Antecedents of Collaborative Networked Learning in Manufacturing

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Table of Contents

List of Figures 7
List of Tables........ 8
List of Abbreviations........ 10
List of Symbols or Mathematical Operants 13
Attestation of Authorship........ 14
Published Papers & Conferences 15
Acknowledgement........ 16
Research Ethics 18
Abstract 19

CHAPTER 1: INTRODUCTION........ 20

1.1 Background to the Study 20
1.2 Rationale of the Study 21
1.3 Statement of Research Problem 22
1.4 Research Aim and Objectives (RO) 23
1.5 Definition of Terms 24
1.6 Key Assumptions of the Research........ 26
1.7 Outline of the Study 27

CHAPTER 2: LITERATURE REVIEW........ 29

2.1 Introduction 29
2.2 Knowledge and Information........ 29
2.2.1 Knowledge and Information Sharing in Manufacturing........ 31
2.2.2 Networked Manufacturing and Virtual Enterprise 32
2.2.3 Networks of Practice in Manufacturing........ 34
2.3 Collaborative Networked Learning 36
2.3.1 Definition of Collaboration Networked Learning 37
2.3.2 Difference between Collaborative Learning and Collaborative Networked Learning 38
2.3.3 Difference between Cooperative Learning and Collaborative Networked Learning 39
2.4 Research Streams in Organizational Learning 41
2.5 Theoretical Paradigms........ 45
2.5.1 Awareness Theory 47
2.5.2 Structuration Theory........ 48

2.5.3 Social Constructivist Theory 49
2.5.4 Network Theory 51
2.5.5 Socio-technical Systems Theory 52

2.6 Framework and Modeling Collaborative Networked Learning 53

2.6.1 Organizational Support 57
2.6.2 Interdependence 58
2.6.3 Interactions 58
2.6.4 Internal-External Learning 59
2.6.5 Perceived Effectiveness 59
2.6.6 Perceived Usefulness 60

2.7 Collaborative Technology 60

2.7.1 Structured Collaboration 62
2.7.2 Unstructured Collaboration 63
2.7.2.1 Asynchronous Learning Network 64

2.7.2.2 Synchronous Learning Network 65

2.8 Applications of Collaborative Networked Learning 67

2.9 Summary 68

CHAPTER 3: RESEARCH FRAMEWORK 70

3.1 Introduction 70

3.2 Restatement of the Research Questions 70

3.3 Conceptual Framework 70

3.4 Research Propositions (RP) 75

3.4.1 Proposition 1 (P_1) Organizational Support is an Antecedent of CNL 76
3.4.2 Proposition 2 (P_2) Positive Interdependence is an Antecedent of CNL 77
3.4.3 Proposition 3 (P_3) Promotive Interactions is an Antecedent of CNL 77
3.4.4 Proposition 4 (P_4) Internal-External Learning is an Antecedent of CNL 78
3.4.5 Proposition 5 (P_5) Employees' Perceived Effectiveness is an Antecedent of CNL 79
3.4.6 Proposition 6 (P_6) Employees' Perceived Usefulness is an Antecedent of CNL 79
3.4.7 Proposition 7(P_7) For MNCs and SMEs, the Influence of CNL is Different.80

3.5 Rationale for the Model Structure 81

3.6 Summary 82

CHAPTER 4: RESEARCH METHODOLOGY 83

4.1 Introduction 83

4.2 Philosophical Position 83

4.3 Research Paradigm ... 84
4.4 Research Approach ... 85
4.4.1 Mixed Methods ... 85
4.4.2 Ethnographic ... 86
4.5 Unit of Analysis ... 88
4.6 Research Strategy and Process ... 88
4.6.1 Quantitative Research Strategy and Data Analysis ... 90
4.6.2 Qualitative Research Strategy and Data Analysis ... 92
4.7 Development of Sample for the Study ... 94
4.7.1 Snowball Sampling for Survey Questionnaire ... 95
4.7.2 Purposive Sampling for Semi-Structured Interview ... 96
4.8 Data Collection Process ... 96
4.9 Ethical Considerations ... 97
4.10 Summary ... 98

CHAPTER 5: DEVELOPMENT OF MEASUREMENT SCALE ... 99
5.1 Introduction ... 99
5.2 Measurement of Constructs ... 99
5.2.1 Scale Development ... 100
5.2.2 Scale Validation ... 102
5.2.3 Development of Instrument ... 104
5.3 Data Collection for Pilot Study ... 104
5.4 Data Preparation ... 105
5.4.1 Missing Data, Multiple Responses and Data Entry ... 105
5.4.2 Outliers ... 106
5.4.3 Assessment of the Normality ... 106
5.5 Profile of Participants ... 107
5.6 Assessment of Dimensionality ... 109
5.7 Assessment of Internal Consistency ... 109
5.8 Assessment of External Consistency ... 111
5.9 Summary ... 111

CHAPTER 6: QUANTITATIVE DATA ANALYSIS AND RESULTS ... 113
6.1 Introduction ... 113
6.2 Restatement of the Research Questions ... 113

6.3 Data Collection for Survey Questionnaire 113
6.4 Data Preparation 115
6.4.1 Missing Data, Multiple Responses and Data Entry 115
6.4.2 Outliers 116
6.4.3 Assessment of the Normality 116
6.5 Profile of Participants 117
6.6 Preliminary Investigations 119
6.6.1 Measurement of Sampling Adequacy and Sphericity 119
6.6.2 Assessment of Communalities 120
6.7 Exploratory Investigation and Item Reduction 122
6.7.1 Factor Analysis – Organizational Support 123
6.7.2 Factor Analysis – Promotive Interaction 123
6.7.3 Factor Analysis – Positive Interdependence 124
6.7.4 Factor Analysis – Internal-External Learning 124
6.7.5 Factor Analysis – Perceived Effectiveness 124
6.7.6 Factor Analysis – Perceived Usefulness 125
6.7.7 Factor Analysis – Collaborative Networked Learning 125
6.8 Development of a Measurement Model 126
6.8.1 Assessment of Unidimensionality 126
6.8.2 Assessment of Multicollinearity 128
6.8.3 Assessment of Internal Consistency 128
6.8.4. Validity of Measurement 131
6.9 Univariate Statistics 133
6.10 Bivariate Statistics 138
6.11 Multivariate Statistics 143
6.11.1 Multiple Regression – Organizational Support 146
6.11.2 Multiple Regression – Promotive Interactions 147
6.11.3 Multiple Regression – Positive Interdependence 149
6.11.4 Multiple Regression – Internal-External Learning 150
6.11.5 Multiple Regression – Perceived Effectiveness 152
6.11.6 Multiple Regression – Perceived Usefulness 153
6.11.7 Regression Models 154
6.12 Summary 159

CHAPTER 7: QUALITATIVE DATA ANALYSIS AND RESULTS 160
7.1 Introduction 160
7.2 Restatement of the Research Questions 160
7.3 Data Collection for Semi-Structured Interviews 161

7.4 Data Entry and Coding 162
7.5 Profile of Participants 163
7.6 Data Validity 164
7.7 Result of Content Analysis 164
7.7.1 Question Categories 165
7.7.2 Hierarchical Coding Scheme 165
7.7.3 Contributions from Individual Participants 168
7.8 Results of Textual Contexts 169
7.8.1 Organizational Support 169
7.8.2 Positive Interdependence 176
7.8.3 Promotive Interactions 179
7.8.4 Internal-External Learning 181
7.8.5 Perceived Effectiveness 185
7.8.6 Perceived Usefulness 188
7.9 Summary 195

CHAPTER 8: DISCUSSION OF RESULTS 197
8.1 Introduction 197
8.2 Evaluation of Research Questions (RQ) 197
8.2.1 Research Question 1 197
8.2.2 Research Question 2 198
8.2.3 Research Question 3 198
8.2.4 Research Question 4 199
8.3 Evaluation of Research Objectives (RO) 200
8.3.1 Research Objective 1 201
8.3.2 Research Objective 2 202
8.3.3 Research Objective 3 203
8.3.4 Research Objective 4 204
8.4 Evaluation of Research Propositions (RP) 207
8.4.1 Proposition P1 208
8.4.2 Proposition P2 209
8.4.3 Proposition P3 210
8.4.4 Proposition P4 211
8.4.5 Proposition P5 212
8.4.6 Proposition P6 213
8.4.7 Proposition P7 213
8.5 Summary 216

CHAPTER 9: CONCLUSION **217**
9.1 Introduction 217
9.2 Contribution of the Study 217
9.2.1 Bridging the Theory and Praxis of CNL in Manufacturing 217
9.2.2 Development of an Integrative CNL Framework for Manufacturing 218
9.2.3 Development of CNL Instrument and Measurement 219
9.2.4 Adopting Mixed Methods in Exploratory Research of CNL 219
9.2.5 Integration of CNL to Operational Management 220
9.2.6 Other Practical Implications of CNL 220
9.3 Research Issues 222
9.4 Recommendations for Future Research 223
9.4.1 Development of New Collaborative Technology 223
9.4.2 Embedding Social Contexts in Collaborative Networked Learning 224
9.4.3 Organizational Design for Collaborative Networked Learning 224
9.4.4 New Paradigm for Workplace Learning 225
REFERENCES **226**
APPENDICES **266**
Appendix A – Ethics approval by AUTEC 267
Appendix B – Survey consent form 268
Appendix C – Participant information sheet 270
Appendix D – Survey questionnaire 274
Appendix E – Survey measurement model 280
Appendix F – Correlation matrix 281
Appendix G – Tables on hours spent on CNL (MNCs and SMEs) 284
Appendix H – Graphs on hours spent on CNL (MNCs and SMEs) 285
Appendix I – Multiple regression stage 1 286
Appendix J – Multiple regression stage 2 291
Appendix K – Hierarchical coding scheme 296

