124	.149
EDF - KPO_MO	.651	-.301	.166	.054	.387	-.089	-.134	-.080	-.297	-.005	-.065	.238
DBS - KOPP	.647	-.118	-.215	-.266	-.047	.284	-.208	-.080	-.221	.108	.195	-.014
DBS - TDK	.629	-.372	-.306	-.188	-.055	.098	.198	-.090	.212	-.112	.051	.034
ITNET- KPO_MO	.621	-.196	.320	.251	-.219	-.013	.229	.317	.069	.058	-.051	-.147
DBS- KPSS	.614	-.288	-.305	-.331	.092	.231	-.036	.161	.104	-.069	-.083	-.161
RC - KCB	.611	-.262	-.081	-.153	-.009	.318	-.328	.078	.177	-.059	-.125	.022
CS - KPO_MO	.600	.148	-.020	-.157	.243	.107	.075	-.014	-.292	.400	-.163	-.158
ITNET- KPSS	.596	-.175	.094	.253	-.192	.131	.300	.300	.160	-.015	.180	-.315
COP - KPO_MO	.581	.209	-.454	.012	-.434	-.049	.118	.018	.061	-.102	-.258	.075
FKS - DBS	.578	.240	.472	-.437	-.159	-.152	-.006	.064	.065	-.117	.037	.062
EDF - TDK	.578	-.383	.108	.195	.506	-.188	.069	.022	.031	-.087	.164	.230
FKS - DMS	.577	.138	.442	-.270	-.171	-.028	.065	-.202	.178	-.279	.227	.079
FKS - JR	.553	.540	.261	-.178	-.089	-.135	.014	-.093	-.045	-.044	-.082	-.034
DM,S- KPSS	.552	-.465	.044	.110	-.222	.309	.032	-.196	.082	.039	.032	-.204
RC - KOPP	.552	.225	-.015	.031	-.051	.311	-.421	-.061	.237	.087	.189	.182
BS - KPO_MO	.551	.196	.384	.460	-.169	.224	-.144	.176	-.072	-.038	-.193	.097
JR - KCB	.546	-.001	-.338	.135	-.040	-.480	-.186	-.323	.290	.077	-.100	.044
DMS - KCB	.544	-.530	.171	.133	-.265	.083	-.100	-.334	-.245	.156	.025	.177
RC - KPO_MO	.538	.288	.073	.247	-.030	.305	-.195	-.136	.229	-.045	-.339	-.003
COP - KPSS	.536	.360	-.461	-.004	-.251	.036	.151	-.049	-.115	.123	.185	.241
FKS - ITNET	.525	.265	.465	-.270	-.081	-.335	-.033	.205	.146	-.050	-.096	.019
DBS - KPO_MO	.510	-.285	-.337	-.318	.106	-.009	-.259	.363	.053	.162	.166	-.126
EDF - KCB	.508	-.471	.065	.110	.270	-.366	-.093	.410	.070	-.062	-.066	.061
JR - KOPP	.502	.078	-.220	.277	.404	-.164	-.322	-.259	-.109	-.039	.124	-.194
ITNET - KOPP	.500	-.255	.482	.297	-.066	-.261	.260	.051	-.076	.053	.049	.199
FKS - EDF	.495	.205	.311	-.372	.102	-.147	-.231	-.011	-.302	-.033	-.196	.247
FKS - RC	.462	.421	.265	-.335	.233	.124	-.244	-.033	-.180	-.133	-.221	-.160
CS - KOPP	.386	.266	.249	-.356	-.031	-.058	.351	.117	.289	.298	.026	.200
DMS - KOPP	.488	-.668	.054	-.100	-.306	-.004	.012	-.014	-.130	.105	-.111	-.181
DMS - TDK	.457	-.577	-.013	.012	-.227	.035	.218	-.453	.152	.058	-.010	-.060
CS - KCB	.295	.570	-.034	-.070	.037	.129	-.006	.199	.155	.518	-.213	-.048
DMS - KPO_MO	.445	-.516	.118	.190	-.290	-.015	-.378	-.070	-.057	.128	.252	.055
JR - KPSS	.491	.499	-.045	.357	.061	-.308	-.115	-.298	.106	.285	.038	-.071
CS - KPSS.	.397	.470	-.152	.102	.412	.090	.231	.168	-.172	.286	.288	-.053
BS - TDK	.420	.427	-.256	.302	.078	.238	-.046	.154	-.249	-.419	.058	-.222
COP - KOPP	.499	.144	-.649	-.035	-.186	-.122	-.127	.084	-.181	-.142	.073	.129
COP - KCB	.589	.149	-.595	-.003	-.300	-.175	-.003	.128	-.043	.026	-.072	.185
COP - TDK	.520	.242	-.533	.131	-.305	-.234	.253	.098	-.136	-.096	-.157	.141
FKS - BS	.455	.374	.521	.009	-.047	.180	.074	-.288	-.005	-.143	.169	-.088
BS - KPSS	.178	.357	.357	.636	.065	.055	-.065	.150	.106	.175	.252	.090
BS - KCB	.246	.355	.188	.575	-.205	.009	-.199	.184	-.025	-.153	-.199	-.128
BS - KOPP	.252	.421	-.101	.537	-.151	.316	.044	.107	-.143	-.078	.165	.144
FKS - CS	.465	.363	.330	-.496	.064	.186	.123	-.280	-.110	-.007	.009	-.039
FKS - COP	.441	.227	.107	-.472	-.205	-.270	.053	.293	-.113	-.191	.279	-.186
EDF- KPSS	.555	-.363	.000	.123	.600	-.056	.040	.201	.023	-.065	-.050	.074
RC - KPSS	.462	-.181	-.009	.019	.220	.547	-.054	.080	.231	.087	-.105	.083
JR - TDK	.398	.305	-.146	.211	.105	-.439	-.277	-.275	.209	-.131	.104	-.300
ITNET - TDK	.434	-.305	-.055	.154	.249	-.028	.651	-.089	-.048	-.067	-.116	-.106
CS - TDK..	.279	.390	-.330	-.049	.329	.209	.491	-.336	-.135	-.059	-.038	.000
RC - TDK	.350	.449	-.287	-.135	.270	.108	.197	.003	.467	-.167	.115	.131

Extraction Method: Principal Component Analysis.
a 12 components extracted.