List of Figures

Figure 2-1 Typology of collaborative networked learning 37
Figure 2-2 Typology between cooperative learning and CNL....................................... 40
Figure 2-3 Focus of research streams in CNL 42
Figure 2-4 Effect of learning on process implementation and mass customization 55
Figure 2-5 Technology Acceptance Model of virtual communities 56
Figure 2-6 Technology Enhanced Learning Environment.. 57
Figure 3-7 Conceptual framework of CNL.. 75
Figure 4-8 Systematic approach to empirical research design....................................... 89
Figure 4-9 Framework of research for quantitative phase 91
Figure 4-10 Framework of research for qualitative phase 93
Figure 6-11 Scree plots after items purification... 127
Figure 6-12 Hours spent using online learning per year 134
Figure 6-13 Hours using shared database or network information per week 135
Figure 6-14 Hours using online meetings per week 136
Figure 6-15 Hours using emails per day 136
Figure 6-16 Regression model H1 – Access information online 155
Figure 6-17 Regression model H2 – Work using online system/network 156
Figure 6-18 Regression model H3 – Share and exchange online information 157
Figure 6-19 Regression model H4 – Participate in online learning............................. 158
Figure 6-20 Regression model H5 - Participate in workgroup activities..................... 159
Figure 8-21 Framework for antecedents of CNL in manufacturing 201

List of Tables

Table 2-1 Differences between collaborative learning and CNL....................................39
Table 2-2 Differences between cooperative learning and CNL......................................41
Table 2-3 Number of researches in streams 2000-2012..44
Table 2-4 Number of researches and theoretical paradigms 2000-2012..........................46
Table 3-5 Empirical studies on related areas 72
Table 3-6 Selection of Constructs for CNL 74
Table 3-7 Research questions, objectives and propositions..81
Table 5-8 Final development of constructs and measures 101
Table 5-9 Normality test for pilot study (n=44)..107
Table 5-10 Demographic profile for pilot study (n=44) 108
Table 5-11 Pilot study - Participants by organizations and departments (n=44)..........109
Table 5-12 Pilot study - Cronbach's alpha for first test (n=44) 110
Table 5-13 Pilot study - Cronbach's alpha for re-test (n =32) 111
Table 6-14 Testing skewness and kurtosis (n= 246)..117
Table 6-15 Main study - Participants by gender, age and education (n=246) 118
Table 6-16 Main study – Participants by organizations and departments (n=246) 119
Table 6-17 Kaiser-Meyer-Olkin and Barlett's test...120
Table 6-18 Item communalities 121
Table 6-19 Factor loading for organizational support..123
Table 6-20 Factor loading for promotive interaction...124
Table 6-21 Factor loading for positive interdependence..124
Table 6-22 Factor loading for internal-external learning...124
Table 6-23 Factor loading perceived effectiveness..125
Table 6-24 Factor loading for perceived usefulness 125
Table 6-25 Factor loading for collaborative networked learning..................................125
Table 6-26 Inter-item correlation matrix 129
Table 6-27 Item-to-total correlation...130
Table 6-28 Main study - Cronbach's alpha..131
Table 6-29 Main study - split-half reliability..131
Table 6-30 Descriptive statistics MNC (n =177) and SME (n = 69) 133

Table 6-31 Comparing mean hours spend using collaborative tools 137
Table 6-32 Independent sample test 138
Table 6-33 Cross-tabulation of manufacturing organization and email at work 140
Table 6-34 Cross-tabulation of manufacturing organization and on-line meeting 141
Table 6-35 Cross-tabulation of manufacturing organization and shared database 142
Table 6-36 Cross-tabulation of manufacturing organization and online learning 143
Table 6-37 Model fit for organizational support 146
Table 6-38 ANOVA for organizational support 146
Table 6-39 Model fit for promotive interactions 147
Table 6-40 ANOVA for promotive interactions 148
Table 6-41 Model fit for positive interdependence 149
Table 6-42 ANOVA for positive interdependence 149
Table 6-43 Model fit for internal-external learning 150
Table 6-44 ANOVA for internal-external learning 151
Table 6-45 Model fit for perceived effectiveness 152
Table 6-46 ANOVA for perceived effectiveness 152
Table 6-47 Model fit for perceived usefulness 153
Table 6-48 ANOVA for perceived usefulness 153
Table 7-49 Demographic profile semi-structured interview (n=11) 163
Table 7-50 Question categories 165
Table 7-51 Hierarchical coding scheme 166
Table 7-52 Nodes and references to participants (n=11) 168
Table 8-53 Summary of the test of propositions 207

List of Abbreviations

Abbreviation used in this thesis and their meanings.

ALN	Asynchronous learning network
AST	Adaptive structuration theory
AUT	Auckland University of Technology
AUTEC	Auckland University of Technology Ethics Committee
AVI	Assembly visual instructions
BOM	Bill-of-material
CAD	Computer aided design
CAR	Corrective action request
CCA	Circuit card assembly
CE	Concurrent engineering
CL	Collaborative learning
CMC	Computer mediated communication
CN	Configuration number
CNL	Collaborative networked learning
CNO	Collaborative network organization
CPD	Collaborative product development
CRM	Customer relationship management
CSCL	Computer supported collaborative learning
CSCW	Computer supported cooperative work
CSILE	Computer supported intentional learning environment
EB	Engineering bulletin
ECO	Engineering change order
ECN	Engineering change notification
ECR	Engineering change request
EDI	Electronic data interchange
eCATS	Electronic corrective action tracking system
ECSI	Enterprise critical success indicators
EIM	Enterprise information management
EIS	Enterprise information system

EME	Extended manufacturing enterprises
EMS	Electronic manufacturing services
EPIC	Enterprise planning and inventory control
ERP	Enterprise resources planning
FLE	Future Learning Environment
GDSS	Group decision support system
HCI	Human-computer interaction
HASS	Highly accelerated stress screening
ICT	Information and communications technology
ISO	International Organization for Standardization
JIT	Just-in-time
KLASS	Knowledge and Learning in Advanced Supply Systems
KM	Knowledge management
KMO	Kaiser-Meyer-Olkin
LMHV	Low mix high volume
LMS	Learning management system
ME	Manufacturing engineer
MES	Manufacturing electronic system
NC	Network computer
MNCs	Multinational companies
MRP	Material resources planning
MRB	Material review board
NPD	New product development
NPI	New product introduction
OD	Organizational development
OECD	Organization for Economic Co-operation and Development
OEE	Overall efficiency and effectiveness rate
PCBA	Printed circuit card assembly
PDC	Product development cycle
PDM	Product database management
PLC	Product lifecycle
P/OM	Production/operations management
PRB	Parts review board

QMS	Quality management system
Q&R	Quality and reliability
QN	Quality notification
R&D	Research and development
RO	Research objectives
RP	Research propositions
RQ	Research questions
SAP	System Applications and Products
SCM	Supply chain management
SDR	Socially desirable responding
SLN	Synchronous learning network
SMEs	Small medium enterprises
SNA	Social network analysis
SOP	Standard operating procedures
SPC	Statistical process control
SPSS	Statistical Package for Social Sciences
SQE	Supplier quality engineer
SSL	Secure socket layer
STS	Socio-technical systems
UCN	Unique control number
VF	Virtual factory
VoIP	Voice over Internet protocol
VPD	Virtual product development
WIP	Work in progress

List of Symbols or Mathematical Operants

α	alpha or the probability of making Type 1 error
β	beta or the probability of making Type 2 error
ϵ_i	residual for the *i* unit
$\leq$	equal or less than
$\geq$	equal or more than
$<$	less than
$>$	more than
$=$	equal
σ	the standard deviation in a population of data
σ^2	the variance in a population of data
R	the multiple correlation coefficient
R^2	the coefficient of determination
χ^2	chi-square
r	Pearson correlation coefficient
P	the probability value e.g. *p*-value or significance of test
s.d.	standard deviation
S.E.	standard error
df	degree of freedom
F	*F*-ratio used in ANOVA
X_i	value of the variable for case *i*
M	mean
n	number of cases
k	constant
$P_{1\ldots n}$	proposition one until the last proposition
nd.	nodes
ref.	reference

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Danny W.H. Quik

Published Papers & Conferences

1. Mohiuddin, A.K.M. and Quik, W.H., (2004) New Factory's Certification Process – Use of Collaborative Technologies as a Tool, *Proceedings of the 4th International Mechanical Engineering Conference (IMEC-2004) & 9th Annual Paper Meet (APM)*, 29-31 December, 2004, Dhaka, Bangladesh, pp. 296-302.

2. Mohiuddin, A.K.M. and Quik, W.H., (2005). Collaborative Technologies in New Factory Certification Process, *Journal of Applied Sciences* 5(2): 267-272.

3. Quik, W.H., and Yeong M.H. (2006). Developing Organizational Capability through Collaborative e-Learning: A Case Study of Eaton Electric Switchgear. *Proceeding of the International Conference on Distance, Collaborative and e-Learning* (DCEL 2006), Kuala Lumpur.

4. Quik, W.H., and Wright, N. (2012). Information Sharing to Transformation: Antecedents of Collaborative Networked Learning in Manufacturing. *Proceeding of the International Conference on Computer, Electrical and System Science, and Engineering, August 28-29, Kuala Lumpur*.

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Danny W.H. Quik

This thesis is dedicated to

my wife Lina, son Kenji and daughter Noriko;

and a very good friend, teacher and mentor

Associate Professor Dr. Nevan Wright

Research Ethics

The ethics application for this study project was approved by the Auckland University of Technology Ethics Committee, AUTEC Reference number 07/115.