Table 4:Rotated Component Matrix(a)

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
FKS - DBS	.900	.092	.088	.096	.107	.033	.014	-.100	-.011	.090	.125	-.002
FKS - ITNET	.785	-.048	.080	.202	.003	.101	.125	-.233	.069	.168	.187	-.129
FKS - DMS	.782	.258	.016	.078	.140	.097	.114	.126	-.302	.086	.114	.090
FKS - CS	.775	.104	-.041	-.084	.176	-.036	.000	.375	.206	-.103	-.005	.053
FKS - JR	.736	-.021	.214	-.027	-.008	.227	.230	.120	.177	.003	.019	-.057
FKS - EDF	.700	.034	.129	.268	.072	.015	-.014	-.122	.237	-.363	-.091	-.057
FKS - COP	.692	-.063	.307	.009	.029	-.172	.001	-.171	.010	.358	-.152	.239
FKS - RC	.677	-.150	-.045	.058	.283	.124	.113	.107	.306	-.148	-.298	-.136
FKS - BS	.654	.199	-.173	-.059	.031	.399	.153	.313	-.044	.038	-.031	.105
I_Design Knowledge (C1-D9)	.532	.316	.373	.389	.341	.274	.256	.129	.176	.140	.009	.047
DMS - KCB	.085	.889	.088	.248	.118	.103	.016	-.078	.024	-.192	.001	.055
DMS - TDK	-.009	.801	.070	.150	.172	-.186	.157	.202	-.142	.129	.161	-.128
DMS - KOPP	.063	.757	.119	.217	.209	-.194	-.075	-.215	.103	.234	-.084	-.141
DM,S- KPSS	.015	.716	.018	.102	.402	.102	.063	.100	-.025	.239	-.033	-.050
DMS - KPO_MO	-.007	.681	.041	.192	.236	.140	.150	-.415	-.101	-.026	-.027	.220
ITNET - KCB	.338	.553	.275	.238	.050	.230	-.128	.096	.105	.257	-.042	.078
COP - TDK	.062	.050	.908	.100	-.074	.126	.116	.135	.073	.125	-.008	-.095
COP - KCB	.058	.082	.897	.079	.192	.046	.167	-.045	.098	.030	.051	.011
COP - KOPP	.027	.010	.827	.074	.223	-.009	.177	-.017	.008	-.052	-.207	.152
COP - KPO_MO	.158	.152	.817	-.068	.182	.140	.124	.101	.013	.119	.050	-.251
COP - KPSS	.152	.094	.753	-.078	.127	.165	.107	.240	.130	-.045	.125	.297
EDF - TDK	.076	.201	-.017	.874	.136	.042	.185	.093	-.064	.017	.074	.177
EDF- KPSS	.003	.051	-.015	.857	.302	.010	.095	.087	.125	.104	-.033	.007
EDF - KCB	.048	.109	.103	.801	.151	-.040	.102	-.366	.024	.236	.021	-.066
EDF - KPO_MO	.241	.339	.041	.735	.161	.071	.100	.015	.184	-.260	-.128	.060
EDF - KOPP	.084	.293	.093	.713	.378	.121	.064	.218	-.161	.032	-.077	-.157
ITNET - KOPP	.283	.467	.002	.538	-.270	.287	-.009	-.075	-.012	.169	.224	.030
RC - KCB	.166	.272	.149	.216	.730	.069	.025	-.110	.006	-.011	-.043	-.123
DBS- KPSS	.132	.182	.285	.261	.676	-.226	-.019	.068	.121	.231	-.116	-.072
RC - KPSS	-.007	.161	-.053	.256	.673	.223	-.114	.193	.116	.020	.134	-.059
RC - KOPP	.257	.094	.153	-.030	.593	.396	.242	-.042	-.019	-.186	.140	.217
DBS - KPO_MO	.051	.064	.288	.277	.590	-.278	.079	-.295	.225	.213	-.054	.233
DBS - KCB	.327	.231	.328	.253	.564	-.249	.157	-.145	.190	.079	-.107	.152
DBS - KOPP	.237	.382	.306	.076	.543	-.053	.036	.054	.215	-.086	-.186	.299
DBS - TDK	.087	.394	.379	.288	.463	-.224	.058	.225	-.142	.212	.105	-.015
BS - KPO_MO	.286	.219	.081	.190	.120	.807	-.018	-.096	.110	.033	-.029	-.152
BS - KPSS	.033	-.076	-.158	.114	-.122	.781	.198	-.044	.061	.093	.204	.271
BS - KCB	.090	-.042	.116	-.012	-.083	.745	.189	-.161	.024	.136	-.182	-.222
BS - KOPP	-.058	-.033	.314	-.064	.014	.734	-.023	.206	-.006	.020	-.088	.226
RC - KPO_MO	.220	.095	.115	.012	.407	.548	.252	.169	.083	-.079	.045	-.338
JR - TDK	.186	-.074	.169	.066	.019	.108	.849	.000	-.067	.082	-.133	.000
JR - KPSS	.195	.024	.229	.027	-.090	.382	.737	.119	.271	-.058	.176	.082
JR - KCB	.049	.199	.448	.210	.110	-.057	.729	-.053	-.038	-.077	.198	-.147
JR - KOPP	.002	.057	.105	.348	.191	.141	.663	.121	.150	-.112	-.321	.164
JR - KPO_MO	.247	.367	.256	.414	-.022	.082	.518	.050	.344	.289	.022	-.111
CS - TDK..	.092	-.115	.276	.053	.028	-.010	.092	.843	.205	-.051	-.051	.052
ITNET - TDK	-.032	.314	.119	.523	-.078	-.077	-.016	.524	.102	.360	.034	-.134
RC - TDK	.218	-.423	.287	.084	.370	.060	.220	.457	-.140	.106	.273	.076
CS - KPO_MO	.294	.164	.152	.201	.220	.031	.099	.216	.702	.005	-.043	.047
CS - KCB	.226	-.265	.176	-.186	.223	.276	.120	.048	.601	.055	.347	-.048
CS - KPSS.	.128	-.266	.186	.204	.070	.246	.141	.371	.490	.145	.035	.468
ITNET- KPSS	.114	.345	.145	.215	.212	.307	.007	.050	.022	.707	.040	.079
ITNET- KPO_MO	.250	.405	.108	.334	.064	.363	-.054	-.122	.114	.530	.122	-.100
CS - KOPP	.539	-.042	.114	.059	.075	-.027	-.077	.132	.195	.164	.596	.061
BS - TDK	.108	-.196	.367	.068	.190	.488	.123	.276	.023	.172	-.550	.083

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 17 iterations.