Abstract

This study aims to investigate the antecedents of collaborative networked learning (hereafter CNL), to develop an integrative CNL framework and to bridge the gap between theory and praxis in manufacturing. Although collaborative learning has been at the forefront of educational and pedagogical studies, there is a lack of research in the mainstream of operations management and information systems. This study explores the antecedents of CNL and the sharing of information among diverse employees within the context of manufacturing industries in Malaysia. The study further extends the boundary of networked learning beyond internal enterprises to include suppliers, customers and external stakeholders.

To provide a holistic perspective of CNL within the complexity of the manufacturing environment required a mixed-method research approach, including empirical investigation using survey questionnaires and semi-structured interviews. The qualitative findings from the interviews were corroborated with a 246 quantitative survey of multinational companies (MNCs) and small-medium enterprises (SMEs) in Malaysia. SPSS software was used for statistical analysis and NVivo for content analysis. The findings and discussions draw upon socio-technical systems (STS) theory, and present the theoretical context and interpretations through the lens of manufacturing employees.

Results of the study show the existence of significant positive influences of organizational support, promotive interactions, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness of CNL among manufacturing employees. The study further provides insights into information sharing and collaboration within MNCs and SMEs. Although employees in MNCs are more engaged in CNL compared to SMEs, a general consensus is found on the importance of collaborative technologies, the usage of online meetings and shared databases. The study offers a basis for empirical validity for measuring CNL in organizational learning, knowledge and information sharing in manufacturing.

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

Collaborative networked learning (CNL) was first proposed by Charles Findley (1988) in his work "*Collaborative networked learning: online facilitation and software support*" as part of an instructional learning design for the future of the knowledge worker. His premise is that through electronic dialogue, learners and experts could interactively communicate within a contextual framework to resolve problems, and/or to improve product or process knowledge. In essence, collaboration begins with the identification of a problem and seeking contribution from multiple parties with mutual interest (Mohrman et al., 2008), aspirations and purposes to determine which collaboration approach is appropriate (Shani et al., 2008) in solving operational or engineering tasks. Collaboration has also been defined as a "process of participating in knowledge communities" (Lipponen, 2002a, p. 73) "in a coordinated, synchronous task to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p. 70). CNL transpires when employees and their workgroups learn or attempt to learn through organizational networks and work interactions. CNL transforms knowledge, experiences and perspectives into a coherent shared understanding and engages employees in knowledge construction (McConnell, 1999; Van den Bossche et al., 2006b).

Expanding on these fundamentals, CNL can be postulated as a pedagogical form of knowledge co-creation and information proliferation among members in networked enterprises and networks of practice. Goodyear, Banks, McConell and Hodgson (2004) theorise collaborative learning as an approach to stimulate interactions between one learner to another, between learners and content experts, and between a learning community or workgroups and their learning resources using information communications technology (ICT). Moreover, CNL is a network that is largely autonomous, geographically distributed and heterogeneous, yet capable of collaborating complex information (Camarinha-Matos & Afsarmanesh, 2006b). Employees in networked enterprises use CNL to proliferate and transform knowledge and learning across the organization. This is consistent with Findley's (1988) underlying premise of interdependency, mutually seeking for a general understanding on problem resolutions.

1.2 Rationale of the Study

This study seeks to revisit the present paradigm that is educational and pedagogical based with the aim being to develop an integrative model for improving the collaborative efforts between employees and their workgroups. The proposed integrative CNL framework should demonstrate how existing collaborative technology could be effectively utilized to include CNL. With the constant advancement in technology, it also creates a fundamental need to study the current state of CNL in manufacturing, as compared to a decade ago when information systems were not the predominant force in supporting both business and operational strategies. Doornbos, Bolhuis and Simons (2004) assert that most work-related learning does not conform to formally organized learning programmes or events, but happens implicitly through work interactions. Henceforth, a shift from a largely educational to a non-educational perspective is needed. Knowledge transfer and collaborative work in manufacturing are different from those in an educational context because of the competitive nature of the roles, hierarchical structures and organizational procedures which commonly govern the environment (Cho et al., 2005).

Previous studies were limited to networking and sharing of information but ignored the potential for CNL. This study extends beyond networking and data transfer to explore how learning within and between organizations can be facilitated. Thus unlike earlier studies of networked learning, this study includes the interactions and collaborations between manufacturing employees and organizations with external stakeholders, suppliers, logistics, and customers.

CNL research is a new field and draws upon a wide range of theoretical perspectives (de Laat et al., 2006b). Previous works were mostly conceptual in nature and did not include empirical groundwork and validation between antecedents of CNL and manufacturing. Along with this argument, Paavola, Lipponen and Hakkarainen (2002) observe the ways in which some of these earlier theoretical models were operationalized. While they complemented each other, there were many fundamental differences between these models in terms of both focus and power. Nonetheless, some studies have made significant contributions and laid the foundations for present CNL research. For instance, Lipponen (2002b) in his study of computer-supported collaborative learning (CSCL) suggests focusing on the effect of technology as a result of interaction between users, users interface with computers, and users application and transfer of new knowledge to various work situations.

The nature of the interaction between users, their peers and workgroups are somewhat different from the nature of the interaction between students and teachers, and this "difference raises questions about the appropriateness of guided learning for understanding and modelling work-related learning" (Doornbos et al., 2004, p.253). While learning provides new knowledge or skills, insights, and the competence to perform well at work, if learning is not shared with others in the organization, the return on the investment is much less (Fulmer, 2000; Tobin, 1997). These contentions are supported by Quik and Yeong (2006) in a small case study where they found employees in MNCs to be sufficiently trained on development tools and methodologies to form new knowledge and that CNL improved employees problem solving skills and boosted innovations and proliferation of best practices.

1.3 Statement of Research Problem

Due to technological advancement, the importance of knowledge transfer is now magnified and effective knowledge sharing is increasingly critical as competition between businesses intensifies (Bhagat et al., 2002). Most organizations leverage on technology to manage and share information among their employees. Even the training function in workplace learning has transformed from individual-based learning to collaborative learning, for example in networks of practice. Accompanying the move towards the decentralisation of the training function, Smith et al. (2002) also found that line managers are increasingly responsible for training their staff and there has been an increase in the number of trainers, coaches and mentors to assist in this process. Organizational learning and training has evolved from an emphasis on formal and structured training to the decentralized participatory approach that is fundamental in CNL. The implementation of kaizen (Elsey & Fujiwara, 2000), six sigma and lean manufacturing, has made it necessary for the integration of learning in manufacturing (Danilovic & Winroth, 2005; Docherty & Shani, 2008; Fenwick & Rubenson, 2005).

Intriguingly, there is lack of research in the area concerning what motivates manufacturing organizations to share and transfer knowledge between their employees, partners, suppliers, as well as their customers. What transpires in employees' learning process through the use of information communication technology (ICT)? At present, the CNL concept is borrowed and adapted from theories and philosophies from other disciplines such as collaborative learning. There is a large disparity in empirical studies in the area from the perspectives of information systems and operations management. Many scholars agree that CNL needs to be firmly grounded in appropriate theoretical approaches and analytic perspectives to increase its rigor and relevance (de Laat & Lally, 2004; de Laat et al., 2006b; Hakkinen et al., 2003; Hodgson & Watland, 2004; Stahl, 2004). One cannot rely on strong theoretical grounding and empirical research covered by other disciplines to fit CNL to manufacturing. One size does not fit all.

1.4 Research Aim and Objectives (RO)

This study answers the call for greater agility and efficiency in information sharing among manufacturing employees. The primary aim of this study is to identify the significant antecedents to organizational learning, development and sharing of organizational knowledge using collaborative technologies within the organizations and their extended enterprises. At present, there is a lack of knowledge concerning the antecedents that promote the sharing of information and collaboration in the manufacturing industry. Henceforth, the objectives of this study are to:

RO1. Develop an integrative CNL framework and bridge the gap between theory and praxis. De Laat and Lally (2003) and Stahl (2004) argue that due to complexities in both the theory and praxis[1], no single theoretical framework is yet capable of offering a sufficiently powerful articulation of description, rhetoric, inference or application of networked learning. In order to achieve this objective and bridge the gap, the research needs to pay close attention to numerous events, activities

[1] According to McNiff et al. (1996) praxis is informed, committed action that gives rise to knowledge.

and tasks that motivates employees in diverse manufacturing organizations to share information.

RO2. Establish a comparative study by comparing and contrasting diverse industries and between MNCs and SMEs. The study also aims to gain a broader and more insightful perspective to strengthen the relevance of the conclusions and supporting framework presented in this thesis.

RO3. Examine networks of manufacturing collaborations and seek to understand the antecedents that set the stage for information sharing and knowledge transformation among members in manufacturing organizations. The findings will serve as a new body of knowledge in CNL research.

RO4. Conduct a multi-disciplinary research that will include experiential learning, workplace learning and consider other research into CNL and knowledge sharing. The study will also revisit and validate the definition of CNL. The proposed CNL framework should be versatile and pragmatic for both MNCs and SMEs.

1.5 Definition of Terms

1.5.1 Multinational Corporation and Small-medium Enterprise

The definition of manufacturing used follows the Malaysia Standard Industrial Classification (MSIC) 2008[2]. Manufacturing is defined as the physical or chemical transformation of materials or components into new products, whether the work is performed by power-driven machines or by hand, whether it is done in a factory or in the worker's home, and whether the products are sold at wholesale or retail. The definition of a manufacturing organization used in this study follows that of the Malaysia Standard Industrial Classification (MSIC) 2008 and has been adopted by the SME Development Council of Malaysia.

[2] Published by the Department of Statistics Malaysia (2011)

i. MNC: A multinational corporation (MNC) also called multinational enterprise (MNE), is a corporation or an enterprise that manages production or delivers services in more than one country.

ii. SME: A small-medium enterprise (SME) is a company that has less than 150 employees with revenue between Ringgit Malaysia 4 to Ringgit Malaysia 10 million per year.

To differentiate MNCs from other larger organizations, the research will adopt the definition provided by the OECD Guideline for Multinationals Enterprises (2011), which defines MNCs as organizations that comprised of companies or other entities established in more than one country, and which are interconnected and coordinate their operations in various ways. The OECD Guideline for Multinationals Enterprises (2011) further stipulate that "while one or more of these entities may be able to exercise a significant influence over the activities of others, their degree of autonomy within the enterprise may vary widely from one multinational enterprise to another. The ownerships of the enterprise may be private, state or mixed" (p.12).

Although the research is focused on the Malaysia context, the research samples are representative of major global multinational companies, for example, Plexus, Flextronics, Robert Borch, Intel, Honeywell, Eaton, AMD, First Solar, Samsung, Sony, Western Digital and many more. In 2008, there were 30,709 SMEs in Malaysia while 1,826 organizations were large establishments, including MNCs (Department of Statistics Malaysia, 2011).

1.5.2 Antecedent

Antecedent is defined as the conditional part of a hypothetical proposition (Oxford University Press, 2013), something existing or happening before, especially as the cause of an event or situation (Cambridge University Press, 2013). The term antecedents in this study describes important preceding or a current course of events, circumstances, or precursors that transpired before employees in manufacturing organizations are likely to adopt CNL. In addition 'antecedent variable' is a term used in multivariate analysis.

In a study of the antecedents that affect the intention to adopt collaborative technologies in the construction industry, Nikas, Poulymenakou and Kriaris considered the prerequisite resources that an organisation must possess in order to adopt a novel technology. Antecedents drivers were found to be all the internal, external factors and perceived benefits that influenced the decision to adopt novel technology (Nikas et al., 2007, p.632).

1.6 Key Assumptions of the Research

The basis of the research includes the following underlying assumptions:

i. The focus of the research is on the manufacturing context. The precedence theories on collaborative learning from the educational and pedagogical context serve as a reference and do not necessary dictate the outline of the research, and neither will the outcome of the research be skewed towards an educational context.

ii. The sample of the research represents the population of manufacturing employees in Malaysia. The sample is used to make inferences to manufacturing employees, it is not intended that the results be generalized to the entire global population of manufacturing employees. Cultural, socio-economy, legislative, educational levels are not equal world-wide.

iii. The participants for the survey were randomly invited using a snowball sampling technique. It is assumed that the participants are representative of the population of Malaysia's manufacturing organizations.

iv. The participants for the semi-structured interviews were invited based upon their present roles and positions in MNCs and SMEs organizations. Their opinions, knowledge, perceptions and experiences on the subject matter are related to their personal views and do not represent those of their peers, supervisors or organizations.

v. The systems described and explained by the participants may be commonly used by other manufacturing organizations, although some systems may be developed, customized and designed specifically for individual organizations. This does not prevent the study from investigating the functionality of those systems to seek for commonality.

vi. Based on the literature review, this research suggests that there is no prior research related to the antecedents of CNL in manufacturing. Exploratory research is used to assess the opportunities for undertaking the study and to test methodology for a larger study in the future (Nardi, 2006).

1.7 Outline of the Study

This thesis consists of eight chapters. The first chapter presents background information pertaining to CNL in the advent of collaborative technologies development and learning in manufacturing organizations. It identifies key issues and outlines the research aim and objectives as well as providing some key definitions relating to the primary subjects of the study.

Chapter 2 reviews past and present literatures to provide a holistic understanding of the definitions of key concepts of CNL, networks of practice, current research streams, theoretical paradigms, collaborative technologies and primary applications that are closely linked with CNL. Identified gaps in the literature shaped the research questions for the study.

Chapter 3 outlines the conceptual framework of the research and the development of CNL model. The research propositions are presented and discussed. The chapter also explains the rationale of the model structure.

Chapter 4 discusses the research design including philosophical assumptions. The rationale for the pragmatic paradigm and mixed-method approach used to examine the propositions developed in Chapter 3 are given. A systematic discussion is also provided on the quantitative and qualitative approaches to data collection techniques, including the development of the questionnaire and selection of participants.

Chapter 5 defines the measurements and explains the development for the scales used for measuring the constructs. It discusses the techniques used in data preparation and presents a preliminary analysis derived from a pilot study, including assessment of dimensionality.

Chapter 6 presents the results from quantitative data analysis of the survey questionnaire. Attention is paid to analysis methods of the quantitative data and data frequency is systematically examined using descriptive statistics and inferential statistics – the aim being to provide an objective view of the phenomena found in the study.

Chapter 7 corroborates the results of the qualitative data analysis of the interview transcripts with the quantitative results of the main research constructs. The research framework used for the quantitative analysis is extended to accommodate the qualitative analysis using NVivo for content analysis technique.

Chapter 8 presents the integrated findings emerging from the quantitative and qualitative data described above, in support of the research objectives, research questions and propositions.

Chapter 9 concludes the study with reviews and reflections of key contributions to the body of knowledge in organizational learning and operational management. The limitations of the research are acknowledged and explained. Further recommendations that build on the research findings are offered for future research.

A list of references and appendices are provided at the end of this thesis.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to review relevant CNL literatures. The purpose of a thorough review of the literature, according to Netemeyer et al. (2003), is to alert the researcher to "previous attempts to conceptualize the constructs of interest and theories in which the construct may prove useful as an independent or dependent variable" (p. 8). It also provides a background to the context of the research, and establishes a bridge between the research and the current state of knowledge on the subject and what could be anticipated in the light of existing theory (Blaikie, 2000, 2010). This chapter begins by discussing the background of the research in the context of the sharing and exchanging of information in manufacturing organizations, the evolution of virtual enterprises, and employees leveraging on networks of practice. Next, it attempts to define what are knowledge, information and data. It then attempts to explain the concept of CNL, and the difference between cooperative and collaborative learning, to provide more clarity to the area of research. It proceeds to discuss several mainstream researches, presenting different theoretical paradigms and highlighting some of the proposed frameworks from similar areas of research. Some pertinent concepts in collaborative technologies exemplifying the differences between structured and unstructured collaborative technologies and between asynchronous and synchronous learning networks are also identified.

2.2 Knowledge and Information

Davenport and Prusak (1998) define knowledge as a mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information (p.5). Information is the basic input for organizational knowledge (Davenport et al., 1998; Garvin, 1993; Kogut & Zander, 1992). Information is data that holds relevance and purpose, while knowledge is information which holds relevance and purpose to create meaning (Davidson & Voss, 2002; Roberts, 2000). Information is transformed into knowledge when employees apply their own experience and contextual understanding to information through action

(Davenport et al., 1998; Nonaka & Takeuchi, 1995). Scholars like Argyris and Schon (1978), Schein (1996), and Senge (1994) posit that knowledge is shared through social interaction and socialisation creates shared understanding that will motivate group collaboration. Before any new ideas are accepted, discussion is needed to align opinions and allow ideas to be shared and integrated into the systems, culture, values and processes of the manufacturing organization (Nonaka et al., 1995). Information from diverse perspectives is converged and integrated into organizational knowledge.

Nonaka and Takeuchi (1996) further define explicit knowledge as information that can easily be communicated among employees; whereas tacit knowledge such as skills, competencies and talents is somewhat more difficult to communicate. Therefore, Blaikie (2010) posits that the aim of scholarly research is to uncover largely tacit, mutual knowledge, symbolic meanings, intentions and rules, which influence social behaviour. When both tacit and explicit knowledge are combined, employees can modify existing knowledge or create new knowledge (Addleson, 2013; Blaikie, 2010). Knowledge does not exist either on its own or in individual minds, but emerges from the process of participation in various cultural practices and shared learning activities (Brown et al., 1989; Lave & Wenger, 1991; Lipponen & Hakkarainen, 2004; Paavola et al., 2004). Employees share knowledge best when they are negotiating the context of shared meanings (Berends, 2005), interacting and aligning for action (Addleson, 2011).

Knowledge is perceived as a cognitive process, in which learning is a matter of construction, acquisition, and outcomes through the process of transfer (Paavola et al., 2004). For constructivists, learning constitutes participation in practices and actions where knowledge is acquired by social activities (Chatenier et al., 2009, p. 354). Essentially, establishing a CNL system requires an understanding of the acquisition and construction of knowledge of employees and their interface with technology at work. Knowledge integration is therefore extending the scope of knowledge sharing, which is the pre-requisite of CNL, where knowledge is effectively distributed, used to perform tasks, (Herrmann et al., 2007), develop new competencies, produce innovations and generate new knowledge (Paavola & Hakkarainen, 2005).

This concept of knowledge construction as a collaborative endeavour spurs this study into investigating how information and knowledge can be learned and shared in manufacturing organizations. Knowledge construction is the outcome of collaborative work (Zenios, 2011), when employees work together on a shared problem, participate in discussion, (Roschelle et al., 1995), negotiations, engagements, creating scenarios about their circumstances, and their goals (Addleson, 2013). Upon closer examination, collaborative knowledge from social epistemology provides invaluable insights as to the relevance of CNL involving cyclic orientations from transmission, transaction to transformation of organizational knowledge and information. Knowledge and information are transmitted through a series of transactional processes using collaborative technologies and other network communicative tools. Knowledge is transformed by the cognitive processing of information and co-constructing new knowledge through engagement (Lipponen, 2002b), as well as interactions and group deliberations. The cyclic process is rejuvenated as new sets of knowledge and information are stored, shared and re-transmitted.