Component Transformation Matrix

Component	1	2	3	4	5	6	7	8	9	10	11	12
1	.462	.367	.397	.411	.386	.221	.251	.103	.171	.152	.009	.034
2	.384	-.581	.197	-.399	-.149	.386	.200	.235	.184	-.102	.030	.073
3	.543	.177	-.667	.100	-.244	.287	-.167	-.164	-.032	.028	.125	-.068
4	-.518	.121	-.016	.192	-.268	.726	.252	.022	-.079	.095	-.039	-.026
5	-.104	-.441	-.396	.599	.145	-.140	.175	.330	.231	-.161	-.089	.107
6	-.143	.110	-.207	-.277	.595	.331	-.474	.373	.053	-.064	-.102	.054
7	.004	.070	.131	.112	-.400	-.130	-.327	.629	.029	.449	.286	-.033
8	-.037	-.434	.159	.242	.117	.163	-.459	-.488	.156	.456	.002	.071
9	-.054	-.203	-.157	-.081	.381	-.008	.311	-.006	-.396	.280	.627	-.231
10	-.197	.191	-.092	-.160	-.004	-.035	.087	-.154	.729	-.064	.527	.212
11	.031	.042	-.085	-.061	.002	-.029	.105	.004	-.296	.181	.006	.924
12	.018	-.052	.276	.287	-.061	.133	-.342	-.030	-.267	-.633	.460	.125

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Frequency of Knoweldege Sharing by Areas / Approaches

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.844
Bartlett's Test of Sphericity	Approx. Chi-Square	242.663
	df	36
	Sig.	.000

Communalities

	Initial	Extraction
FKS - RC	1.000	.551
FKS - CS	1.000	.651
FKS - BS	1.000	.498
FKS - JR	1.000	.658
FKS - COP	1.000	.455
FKS - ITNET	1.000	.660
FKS - DBS	1.000	.809
FKS - DMS	1.000	.639
FKS - EDF	1.000	.522

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.443	60.478	60.478	5.443	60.478	60.478
2	.885	9.835	70.313			
3	.831	9.234	79.547			
4	.504	5.598	85.146			
5	.446	4.957	90.103			
6	.330	3.668	93.770			
7	.261	2.905	96.676			
8	.209	2.327	99.003			
9	.090	.997	100.000			

Extraction Method: Principal Component Analysis.

Scree Plot

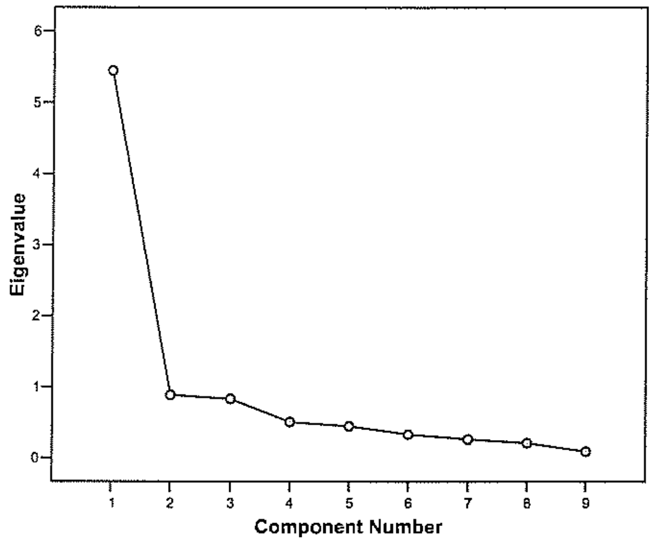


Table 9: Component Matrix(a)

	Component
	1
FKS - DBS	.900
FKS - ITNET	.812
FKS - JR	.811
FKS - CS	.807
FKS - DMS	.799
FKS - RC	.743
FKS - EDF	.723
FKS - BS	.706
FKS - COP	.674

Extraction Method: Principal Component Analysis.
a 1 components extracted.

Reproduced Correlations

		FKS - RC	FKS - CS	FKS - BS	FKS - JR	FKS - COP	FKS - ITNET	FKS - DBS	FKS - DMS	FKS - EDF
Reproduced Correlation	FKS - RC	.551(b)	.599	.524	.602	.501	.603	.668	.594	.537
	FKS - CS	.599	.651(b)	.570	.654	.544	.655	.726	.645	.583
	FKS - BS	.524	.570	.498(b)	.572	.476	.573	.635	.564	.510
	FKS - JR	.602	.654	.572	.658(b)	.547	.659	.730	.648	.586
	FKS - COP	.501	.544	.476	.547	.455(b)	.548	.607	.539	.487
	FKS - ITNET	.603	.655	.573	.659	.548	.660(b)	.731	.649	.587
	FKS - DBS	.668	.726	.635	.730	.607	.731	.809(b)	.719	.650
	FKS - DMS	.594	.645	.564	.648	.539	.649	.719	.639(b)	.577
	FKS - EDF	.537	.583	.510	.586	.487	.587	.650	.577	.522(b)
Residual(a)	FKS - RC		.083	-.044	-.042	-.125	-.067	-.124	-.206	.111
	FKS - CS	.083		.085	-.067	-.090	-.157	-.090	-.031	-.076
	FKS - BS	-.044	.085		.009	-.209	-.134	-.123	.082	-.140
	FKS - JR	-.042	-.067	.009		-.016	-.023	-.044	-.086	-.086
	FKS - COP	-.125	-.090	-.209	-.016		.011	.012	-.011	-.071
	FKS - ITNET	-.067	-.157	-.134	-.023	.011		.076	-.071	-.007
	FKS - DBS	-.124	-.090	-.123	-.044	.012	.076		.083	-.028
	FKS - DMS	-.206	-.031	.082	-.086	-.011	-.071	.083		-.150
	FKS - EDF	.111	-.076	-.140	-.086	-.071	-.007	-.028	-.150	

Extraction Method: Principal Component Analysis.
a Residuals are computed between observed and reproduced correlations. There are 24 (66.0%) nonredundant residuals with absolute values greater than 0.05.
b Reproduced communalities

APPENDIX F8

Table 1: Summary of Open-Ended Questions to Question Section D.10

No.	Respondents Responses
1.	By conducting a more design aesthetic and particularly - award environment and mindset among the public to promote eagerness among the professional to excel. Be critical of functions and practicality. Make professional accountable for their action and decision, and give credit when it is due. When one is self-motivated, all of the above approaches work.
2.	Everybody should know everything in the practice but at the same time one should specialise in something, so that you can achieve a quality work and not by jumble up everything into one. Specialising in something is very important so that you can contribute the best to the industry and on award.
3.	Based on my experience, reading and observe on/about current projects is helpful to enhance the designer's construction knowledge. Through this, you can be more creative. Companies should have a library for those designers to have an idea. Bring them to places that they will create and combine new ideas on design.
4.	Before one becomes a designer / design engineer it is necessary to have construction or site engineering experiences. Addition to this would be operations and maintenance experiences. There are many aspects of installation which cannot be covered by codes and standards alone but have developed over times based on operation / commissioning experiences.e.g.it would be difficult for a piping design engineer to understand the need to have individual tagging number for exactly the same type / rating valves if he has never involved in operation / installation / commissioning. Internet / intranet is also the current most effective tool for communication and transfer of knowledge.
5.	On hand practice. Motivation and keenness to learn
6.	Each company should start their own R&D unit regardless of size of company
7.	From experience, I feel the most important factor that is overlooked during the design and the construction stage is practicability. As designers are educated and qualified no doubt, there are certain aspects that cannot be transferred from text books to the real world. There are certain methods that the site personnel (whether they have formal training or not) can observe, and their opinions through an open discussion should be fairly addressed. Often this problem arises due to the attitude of the designers into thinking and stereotyping that all contractors reasoning for changes or reengineering are due to financial reasons.
8.	It all start with education. Provide more syllabuses that more focusing on how to deal and manage construction. Expose them to real world. Lectures from P.E are needed to share experiences.
9.	Site exposure. Understanding site overall. Strong on basic design / foundation
10.	conduct competition on construction inventory system
11.	Adopting other than traditional contract procurement such as design and built which will enhances the design requirements, improving design specification and
12.	Change the culture of designers. Designer shall get the experience on site to the project which he designed.
13.	Designer shall expose themselves in the methodology of actual construction
14.	Employer to pay for training. Emphasis on continuous improvements
15.	The designer should go out into the field to feel, instead of sitting behind his/her desk designing. In this way, he /she can better foresee what he/she needs to design to the client's requirements.

Appendix F9: Correlations Analysis

9.1. Application of Research Collaboration (RC) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	RC - KOPP	RC - KCB	RC - KPO_MO	RC - TDK	RC - KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.561(**)	.568(**)	.552(**)	.372(*)	.438(**)
	Sig. (2-tailed)	.	.000	.000	.000	.015	.004
	N	42	42	42	42	42	42
RC - KOPP	Pearson Correlation	.561(**)	1	.520(**)	.601(**)	.370(*)	.363(*)
	Sig. (2-tailed)	.000	.	.000	.000	.016	.018
	N	42	42	42	42	42	42
RC - KCB	Pearson Correlation	.568(**)	.520(**)	1	.433(**)	.223	.577(**)
	Sig. (2-tailed)	.000	.000	.	.004	.156	.000
	N	42	42	42	42	42	42
RC - KPO_MO	Pearson Correlation	.552(**)	.601(**)	.433(**)	1	.308(*)	.302
	Sig. (2-tailed)	.000	.000	.004	.	.047	.052
	N	42	42	42	42	42	42
RC - TDK	Pearson Correlation	.372(*)	.370(*)	.223	.308(*)	1	.289
	Sig. (2-tailed)	.015	.016	.156	.047	.	.064
	N	42	42	42	42	42	42
RC - KPSS	Pearson Correlation	.438(**)	.363(*)	.577(**)	.302	.289	1
	Sig. (2-tailed)	.004	.018	.000	.052	.064	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Note: the result using1-tailed test show similar results for all

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.701(a)	.492	.421	.29744	.492	6.969	5	36	.000	2.573

a Predictors: (Constant), RC - KPSS, RC - TDK, RC - KPO_MO, RC - KCB, RC - KOPP
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.083	5	.617	6.969	.000(a)
	Residual	3.185	36	.088		
	Total	6.268	41			

a Predictors: (Constant), RC - KPSS, RC - TDK, RC - KPO_MO, RC - KCB, RC - KOPP
b Dependent Variable: I_Design Knowledge (C1-D9)

9.2. Application of Conferences and Seminars (CS) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	CS - KOPP	CS - KCB	CS - KPO_MO	CS - TDK..	CS - KPSS.
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.417(**)	.336(*)	.605(**)	.310(*)	.436(**)
	Sig. (2-tailed)	.	.006	.030	.000	.046	.004
	N	42	42	42	42	42	42
CS - KOPP	Pearson Correlation	.417(**)	1	.400(**)	.400(**)	.190	.297
	Sig. (2-tailed)	.006	.	.009	.009	.229	.056
	N	42	42	42	42	42	42
CS - KCB	Pearson Correlation	.336(*)	.400(**)	1	.405(**)	.244	.483(**)
	Sig. (2-tailed)	.030	.009	.	.008	.120	.001
	N	42	42	42	42	42	42
CS - KPO_MO	Pearson Correlation	.605(**)	.400(**)	.405(**)	1	.419(**)	.503(**)
	Sig. (2-tailed)	.000	.009	.008	.	.006	.001
	N	42	42	42	42	42	42
CS - TDK..	Pearson Correlation	.310(*)	.190	.244	.419(**)	1	.518(**)
	Sig. (2-tailed)	.046	.229	.120	.006	.	.000
	N	42	42	42	42	42	42
CS - KPSS.	Pearson Correlation	.436(**)	.297	.483(**)	.503(**)	.518(**)	1
	Sig. (2-tailed)	.004	.056	.001	.001	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.647(a)	.419	.339	.31800	.419	5.196	5	36	.001	2.040

a Predictors: (Constant), CS - KPSS., CS - KOPP, CS - TDK.., CS - KCB, CS - KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.627	5	.525	5.196	.001(a)
	Residual	3.641	36	.101		
	Total	6.268	41			

a Predictors: (Constant), CS - KPSS., CS - KOPP, CS - TDK.., CS - KCB, CS - KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