2.2.1 Knowledge and Information Sharing in Manufacturing

Knowledge sharing is described as the "dissemination of information and knowledge" across an organization (Yang, 2004, p. 119). It involves providing organizational knowledge to employees to improve effectiveness and flexibility so as to spur innovation (Belanger & Allport, 2008; Rafaeli & Ravid, 2003). In today's manufacturing environment, there is a significant emphasis on multi-organizational collaboration, thus knowledge sharing is becoming part of an intricate network unrestricted by geographical boundaries. With the continually strong demand on cost reduction, quality and productivity improvement, CNL could provide the means for sharing and integrating knowledge, and enabling diverse virtual teams to collaborate. CNL can be manifested in many forms and functions, including virtual enterprises, virtual teams, networks of practice and other technical and non-technical collaboratories. With information highly distributed through organizations, it has become paramount for networks to focus on information management to improve knowledge construction (Achrol & Kotler, 1999), and effectively adapt to constantly changing environments (Lusch et al., 2010).

Collaboration involves intra and inter-organizations (customers and suppliers, or nodes in a network) sharing information to make forecasts (McCarthy & Golicic, 2002; Poler et al., 2008) and improving inventory performance throughout the manufacturing organizations (Rubiano & Crespo, 2003). The Knowledge and Learning in Advanced Supply Systems (KLASS) focus on the automotive and aerospace industries to develop CNL with suppliers (Rhodes & Carter, 2003). Web-centred learning has supported the development of e-commerce capabilities and network group learning between multiple or linked workplaces. CO-IMPROVE was developed to support and foster inter-organizational collaborative improvement between extended manufacturing enterprises (EME) (Coghlan & Coughlan, 2006) by expanding customer-supplier collaborative relationships within the network to seek best practices and consequently enhance overall EME performance (Nielsen et al., 2008). The best practices lend themselves to the process oriented view of knowledge management, whilst measurement applies directly to a resource-based view of the organization with knowledge as a valuable asset (Truch et al., 2000).

2.2.2 Networked Manufacturing and Virtual Enterprise

Virtual enterprises can be described as a network of organizations (Danilovic et al., 2005) from which temporary alignments are formed and combined with specific core capabilities of members to exploit manufacturing opportunities (Camarinha-Matos & Afsarmanesh, 2006) and to accomplish innovative problem solving (Malhotra et al., 2007) associated with a specific product or service (Cao & Dowlatshahi, 2005). In order to reduce time-to-market and costs, many manufacturing organizations have established virtual enterprises to share information and to accelerate product development. Virtual enterprise ensures appropriate manufacturing operations are assigned to the designated units or to the best interest of the virtual consortium (Zhan et al., 2003).

Global competition has brought about changes that are characterized by product proliferation with shorter life cycles, innovative process technology, and customer demand for quick responses, lower costs and greater customization (Cao & Dowlatshahi, 2005b; Kamrani, 2008; Yam et al., 2007). Manufacturing organizations have to adapt their business strategies to compete in the new collaborative economy of suppliers, manufacturers, distributors and customers (Basu, 2001). Integrated, dynamic supply chains and virtual enterprises are dominating this trend (Camarinha-Matos & Afsarmanesh, 2006a). By adopting information communication technology (ICT) manufacturing organizations foster changes in managing customer relationships, manufacturing, procurement, and supply chain (Agarwal & Sambamurthy, 2002; Barua et al., 2004; Camarinha-Matos et al., 2006a); to enhance their competitive capabilities (Sambamurthy et al., 2003), products and services (Berry et al., 2006; Chen & Tsou, 2007); and as enablers of innovation (Corso & Paolucci, 2001; Dewett & Jones, 2001; Xu et al., 2005).

CNL dynamically transforms virtual enterprises and virtual teams to create a more innovative, profitable, higher quality product for market. It involves moving from transactional interactions to co-construction of knowledge, collaborative development, and design innovations involving multiple parties. A consumer electronics manufacturer has to collaborate with component suppliers, electronic manufacturing services (EMS), or contract manufacturers in the design and development of products or components (Sayah & Zhang, 2005). The establishment of networked manufacturing is a deliberate attempt to organize virtual teams within the organization with external partners including customers, suppliers and developers.

Virtual teams work in geographically dispersed locations using information technology to accomplish work projects (Hertel et al., 2005; Kauppila et al., 2011; Sarker et al., 2003), solve complex problems or tasks (Curseu et al., 2008) and to share decision making responsibilities and operate independently (Kerber & Buono, 2004). Virtual teams serve as knowledge actors, sharing and mediating knowledge as well as promoting learning throughout the organization (Kauppila et al., 2011; Ratcheva, 2008). The collaborative product development (CPD) platform provides communication channels for geographically dispersed teams to disseminate, share, document and manipulate product data such as product drawings and the bill of materials and process specifications in the networked environment. Product design and development teams can work concurrently in the design and analyse the workflow (Zhan et al., 2003). Benefits of collaboration include higher return and accelerated product development, reduced developmental cost, increased flexibility, reduced risk and access to the product development capability of the suppliers (Mallick et al., 2010).

2.2.3 Networks of Practice in Manufacturing

Networks of practice have been widely studied under a variety of titles (Brown & Duguid, 1991, 2000) including knowledge building communities (Scardamalia & Bereiter, 1994), knowledge communities (Erickson & Kellogg, 2001), virtual communities (Lin, 2007b), and communities of practice (Johnson, 2001; Lave et al., 1991). Garcia (2010) posits that the different between a network of practice and a community of practice rests in electronic communication. However, Brown and Duguid (2000) use the term "networks" to described loose epistemic groups and relationships that have varying degrees of proximity but do not have the degree of cohesion required for a community (as cited by Jones & Esnault, 2004). Jones and Esnault (2004) argue that the term "networks" allows for scalability in analysis as each network can be carefully studied, and each node can be a network by itself in a complex system of communications and collaborations. The term "practice" denotes the actions of employees and workgroups performing their work and work practices that involve interaction among employees. Networks of practice serves as virtual workspace and source of information where knowledge can be captured, codified, stored, shared, and transferred among manufacturing employees.

Manufacturing organizations form an integral part of an activity system which are closely interconnected and consist of multiple networks of practice (Guile & Griffiths, 2001; McDermott & Archibald, 2010). A network of practice consists of groups of employees who share a concern, a set of problems or expertise and passion for a joint enterprise (Brown et al., 2000; Wenger et al., 2002; Wenger & Snyder, 2000) and are informally bound by their shared competence and mutual interest in a given practice (Choi, 2006; Katzenbach & Smith, 2003). Wenger (1998) describes the structure as 'mutual engagement', 'joint enterprise' and 'shared repertoire' (p.72-73). Through participation in the networks of practice, employees build collaborative relationships and through these interactions joint enterprises emerge. The networks of practice continuously evolve as employees attempt to improve their knowledge domain as well as develop their own conceptual artefacts (Hass et al., 2003; Scardamalia et al., 1994), share their experience and knowledge (Choi, 2006; Scarbrough, 1996) and expand their socio-professional circles (Bouhnik et al., 2009). Nonetheless, a network of practice is a dynamic system that requires employees to interact on an on-going basis. A network of practice influences ways in which employees operate and switch between other networks. Over a period of time it develops into shared repertoires of knowledge and methodologies that are proliferated across the manufacturing organization.

Learning transcends across knowledge networks regardless of formal boundaries or geographical distance (Garcia, 2010; Vaast, 2004; Wasko & Faraj, 2008). A network enables employees to collaborate in network communities and for organizations to exchange information and manage knowledge (Garcia, 2010). It is through this collaboration and narration that members of a network of practice negotiate meaning and joint enterprise (Addleson, 2013; Coghlan & Shani, 2008). Therefore, collaborative technologies play a pivotal role by providing the workspace and capacity to interact in virtual networks of communities or virtual teams. The technological augmentation of a network of practice further enhances the quality of collaborative support while providing improved opportunities to distribute and extend the inherent expertise across an organization (Eales, 2003).

Networks of practice provide many benefits to organizations, including access to expertise, improved collaboration, and accelerated work performance. Networks of practice are especially valuable for MNCs that constantly face challenges in disseminating organizational knowledge which resides in individuals and dispersed teams when the opportunity for face-to-face interactions are rather limited (Li et al., 2009). A network of practice develops a repertoire of tacit and explicit means of communicating and working, enabling the community to perform its practice in a satisfying manner (Teigland, 2003). Moreover, the reuse of lessons learned and the adoption of best practices can lead to significant cost savings and process simplification (Hass et al., 2003). The establishment of a network of practice is a deliberate attempt to organize workgroups within the organization and with external partners such as customers, suppliers and developers. A network of practice bridges expertise from various functions and extended enterprises into a common platform for a discourse in specific areas of interest and resolutions.

2.3 Collaborative Networked Learning

This thesis uses the network metaphor in a broader perspective to describe the integral networked organization that connects its employees, customers, suppliers and partners. According to Addleson (2013) a network is a “hodgepodge of people with varying interests, motives, and levels of commitment, as well as diverse specializations, who may report to bosses with different agendas” (p. 38). Boot and Renolds (1997) suggest using a multifaceted concept such as ‘network’ rather than viewing organizations in terms of groups to reflect the dynamic nature of work organizations and the way learning is organized. It enables researchers to fundamentally think about any manufacturing organization as a network that supports patterns of activities that relate to manufacturing operations. The increase of outsourcing also creates more dependence on a network (Basu, 2001). According to Camarinha-Matos and Afsarmanesh (2006) a network consists of a variety of entities that are autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, socio-capita and goals; yet their interactions are well supported by computers to collaborate and to achieve common goals.