9.3. Application of Brainstorming (BS) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	BS - KOPP	BS - KCB	BS - KPO_MO	BS - TDK	BS - KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.293	.290	.584(**)	.450(**)	.241
	Sig. (2-tailed)	.	.059	.062	.000	.003	.124
	N	42	42	42	42	42	42
BS - KOPP	Pearson Correlation	.293	1	.497(**)	.466(**)	.506(**)	.549(**)
	Sig. (2-tailed)	.059	.	.001	.002	.001	.000
	N	42	42	42	42	42	42
BS - KCB	Pearson Correlation	.290	.497(**)	1	.612(**)	.500(**)	.534(**)
	Sig. (2-tailed)	.062	.001	.	.000	.001	.000
	N	42	42	42	42	42	42
BS - KPO_MO	Pearson Correlation	.584(**)	.466(**)	.612(**)	1	.470(**)	.600(**)
	Sig. (2-tailed)	.000	.002	.000	.	.002	.000
	N	42	42	42	42	42	42
BS - TDK	Pearson Correlation	.450(**)	.506(**)	.500(**)	.470(**)	1	.281
	Sig. (2-tailed)	.003	.001	.001	.002	.	.072
	N	42	42	42	42	42	42
BS - KPSS	Pearson Correlation	.241	.549(**)	.534(**)	.600(**)	.281	1
	Sig. (2-tailed)	.124	.000	.000	.000	.072	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.644(a)	.414	.333	.31937	.414	5.090	5	36	.001	2.193

a Predictors: (Constant), BS - KPSS, BS - TDK, BS - KCB, BS - KOPP, BS - KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.596	5	.519	5.090	.001(a)
	Residual	3.672	36	.102		
	Total	6.268	41			

a Predictors: (Constant), BS - KPSS, BS - TDK, BS - KCB, BS - KOPP, BS - KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

9.4. Application of Job Rotation and Observation (JR) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	JR - KOPP	JR - KCB	JR - KPO_MO	JR - TDK	JR - KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.496(**)	.519(**)	.754(**)	.413(**)	.530(**)
	Sig. (2-tailed)	.	.001	.000	.000	.007	.000
	N	42	42	42	42	42	42
JR - KOPP	Pearson Correlation	.496(**)	1	.497(**)	.491(**)	.595(**)	.583(**)
	Sig. (2-tailed)	.001	.	.001	.001	.000	.000
	N	42	42	42	42	42	42
JR - KCB	Pearson Correlation	.519(**)	.497(**)	1	.625(**)	.648(**)	.627(**)
	Sig. (2-tailed)	.000	.001	.	.000	.000	.000
	N	42	42	42	42	42	42
JR - KPO_MO	Pearson Correlation	.754(**)	.491(**)	.625(**)	1	.553(**)	.610(**)
	Sig. (2-tailed)	.000	.001	.000	.	.000	.000
	N	42	42	42	42	42	42
JR - TDK	Pearson Correlation	.413(**)	.595(**)	.648(**)	.553(**)	1	.659(**)
	Sig. (2-tailed)	.007	.000	.000	.000	.	.000
	N	42	42	42	42	42	42
JR - KPSS	Pearson Correlation	.530(**)	.583(**)	.627(**)	.610(**)	.659(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.775(a)	.601	.546	.26359	.601	10.842	5	36	.000	1.921

a Predictors: (Constant), JR - KPSS, JR - KOPP, JR - KPO_MO, JR - KCB, JR - TDK
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.767	5	.753	10.842	.000(a)
	Residual	2.501	36	.069		
	Total	6.268	41			

a Predictors: (Constant), JR - KPSS, JR - KOPP, JR - KPO_MO, JR - KCB, JR - TDK
b Dependent Variable: I_Design Knowledge (C1-D9)

9.5. Application of Community of Practice (COP) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	COP - KOPP	COP - KCB	COP - KPO_MO	COP - TDK	COP - KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.474(**)	.556(**)	.565(**)	.510(**)	.539(**)
	Sig. (2-tailed)	.	.002	.000	.000	.001	.000
	N	42	42	42	42	42	42
COP - KOPP	Pearson Correlation	.474(**)	1	.786(**)	.619(**)	.757(**)	.654(**)
	Sig. (2-tailed)	.002	.	.000	.000	.000	.000
	N	42	42	42	42	42	42
COP - KCB	Pearson Correlation	.556(**)	.786(**)	1	.840(**)	.790(**)	.741(**)
	Sig. (2-tailed)	.000	.000	.	.000	.000	.000
	N	42	42	42	42	42	42
COP - KPO_MO	Pearson Correlation	.565(**)	.619(**)	.840(**)	1	.779(**)	.661(**)
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000
	N	42	42	42	42	42	42
COP - TDK	Pearson Correlation	.510(**)	.757(**)	.790(**)	.779(**)	1	.712(**)
	Sig. (2-tailed)	.001	.000	.000	.000	.	.000
	N	42	42	42	42	42	42
COP - KPSS	Pearson Correlation	.539(**)	.654(**)	.741(**)	.661(**)	.712(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.612(a)	.374	.287	.33010	.374	4.304	5	36	.004	2.493

a Predictors: (Constant), COP - KPSS, COP - KOPP, COP - KPO_MO, COP - TDK, COP - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.345	5	.469	4.304	.004(a)
	Residual	3.923	36	.109		
	Total	6.268	41			

a Predictors: (Constant), COP - KPSS, COP - KOPP, COP - KPO_MO, COP - TDK, COP - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

9.6. Application of Intranet (ITNET) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	ITNET - KOPP	ITNET - KCB	ITNET- KPO_MO	ITNET - TDK	ITNET- KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.509(**)	.659(**)	.609(**)	.412(**)	.577(**)
	Sig. (2-tailed)	.	.001	.000	.000	.007	.000
	N	42	42	42	42	42	42
ITNET - KOPP	Pearson Correlation	.509(**)	1	.562(**)	.649(**)	.448(**)	.420(**)
	Sig. (2-tailed)	.001	.	.000	.000	.003	.006
	N	42	42	42	42	42	42
ITNET - KCB	Pearson Correlation	.659(**)	.562(**)	1	.706(**)	.399(**)	.644(**)
	Sig. (2-tailed)	.000	.000	.	.000	.009	.000
	N	42	42	42	42	42	42
ITNET- KPO_MO	Pearson Correlation	.609(**)	.649(**)	.706(**)	1	.409(**)	.717(**)
	Sig. (2-tailed)	.000	.000	.000	.	.007	.000
	N	42	42	42	42	42	42
ITNET - TDK	Pearson Correlation	.412(**)	.448(**)	.399(**)	.409(**)	1	.429(**)
	Sig. (2-tailed)	.007	.003	.009	.007	.	.005
	N	42	42	42	42	42	42
ITNET- KPSS	Pearson Correlation	.577(**)	.420(**)	.644(**)	.717(**)	.429(**)	1
	Sig. (2-tailed)	.000	.006	.000	.000	.005	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.712(a)	.507	.439	.29293	.507	7.409	5	36	.000	2.067

a Predictors: (Constant), ITNET- KPSS, ITNET - KOPP, ITNET - TDK, ITNET - KCB, ITNET- KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.179	5	.636	7.409	.000(a)
	Residual	3.089	36	.086		
	Total	6.268	41			

a Predictors: (Constant), ITNET- KPSS, ITNET - KOPP, ITNET - TDK, ITNET - KCB, ITNET- KPO_MO
b Dependent Variable: I_Design Knowledge (C1-D9)