These connections have to be recognized and negotiated before employees can work at collaborating (Addleson, 2013). Haythornthwaite (2008) postulates that the participatory learning created by networked technologies brings knowledge creation from expert to learner to CNL and self-discovery. Figure 2-1 illustrates the transformation concepts of individual learning, to learner-expert mentoring or an apprenticeship scheme, and finally to the emergence of collaborative networked learning (CNL).

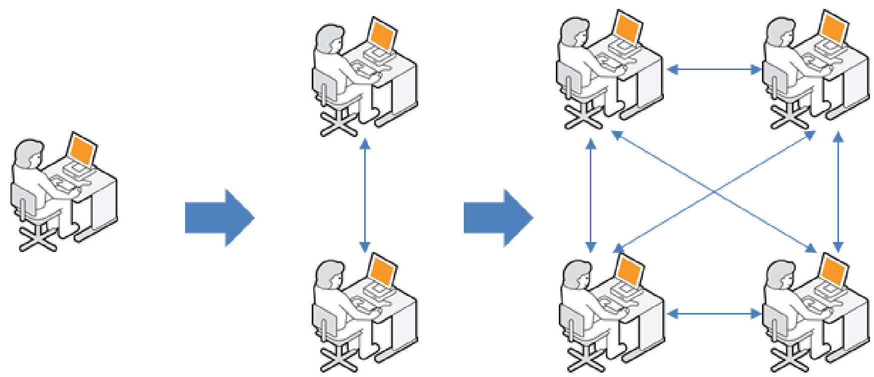

Figure 2-1 Typology of collaborative networked learning

CNL promotes the process of collaborative learning as integral networks of individual experts, contributing information and knowledge in their different roles and reference domains. In this context, learning focus is shifted from individual learning to learner expert system, to CNL. It is argued that the term collaborative networked learning reflects the essence of learning in a networked organization using computer networks to share information and knowledge. This contention is notably supported by Jones and Esnault (2004) and Camarinha-Matos and Afsarmanesh (2006) and hence serves as the basis for this study.

2.3.1 Definition of Collaboration Networked Learning

Findley (1989) first defines CNL as learning which occurs through electronic communications between self-directed learners and experts. CNL is a means to promote interactions between one learner to another; between learners and content experts; and between a learning community or workgroups and their learning resources using ICT (Brophy, 2001; de Laat, 2006; Goodyear, 2000; Goodyear et al., 2004; Goodyear et al., 2005; Jones et al., 2004). Collaboration begins with the identification of a problem that involves multiple parties with a mutual interest (Addleson, 2013; Camarinha-Matos et al., 2006a; Dillenbourg, 1999; Dillenbourg et al., 1996; Mohrman et al., 2008), aspirations and purposes in determining the appropriate collaboration approach (Shani et al., 2008). Individuals and work groups share information, resources and responsibilities to plan, implement and evaluate a program to achieve common goals (Camarinha-Matos et al., 2006a). Collaboration can also be defined as a "process of participating in knowledge communities” (Lipponen, 2002a, p. 73). CNL brings together individuals and workgroups to learn or attempt to learn through organizational network systems (e.g. intranet, extranet or internet), shared resources, networks of practice and projects through reciprocal collaborations. In every sense, CNL is a network that is largely autonomous, geographically distributed and heterogeneous, yet it is capable of collaboration to share complex information to achieve compatible goals (Camarinha-Matos et al., 2006b; Lipponen, 2002b). CNL transforms knowledge, experiences and perspectives into a coherent shared understanding and engages employees in knowledge construction (McConnell, 1999; Van den Bossche et al., 2006b). By expanding on these principles and definitions, CNL can be broadly defined as a systematic form of knowledge and information proliferation among members through interacting, engaging, facilitating mutual understanding and shared goals in the virtual enterprise. Employees use CNL to share, proliferate and transform organizational knowledge and learning.

2.3.2 Difference between Collaborative Learning and Collaborative Networked Learning

Although collaborative learning and CNL are computer-mediated, CNL is not collaborative learning. Lipponen (2002b) acknowledges that collaborative learning has a designed pedagogical purpose. While collaborative learning addresses pedagogical issues, curriculum design and course development in educational research, CNL’s primary focus is in both formal and informal organizational learning and sharing of information, which addresses the process of knowledge construction and transformation through the network. In CNL, employees or learners develop and maintain shared conceptions of a subject matter (Roschelle et al., 1995), then move swiftly to integrate each other’s perspectives and ideas to make sense of a task (Nastasi & Clements, 1992) and build new sets of knowledge (Dillenbourg et al., 1996; McGrath, 1984). Learning has thus evolved from an emphasis on formal training to the informal learning that is fundamental in CNL. Much of the work learning happens informally (Thompson, 2010) as it involves the goal of understanding and knowledge or skill acquisition which occurs without the presence of externally imposed curricular criteria (Livingstone, 2001).

In CNL, work can be conducted anytime, anywhere in a virtual workspace to overcome geographical challenges faced by global organizations (Cascio & Shurygailo, 2003). Unlike the educational context in which participants are considered to be homogenous, Curseu et al. (2008) posit that heterogeneity is unique and beneficial for the development of complex knowledge structures for work organizations. These differences are summarized in Table 2-1.

Table 2-1 Differences between collaborative learning and CNL

Dimensions	Collaborative learning	Collaborative Networked Learning
Focus	Study groups	Peer-to-peer or workgroups
Purpose	Teaching and Learning (exploratory)	Problem resolution (developmental)
Environment	Institution of learning/schools	Adaptable to workplace learning
Participants	Homogenous (students)	Heterogeneous (learners/employees)
Pre-requisite	Little or no-prior knowledge	Some expert knowledge required
Adaptability	Limited to technology/curriculum	Flexible in delivery of content
Content	Curriculum based	Project, problem or work-based
Technology	Asynchronous	Synchronous and Asynchronous
Group structure	Simple network or single group	Multiplicity of complex networks
Course structure	Formal and pedagogical	Formal and informal (situational)
Instructor preparation	Extensive pre-preparation	Some coordination required
Time/Location	Mostly scheduled or co-located	Anytime and geographical dispersed

2.3.3 Difference between Cooperative Learning and Collaborative Networked Learning

According to Yazici (2005) collaborative and cooperative learning involve the instructional use of small groups or teams where peer interaction plays a key role in learning (p.217). Hence, some scholars used the term cooperative and collaborative interchangeably to mean employees working interdependently on a common learning task. Collaboration should not be misconstrued with the term cooperation. There must be a clear epistemological distinction (Bruffee, 1995; Flannery, 1994). Cooperation is accomplished by the division of labour among employees, as an activity where each person is responsible for a portion of the problem solving, whereas collaboration involves the mutual engagement of participants in a coordinated effort to solve the problem together (Camarinha-Matos et al., 2006a; Dillenbourg, 1999; Laurillard, 2009b; Roschelle et al., 1995). According to Dillenbourg et al. (1996), “in cooperation the task is split (hierarchically) into independent sub-tasks, but in collaboration, cognitive processes may be (heterarchially) divided into intertwined layers” (p.2). As illustrated in Figure 2-2, the difference is in the manner in which the project's tasks are divided. In cooperative learning, the fundamental approach to group analysis is project centred, whereby the primary task is segmented and assigned to individual employees. In contrast, in CNL every employee is required to contribute to the totality of the primary task which often institutes a sense of interdependencies.

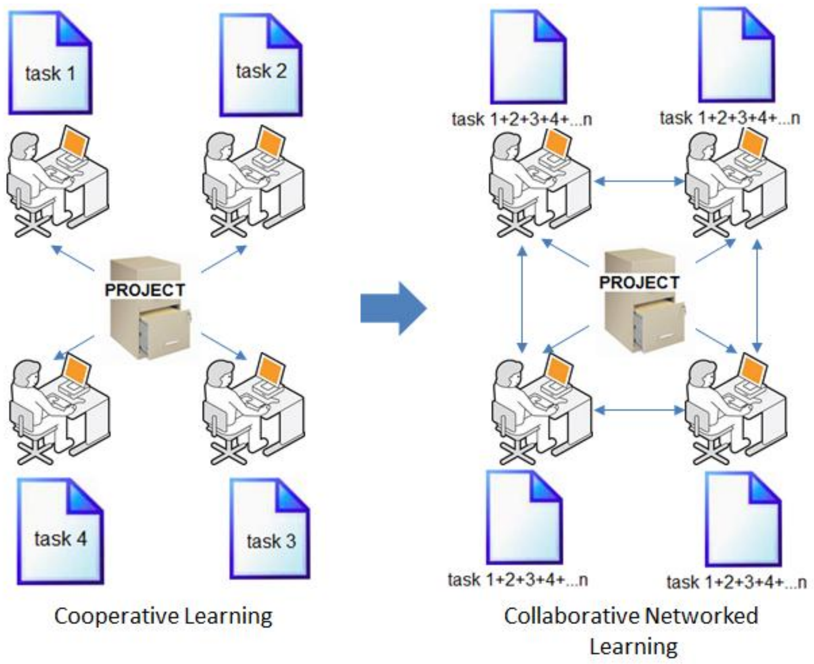

Figure 2-2 Typology between cooperative learning and CNL

In the opinion of Curtis and Lawson (2001) and Camarinha-Matos and Afsarmanesh (2006b), cooperative learning is the aggregated value of individual components where each member performs part of the job in a quasi-independent manner. McConnell (2002) distinguishes between collaborative and cooperative learning depending on the nature on the problem: collaboration if the outcome is shared, or cooperation if individuals are engaged in discussions and reflection on their own individual assignments with others. To summarize, Webb and Palincsar (1996) say that work is 'cooperation based' if members share a divided workload, or 'collaboration based' if members develop shared meanings.