9.7. Application of Intranet (ITNET) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	DBS - KOPP	DBS - KCB	DBS - KPO_MO	DBS - TDK	DBS- KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.613(**)	.663(**)	.453(**)	.570(**)	.557(**)
	Sig. (2-tailed)	.	.000	.000	.003	.000	.000
	N	42	42	42	42	42	42
DBS - KOPP	Pearson Correlation	.613(**)	1	.735(**)	.552(**)	.566(**)	.601(**)
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000
	N	42	42	42	42	42	42
DBS - KCB	Pearson Correlation	.663(**)	.735(**)	1	.781(**)	.613(**)	.648(**)
	Sig. (2-tailed)	.000	.000	.	.000	.000	.000
	N	42	42	42	42	42	42
DBS - KPO_MO	Pearson Correlation	.453(**)	.552(**)	.781(**)	1	.554(**)	.652(**)
	Sig. (2-tailed)	.003	.000	.000	.	.000	.000
	N	42	42	42	42	42	42
DBS - TDK	Pearson Correlation	.570(**)	.566(**)	.613(**)	.554(**)	1	.687(**)
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000
	N	42	42	42	42	42	42
DBS- KPSS	Pearson Correlation	.557(**)	.601(**)	.648(**)	.652(**)	.687(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.726(a)	.528	.462	.28675	.528	8.046	5	36	.000	2.207

a Predictors: (Constant), DBS- KPSS, DBS - KOPP, DBS - KPO_MO, DBS - TDK, DBS - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.308	5	.662	8.046	.000(a)
	Residual	2.960	36	.082		
	Total	6.268	41			

a Predictors: (Constant), DBS- KPSS, DBS - KOPP, DBS - KPO_MO, DBS - TDK, DBS - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

9.8. Application of Document Management Systems (DMS) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSs

Correlations

Variables		I_Design Knowledge (C1-D9)	DMS - KOPP	DMS - KCB	DMS - KPO_MO	DMS - TDK	DM,S- KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.419(**)	.498(**)	.399(**)	.397(**)	.501(**)
	Sig. (2-tailed)	.	.006	.001	.009	.009	.001
	N	42	42	42	42	42	42
DMS - KOPP	Pearson Correlation	.419(**)	1	.676(**)	.614(**)	.677(**)	.618(**)
	Sig. (2-tailed)	.006	.	.000	.000	.000	.000
	N	42	42	42	42	42	42
DMS - KCB	Pearson Correlation	.498(**)	.676(**)	1	.763(**)	.683(**)	.716(**)
	Sig. (2-tailed)	.001	.000	.	.000	.000	.000
	N	42	42	42	42	42	42
DMS - KPO_MO	Pearson Correlation	.399(**)	.614(**)	.763(**)	1	.486(**)	.554(**)
	Sig. (2-tailed)	.009	.000	.000	.	.001	.000
	N	42	42	42	42	42	42
DMS - TDK	Pearson Correlation	.397(**)	.677(**)	.683(**)	.486(**)	1	.670(**)
	Sig. (2-tailed)	.009	.000	.000	.001	.	.000
	N	42	42	42	42	42	42
DMS- KPSS	Pearson Correlation	.501(**)	.618(**)	.716(**)	.554(**)	.670(**)	1
	Sig. (2-tailed)	.001	.000	.000	.000	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.543(a)	.295	.197	.35046	.295	3.007	5	36	.023	2.183

a Predictors: (Constant), DM,S- KPSS, DMS - KPO_MO, DMS - TDK, DMS - KOPP, DMS - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.846	5	.369	3.007	.023(a)
	Residual	4.422	36	.123		
	Total	6.268	41			

a Predictors: (Constant), DM,S- KPSS, DMS - KPO_MO, DMS - TDK, DMS - KOPP, DMS - KCB
b Dependent Variable: I_Design Knowledge (C1-D9)

9.9. Application of Electronic Discussion Forums (EDF) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSS

Correlations

Variables		I_Design Knowledge (C1-D9)	EDF - KOPP	EDF - KCB	EDF - KPO_MO	EDF - TDK	EDF- KPSS
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.625(**)	.464(**)	.632(**)	.551(**)	.527(**)
	Sig. (2-tailed)	.	.000	.002	.000	.000	.000
	N	42	42	42	42	42	42
EDF - KOPP	Pearson Correlation	.625(**)	1	.609(**)	.646(**)	.754(**)	.728(**)
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000
	N	42	42	42	42	42	42
EDF - KCB	Pearson Correlation	.464(**)	.609(**)	1	.601(**)	.690(**)	.757(**)
	Sig. (2-tailed)	.002	.000	.	.000	.000	.000
	N	42	42	42	42	42	42
EDF - KPO_MO	Pearson Correlation	.632(**)	.646(**)	.601(**)	1	.780(**)	.733(**)
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000
	N	42	42	42	42	42	42
EDF - TDK	Pearson Correlation	.551(**)	.754(**)	.690(**)	.780(**)	1	.774(**)
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000
	N	42	42	42	42	42	42
EDF- KPSS	Pearson Correlation	.527(**)	.728(**)	.757(**)	.733(**)	.774(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.
	N	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.699(a)	.488	.417	.29851	.488	6.869	5	36	.000	1.948

a Predictors: (Constant), EDF- KPSS, EDF - KOPP, EDF - KPO_MO, EDF - KCB, EDF - TDK
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.060	5	.612	6.869	.000(a)
	Residual	3.208	36	.089		
	Total	6.268	41			

a Predictors: (Constant), EDF- KPSS, EDF - KOPP, EDF - KPO_MO, EDF - KCB, EDF - TDK
b Dependent Variable: I_Design Knowledge (C1-D9)

9.10. Frequency of Knowledge Sharing (FKS) and Improved Designer Construction Knowledge – in respect of KOPP, KCB, KPMO_MO, TDK and KPSS

Correlations

Variables		I_Design Knowledge (C1-D9)	FKS - RC	FKS - CS	FKS - BS	FKS - JR	FKS - COP	FKS - ITNET	FKS - DBS	FKS - DMS	FKS - EDF
I_Design Knowledge (C1-D9)	Pearson Correlation	1	.520(**)	.523(**)	.527(**)	.615(**)	.469(**)	.576(**)	.626(**)	.619(**)	.531(**)
	Sig. (2-tailed)	.	.000	.000	.000	.000	.002	.000	.000	.000	.000
	N	42	42	42	42	42	42	42	42	42	42
FKS – RC	Pearson Correlation	.520(**)	1	.683(**)	.480(**)	.561(**)	.376(*)	.536(**)	.544(**)	.387(*)	.648(**)
	Sig. (2-tailed)	.000	.	.000	.001	.000	.014	.000	.000	.011	.000
	N	42	42	42	42	42	42	42	42	42	42
FKS – CS	Pearson Correlation	.523(**)	.683(**)	1	.654(**)	.588(**)	.454(**)	.498(**)	.636(**)	.614(**)	.507(**)
	Sig. (2-tailed)	.000	.000	.	.000	.000	.003	.001	.000	.000	.001
	N	42	42	42	42	42	42	42	42	42	42
FKS – 8S	Pearson Correlation	.527(**)	.480(**)	.654(**)	1	.581(**)	.267	.439(**)	.512(**)	.646(**)	.369(*)
	Sig. (2-tailed)	.000	.001	.000	.	.000	.088	.004	.001	.000	.016
	N	42	42	42	42	42	42	42	42	42	42
FKS - JR	Pearson Correlation	.615(**)	.561(**)	.588(**)	.581(**)	1	.531(**)	.636(**)	.686(**)	.562(**)	.500(**)
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000	.000	.000	.000	.001
	N	42	42	42	42	42	42	42	42	42	42
FKS - COP	Pearson Correlation	.469(**)	.376(*)	.454(**)	.267	.531(**)	1	.559(**)	.619(**)	.528(**)	.416(**)
	Sig. (2-tailed)	.002	.014	.003	.088	.000	.	.000	.000	.000	.006
	N	42	42	42	42	42	42	42	42	42	42
FKS - ITNET	Pearson Correlation	.576(**)	.536(**)	.498(**)	.439(**)	.636(**)	.559(**)	1	.806(**)	.578(**)	.580(**)
	Sig. (2-tailed)	.000	.000	.001	.004	.000	.000	.	.000	.000	.000
	N	42	42	42	42	42	42	42	42	42	42

FKS - DBS	Pearson Correlation	.626(**)	.544(**)	.636(**)	.512(**)	.686(**)	.619(**)	.806(**)	1	.802(**)	.622(**)
	Sig. (2-tailed)	.000	.000	.000	.001	.000	.000	.000	.	.000	.000
	N	42	42	42	42	42	42	42	42	42	42
FKS - OMS	Pearson Correlation	.619(**)	.387(*)	.614(**)	.646(**)	.562(**)	.528(**)	.578(**)	.802(**)	1	.428(**)
	Sig. (2-tailed)	.000	.011	.000	.000	.000	.000	.000	.000	.	.005
	N	42	42	42	42	42	42	42	42	42	42
FKS - EDF	Pearson Correlation	.531(**)	.648(**)	.507(**)	.369(*)	.500(**)	.416(**)	.580(**)	.622(**)	.428(**)	1
	Sig. (2-tailed)	.000	.000	.001	.016	.001	.006	.000	.000	.005	.
	N	42	42	42	42	42	42	42	42	42	42

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.738(a)	.545	.417	.29863	.545	4.254	9	32	.001	2.518

a Predictors: (Constant), FKS - EDF, FKS - BS, FKS - COP, FKS - RC, FKS - ITNET, FKS - JR, FKS - DMS, FKS - CS, FKS - DBS
b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.414	9	.379	4.254	.001(a)
	Residual	2.854	32	.089		
	Total	6.268	41			

a Predictors: (Constant), FKS - EDF, FKS - BS, FKS - COP, FKS - RC, FKS - ITNET, FKS - JR, FKS - DMS, FKS - CS, FKS - DBS
b Dependent Variable: I_Design Knowledge (C1-D9)

9.11. Overall model (without FKS)

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.995(a)	.990	.599	.24749	.990	2.533	40	1	.467	2.000

a Predictors: (Constant), EDF- KPSS, CS - KCB, JR - TDK, BS - KOPP, ITNET - KCB, CS - TDK.., COP - KOPP, RC - KCB, CS - KOPP, DMS - TDK, BS - KCB, RC - KOPP, CS - KPO_MO, RC - KPSS, DBS - KOPP, RC - TDK, ITNET- KPSS, RC - KPO_MO, COP - KPO_MO, BS - TDK, COP - KPSS, CS - KPSS., DBS- KPSS, ITNET - TDK, EDF - KOPP, DBS - TDK, BS - KPSS, ITNET- KPO_MO, DBS - KPO_MO, JR - KPSS, JR - KOPP, EDF - KPO_MO, DM,S- KPSS, DBS - KCB, EDF - KCB, DMS - KPO_MO, ITNET - KOPP, EDF - TDK, DMS - KCB, COP - TDK

b Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.207	40	.155	2.533	.467(a)
	Residual	.061	1	.061		
	Total	6.268	41			

a Predictors: (Constant), EDF- KPSS, CS - KCB, JR - TDK, BS - KOPP, ITNET - KCB, CS - TDK.., COP - KOPP, RC - KCB, CS - KOPP, DMS - TDK, BS - KCB, RC - KOPP, CS - KPO_MO, RC - KPSS, DBS - KOPP, RC - TDK, ITNET- KPSS, RC - KPO_MO, COP - KPO_MO, BS - TDK, COP - KPSS, CS - KPSS., DBS- KPSS, ITNET - TDK, EDF - KOPP, DBS - TDK, BS - KPSS, ITNET- KPO_MO, DBS - KPO_MO, JR - KPSS, JR - KOPP, EDF - KPO_MO, DM,S- KPSS, DBS - KCB, EDF - KCB, DMS - KPO_MO, ITNET - KOPP, EDF - TDK, DMS - KCB, COP - TDK

b Dependent Variable: I_Design Knowledge (C1-D9)

Model Summary(i)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.754(a)	.568	.557	.26018	.568	52.593	1	40	.000	
2	.862(b)	.743	.729	.20339	.175	26.455	1	39	.000	
3	.900(c)	.809	.794	.17733	.067	13.304	1	38	.001	
4	.924(d)	.854	.838	.15714	.045	11.392	1	37	.002	
5	.945(e)	.894	.879	.13609	.039	13.333	1	36	.001	
6	.957(f)	.915	.901	.12317	.022	8.948	1	35	.005	
7	.964(g)	.930	.916	.11362	.015	7.131	1	34	.012	
8	.969(h)	.940	.925	.10690	.010	5.410	1	33	.026	2.119