CNL demands some form of coordination due to its joint creation facet in sharing risks, resources, responsibilities, and sometimes rewards (Camarinha-Matos et al., 2006b), which also "involves seeking divergent insights and spontaneity, and not simply a structured harmony" (Camarinha-Matos et al., 2006a, p. 29). CNL occurs when employees and their organization work together to co-construct and transform knowledge (Barkley et al., 2005; Matthew, 1996). The product of team endeavours and consensus is in the discovery and sharing of knowledge. The differences are summarized in Table 2-2.

Table 2-2 Differences between cooperative learning and CNL

Dimensions	Cooperative learning	Collaborative Networked Learning
Focus	Peer-to-peer or workgroups	Peer-to-peer or workgroups
Environment	Institution of learning and workplace	Adaptable to workplace learning
Participation	Division of labour	Mutual engagement
Pre-requisite	Similar level of knowledge	Different expert knowledge
Problem solving	Contributes part of the resolution	Coordinated effort among members
Task parcel	Hierarchically divided into sub-tasks	Heterarchially divided into multi-layers
Dependency	Quasi-independent	Highly interdependent
Knowledge	Discovery, acquisition and reflection	Co-construction

Cooperative learning is not always embraced because it challenges the established notions of expertise, working identities and relationships based on traditional hierarchies or canonical knowledge (Cullen et al., 2002; Rockwood, 1995). Knowledge does not necessarily accrue to any individual employee. Instead, it is widely distributed across the networks and CNL supports interaction and the sharing of information among diverse members (heterogeneous) of the manufacturing community.

2.4 Research Streams in Organizational Learning

Docherty and Shani (2008) identify four broad streams in collaborative research, namely: work organization; organizational learning; learning at work; and organizational design streams. The work organization stream focuses on organizational workgroups that would enable self-management (e.g. Emery, 1982; Gustavsen, 1992; Mohrman et al., 1995). Learning is becoming the prime responsibility of employees within their enterprises and workgroups. Manufacturing is shifting towards greater interdependence among individuals and workgroups to create collective and synergistic products and services through CNL. The organization learning stream addresses the depth and character of the learning process (Issacs, 1993; Senge, 1994) that may be acquired through evaluation, study, experience and innovation (Edmonson, 2002; Goodyear, 2000; Rooke et al., 2007; Vince, 2004). Research approaches such as these examine the conditions under which effective collaborative knowledge construction is achieved (Baker et al., 1999; Bereiter & Scardamalia, 2003; Lipponen, 2002b; Scardamalia et al., 1994; Wenger, 1998). Learning in the work stream evolved from the emphasis on the formal vocational training milieu to the experiential learning of employees and workgroups (Huang, 2002). Research in the organizational design stream believes that conditions for learning need to be designed and not left to emergence (Lipshitz et al., 1996). The focus is on self-directed learning and problem solving oriented learning in relation to the needs of the workplace. Gustavsen (2001) developed democratic dialogues for the use of collaborative research to facilitate learning across communities and inter-organizationally, incorporating both structural and procedural components. Others consider a wider span of studies that include regulatory, sectorial environment and characteristics of the operations, for example, different market conditions, regulations and technology may influence the way organizations engage with collaborative learning (Billet, 2004; Cullen et al., 2002; Fuller et al., 2007; Hager, 2004; Illeris, 2003; Lakkala, 2007; Phelan et al., 2004; Strijbos et al., 2007b). New didactic technologies are constantly being introduced to help employees to cope with changes through learning. The different research streams and their relationships with CNL are illustrated in Figure 2-3.

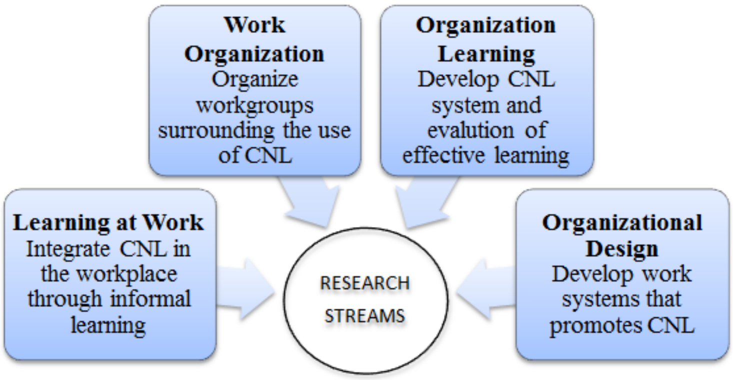

Figure 2-3 Focus of research streams in CNL

Encapsulating the fundamental distinctions between different streams provides clarity and support of CNL and how it fits into organizational learning. A review of several journal publications (see Table 2-3) on organizational learning, knowledge management, learning technologies, interactive learning and workplace learning revealed the popularity of these research streams. A total of 6,162 articles from 11 journal publications (from the year 2000 to 2012) were analysed. The journals were selected based upon primary areas of research related to collaborative learning, operations management, computer supported learning, learning technology, knowledge management and networked learning. The scopes of the journals are as follows:

i. The *Journal of Workplace Learning* focuses on formal, informal and incidental learning in the workplace for employees and workgroups, and explores the organizational, policy, political, resource issues and other factors which influence learning.

ii. The *Journal of Knowledge Management* focuses on strategies, tools, techniques and technologies for managing knowledge in organizations.

iii. The *Knowledge and Information Systems (KAIS)* provides a forum for research on new advances related to knowledge systems and advanced information systems, including their theoretical foundations, infrastructure, enabling technologies and emerging applications.

iv. The *Knowledge Management Research and Practice (KMRP)* discusses the current state of the knowledge management field that encompasses areas such as: managing knowledge; organizational learning; intellectual capital; and knowledge economics.

v. The *International Journal of Learning Technologies (IJLT)* publishes articles related to theoretical foundations, design and implementation of instructional technologies.

vi. The *Journal of Interactive Learning Research (JILR)* publishes articles related to the underlying theory, design, implementation, effectiveness, and impact of interactive learning environments in education and training.

vii. The *Journal of Operations Management (JOM)* publishes articles related to operations management and supply chain empirical research that impact on operations management theory and practice.

viii. The *International Journal of Computer-Supported Collaborative Learning* investigates technological designs for collaboration and learning through collaborative activity in education, business, and society.

ix. The *Management Learning* publishes research on organizational learning to advance theory and practice.

x. The *Learning Organization* focuses on issues around organizational learning and promotes critical analysis such as culture, organizational power, politics, managerial ideologies, and employees’ participation in learning.

xi. The *Computer Supported Cooperative Work (CSCW)* disseminates research results and ideas concerning theoretical, practical, technical, and social issues in CSCW.

Table 2-3 Number of researches in streams 2000-2012

Journal Publications	Total issues 2000-2012	Total articles 2000-2012	Collaborative learning		Workplace learning		Knowledge building		Networks of practice	
			n	%	n	%	n	%	n	%
Journal of Workplace Learning	105	452	8	12	106	82	2	6	11	11
Journal of Knowledge Management	72	599	2	3	1	1	1	3	17	17
Knowledge and Information Systems (KAIS)	132	2764					1	3	4	4
Knowledge Management Research and Practice (KMRP)	37	275	3	5			3	9	14	14
International Journal of Learning Technology (IJLT)	24	141	6	9			1	3	4	4
Journal of Interactive Learning Research (JILR)	49	297	8	12	1	1			3	3
Journal of Operational Management (JOM)	62	475	1	2						
International Journal of Computer Supported Collaborative Learning (ijCSCL)	28	170	28	42			13	41	1	1
Management Learning	58	370	1	2	6	5	2	6	5	5
The Learning Organization	74	345	3	5	10	8	5	16	21	21
Computer Support Cooperative Work (CSCW)	52	274	6	9	5	4	4	13	19	19
Total	**693**	**6162**	**66**	**100**	**129**	**100**	**32**	**100**	**99**	**100**

The contexts of the articles were reviewed with particular attention given to the treatment of collaborative learning, workplace learning, knowledge building and networks of practice. The result shows that the *Journal of Workplace Learning* pays more attention to workplace learning with 106 articles (82%) published in the related area. The *Learning Organization* and *Computer Support Collaborative Works* published the most articles on networks of practice, with 21 (21%) articles and 19 (19%) articles respectively. From all of the eleven journals, workplace learning was the most popular area of research with 129 articles, followed by networks of practice with 99 articles and collaborative learning with 66 articles published. Surprisingly, this review did not find any article with a special focus on the area of CNL.

2.5 Theoretical Paradigms

It is interesting to note that the research on CNL is still new and where technology continues to evolve, the possibility of expanding the study of CNL will certainly grow. The theoretical study on CNL in manufacturing is at its infancy stage, although there are researches which support CNL infrastructures, architectures, systems and processes that have been developed and expanded. There are a few well developed pedagogical models for computer support collaborative learning (e.g. Cognition and Technology Group at Vanderbilt U., 1997), but little is known on how different practices and networked learning environments fit into different virtual learning communities and cultures, or even support social learning within different organizational structures and styles (Daradoumis & Marquès, 2000). CNL is a good example where the processes and practices of collaborative learning in manufacturing organizations need exploration.