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB
g Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB
h Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB, BS - KPO_MO
i Dependent Variable: I_Design Knowledge (C1-D9

ANOVA(i)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.560	1	3.560	52.593	.000(a)
	Residual	2.708	40	.068		
	Total	6.268	41			
2	Regression	4.655	2	2.327	56.258	.000(b)
	Residual	1.613	39	.041		
	Total	6.268	41			
3	Regression	5.073	3	1.691	53.772	.000(c)
	Residual	1.195	38	.031		
	Total	6.268	41			
4	Regression	5.354	4	1.339	54.206	.000(d)
	Residual	.914	37	.025		
	Total	6.268	41			
5	Regression	5.601	5	1.120	60.485	.000(e)
	Residual	.667	36	.019		
	Total	6.268	41			
6	Regression	5.737	6	.956	63.025	.000(f)
	Residual	.531	35	.015		
	Total	6.268	41			
7	Regression	5.829	7	.833	64.503	.000(g)
	Residual	.439	34	.013		
	Total	6.268	41			
8	Regression	5.891	8	.736	64.437	.000(h)
	Residual	.377	33	.011		
	Total	6.268	41			

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB

g Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB
h Predictors: (Constant), JR - KPO_MO, RC - KOPP, ITNET - KCB, EDF - KOPP, COP - KPSS, CS - KCB, DBS - KCB, BS - KPO_MO
i Dependent Variable: I_Design Knowledge (C1-D9)

Model Summary(r)

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.754(a)	.568	.557	.26018	.568	52.593	1	40	.000	
2	.862(b)	.743	.729	.20339	.175	26.455	1	39	.000	
3	.910(c)	.829	.815	.16802	.086	19.153	1	38	.000	
4	.936(d)	.876	.862	.14505	.047	13.988	1	37	.001	
5	.952(e)	.907	.894	.12744	.031	11.930	1	36	.001	
6	.964(f)	.929	.917	.11287	.022	10.891	1	35	.002	
7	.975(g)	.951	.940	.09552	.022	14.867	1	34	.000	
8	.983(h)	.967	.959	.07917	.017	16.504	1	33	.000	
9	.988(i)	.975	.968	.06951	.008	10.807	1	32	.002	
10	.991(j)	.981	.976	.06116	.006	10.329	1	31	.003	
11	.993(k)	.985	.980	.05519	.004	8.078	1	30	.008	
12	.994(l)	.988	.983	.05120	.002	5.847	1	29	.022	
13	.995(m)	.990	.986	.04646	.002	7.222	1	28	.012	
14	.996(n)	.992	.988	.04343	.002	5.041	1	27	.033	
15	.996(o)	.991	.987	.04428	-.001	2.098	1	27	.159	
16	.996(p)	.993	.989	.04074	.002	6.069	1	27	.020	
17	.997(q)	.994	.991	.03696	.001	6.805	1	26	.015	2.455

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP

g Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS

h Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC

i Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP

j Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET- KPO_MO

k Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET- KPO_MO, DBS - KOPP

l Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS

m Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF

n Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO

o Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO

p Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO, EDF - KPO_MO

q Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO, EDF - KPO_MO, JR - KCB

r Dependent Variable: I_Design Knowledge (C1-D9)

ANOVA(r)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.560	1	3.560	52.593	.000(a)
	Residual	2.708	40	.068		
	Total	6.268	41			
2	Regression	4.655	2	2.327	56.258	.000(b)
	Residual	1.613	39	.041		
	Total	6.268	41			
3	Regression	5.195	3	1.732	61.347	.000(c)
	Residual	1.073	38	.028		
	Total	6.268	41			
4	Regression	5.490	4	1.372	65.232	.000(d)
	Residual	.778	37	.021		
	Total	6.268	41			
5	Regression	5.683	5	1.137	69.988	.000(e)
	Residual	.585	36	.016		
	Total	6.268	41			
6	Regression	5.822	6	.970	76.163	.000(f)
	Residual	.446	35	.013		
	Total	6.268	41			
7	Regression	5.958	7	.851	93.272	.000(g)
	Residual	.310	34	.009		
	Total	6.268	41			
8	Regression	6.061	8	.758	120.892	.000(h)
	Residual	.207	33	.006		
	Total	6.268	41			
9	Regression	6.113	9	.679	140.596	.000(i)
	Residual	.155	32	.005		
	Total	6.268	41			
10	Regression	6.152	10	.615	164.457	.000(j)
	Residual	.116	31	.004		

	Total	6.268	41			
11	Regression	6.177	11	.562	184.377	.000(k)
	Residual	.091	30	.003		
	Total	6.268	41			
12	Regression	6.192	12	.516	196.804	.000(l)
	Residual	.076	29	.003		
	Total	6.268	41			
13	Regression	6.208	13	.478	221.197	.000(m)
	Residual	.060	28	.002		
	Total	6.268	41			
14	Regression	6.217	14	.444	235.398	.000(n)
	Residual	.051	27	.002		
	Total	6.268	41			
15	Regression	6.213	13	.478	243.784	.000(o)
	Residual	.055	28	.002		
	Total	6.268	41			
16	Regression	6.223	14	.445	267.783	.000(p)
	Residual	.045	27	.002		
	Total	6.268	41			
17	Regression	6.232	15	.415	304.120	.000(q)
	Residual	.036	26	.001		
	Total	6.268	41			

a Predictors: (Constant), JR - KPO_MO
b Predictors: (Constant), JR - KPO_MO, RC - KOPP
c Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS
d Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS
e Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK
f Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP
g Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS
h Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC
i Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP
j Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET-KPO_MO
k Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET-KPO_MO, DBS - KOPP

l Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET-KPO_MO, DBS - KOPP, EDF- KPSS

m Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET-KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF

n Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, EDF - KOPP, ITNET-KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO

o Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO

p Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO, EDF - KPO_MO

q Predictors: (Constant), JR - KPO_MO, RC - KOPP, FKS - DMS, DBS- KPSS, BS - TDK, ITNET - KOPP, COP - KPSS, FKS - RC, ITNET- KPO_MO, DBS - KOPP, EDF- KPSS, FKS - EDF, RC - KPO_MO, EDF - KPO_MO, JR - KCB

r Dependent Variable: I_Design Knowledge (C1-D9)