From the literature (see Table 2-4) it is found that the majority of the articles are based on network theory (n=58), awareness theory (n=27) and constructivism theory (n=27) published between the year 2000 and 2012. *Journal of Computer Support and Cooperative Work (CSCW)* published 20 (74%) articles based on awareness theory, while *The Learning Organization* published 22 (38%) articles based on network theory.

Table 2-4 Number of researches and theoretical paradigms 2000-2012

Journal Publications	Total issues 2000-2012	Total articles 2000-2012	Awareness Theory		Structuration Theory		Constructivist Theory		Network Theory		Socio-Technical Theory	
			n	%	n	%	n	%	n	%	n	%
Journal of Workplace Learning	105	452	1	4	3	25	1	4	1	2	3	17
Journal of Knowledge Management	72	599							3	5	1	6
Knowledge and Information Systems (KAIS)	132	2764							4	7		
Knowledge Management Research and Practice (KMRP)	37	275			1	8	2	7	5	9	1	6
International Journal of Learning Technology (IJLT)	24	141					1	4	3	5	1	6
Journal of Interactive Learning Research (JILR)	49	297	1	4			3	11	1	2	1	6
Journal of Operational Management (JOM)	62	475							1	2		
International Journal of Computer Supported Collaborative Learning (ijCSCL)	28	170	3	11			2	7	2	3		
Management Learning	58	370					5	19	1	2		
The Learning Organization	74	345	2	7	4	33	10	37	22	38	6	33
Computer Support Cooperative Work (CSCW)	52	274	20	74	4	33	3	11	15	26	5	28
Total	**693**	**6162**	**27**	**100**	**12**	**100**	**27**	**100**	**58**	**100**	**18**	**100**

Moving from a behaviourist and cognitive to a constructivist paradigm, collaborative learning research has evolved from the transmission model with an emphasis on pedagogical studies to a transformational model that is learner-oriented, where knowledge is actively constructed and the learning process is facilitated through social interaction. In the same way, CNL combines ideas from socio-constructivist theories of learning using technology. Technological affordance (Brown et al., 2000) offers new possibilities of collaborating in a virtual workspace, which affords significant time-space independence for employees and their experts (Hara et al., 2000; Lipponen et al., 2004; McConnell, 2000).

2.5.1 Awareness Theory

Awareness theory is based upon the fundamentals of cognitive capability to determine the cause and effect of learning within a social environment. Awareness is widely described and investigated in research on teamwork and collaboration (Carroll, 2008) and was introduced because the traditional process flow-models such as data flow and workflow models proved to be inadequate in addressing the awareness requirement of users in collaborative work (Daneshgar et al., 2005). Awareness modelling emerged from the area of computer supported cooperative work (CSCW) and has been at the forefront of research for the last 20 years (Agre, 2001; Benford et al., 1994; Carroll et al., 2009; Dourish & Bellotti, 1992; Gutwin et al., 1995; Jones et al., 2008). The review of CSCW research and the field studies of Bjerrum and Bødker (2003), Gutwin and Greenberg (2002) and Christiansen (2001) lead to an understanding of social awareness through the analysis of space, mediators, and human conduct and culture. Daneshgar et al. (2005) introduced the Awareness Net conceptual model for collaborative processes within a virtual community. Endley (1995) also presented a theoretical model of situation awareness in dynamic decision making. Jones et al. (2008) posit that "place-activity-people" aggregates the influence information needs and people's willingness to share information (p.147).

In awareness theory, knowledge is constructed through definitive consciousness and information awareness within the workgroup and its members (Gross et al., 2005). Knowledge provides members with relevant information about their collaborators, their activity, situation, or specific processes and occurrences (Gutwin et al., 2002). In that sense, members are well informed about others' conceptual knowledge. Digital concept mapping tools such as Cmap (see http://cmap.ihmc.us/) fosters knowledge and information awareness. This has been demonstrated in an empirical study for simulated virtual groups by Engelmann, Tergan and Hesse (2010b). Knowledge and information awareness are fostered by means of digital concept maps providing the conceptual knowledge of the collaboration partners, as well as the background information underlying this knowledge (Engelmann & Hesse, 2010a). To support collaboration interactions, Carroll et al. (2009) posit that members must attain and maintain reciprocal awareness of shared activity and information systems must design strategies surrounding awareness support.

2.5.2 Structuration Theory

The underlying principle of structuration theory suggested by Poole and DeSanctis (1994) and Orlikowski (Orlikowski, 1992a; 2000) is that CNL should be based on the needs of technology users and their workgroups in appropriation of available technologies. It evolves from Giddens's (1984) earlier proposition which seeks to resolve the contradictions of agency and structure theories that emphasize human action and structuralism. Gidden (1984) uses duality to explain the reciprocal relationship of human interaction and social structure. When employees interact with their colleagues or workgroups they change the social structure and learning continues to evolve as interactions continue. The structuring of technologies refers to users' manipulation of technologies to accomplish work and draws on a particular context of their work (Majchrzak et al., 2000). Similarly, Seufert et al. (1999) propose a networks reference model outlining the different dimensions using Giddens's (1984) duality of structure. Orlikowski et al. (1995) further introduced meta-structuring and technology-use mediation as another source of structure. More recent work from Adamides and Karacapilidis (2006) demonstrate reliance on structuration theory for developing the enhanced process modelling construct (EPMC) and for adapting a participative problem-resolution methodology (G-MoBSA) to the specific domain (p.572).

Studies that utilize structuration theory attempt to explain the relationship between information technology and organization structure and identity. For instance, Weisinger and Salipante (1995) use structuration theory in explaining how voluntary organizations in the United States create a pluralistic membership by initiating cross-unit interactions where the focus is on the organization's superordinate identity. Rice (1994) reviews the empirical research on the interplay of computer-mediated communication (CMC) and information systems with pre-existing social and organizational structures. Others like Lyytinen and Ngwenyama (1992) apply structuration theory to the research of computer supported cooperative work (CSCW) and find that organization structure provides essential support in the implementation of a CSCW system.

Poole and DeSanctis (1994), however, suggest using an adaptive version of structuration theory in their study of group decision support system (GDSS). Studies that use structuration theory focus on the appropriation and change in technology and its impact on work structure. Adaptive structuration theory (AST) claims that appropriation of technology does indeed affect the group decision making process, and in turn does affect outcomes. It is further suggested that the appropriation of technology is based on the needs and desire of the users (Belanger et al., 2008; Clear, 1999; Orlikowski, 1996) and concludes that technologies adaptation evolves over time, sometimes gradually, other times interrupted (Majchrzak et al., 2000; Tyre & Orlikowski, 1994). The improved technology enables users to share knowledge and access information in a timely fashion (Balenger et al., 2008). AST posits that the effective appropriation is influenced by faithfulness of the appropriation, the group's attitudes towards the structures and the group's level of consensus (Clear, 1999).

2.5.3 Social Constructivist Theory

Collaborative learning which combines constructivism and social learning is known as social constructivism (Laurillard, 2009b; Vygotsky, 1978). Social constructivist theory is socially grounded on a situated view of the learning process, as in 'cognitive apprenticeship' (Brown et al., 1989), socially 'shared cognition' (Resnick, 1991; Stahl, 2004), learner-oriented approach (Driscoll, 2000; Pereira, 2001) and 'situated learning' (Lave et al., 1991). Constructivism offers significant insights into the means of facilitating the development of problem solving capabilities (Ellis & Hafner, 2008) and emphasizes active involvement in knowledge building by integrating new information with existing experience (Niederhauser et al., 1999). Adopting a sociocultural constructivist view of learning warrants conceptualising the actions of the learner within the influences of the social origins of knowledge (Smith, 2006). According to constructivism, knowledge is constructed by social interaction and collaboration learning (Brophy, 2001; Huang, 2002; McDonald & Gibson, 1998).

Social constructivism assumes that an employee’s capacity for cognitive development is enhanced with the presence of scaffolding or guidance during interaction. Employees may appropriate knowledge that is shared and jointly created by the workgroup through dialogic discussions and interactions. Hence, constructivist-based learning settings reflect the conversational paradigm (Laurillard, 2002) and emphasize the necessity of collaborative effort in the knowledge construction process (Lim, 2010). Participation in networks of practice focus on the construction of knowledge and sense-making, which is central to the study of online learning (Booth & Hulten, 2003; de Laat, 2006) and functions in the context and environment in which social interaction and learning take place.

Social constructivism promotes the design of a knowledge reflection process by gathering insights on similar issues and past experiences. Problems and processes are viewed from the perspectives of one another (Bryman, 1988). The main focus of the social constructivist is on value interaction and negotiation among learners who together construct new meaning to the knowledge (Bruffee, 1995; Dillenbourg et al., 1996). Social constructivists also look at ways that collaborative interactions catalyse cognitive development and they emphasize the role of co-construction of knowledge, where learning is maximized in one’s own zone of proximal development (Vygotsky, 1987).

In the constructivist’s world view, knowledge is not drawn from a pre-conceived theory, rather it is constructed on the patterns derived from the data (Wilson & Salmons, 2009). Thus knowledge is drawn on contextual theories about learning and situated learning (Cullen et al., 2002). The broad trends in organizational learning can then focus on individuals in relation to their social context, environment and network of practice (Illeris, 2003). According to Strijbos (2004) this is not a recent discovery as Illich (1971) and Reimer (1971) argued that most learning does not require formal schooling and that schooling could be replaced with self-motivated learning taking place through learning webs or networks of people.

2.5.4 Network Theory

Network theory (Latour, 1991) explores the roles of human and non-human elements as equals in an interactional network of connectivity as well as social behaviour leading to sharing of information and collaborative learning. It also relates to complex interrelated actors and their relationships with multiple domains or environments (Poell et al., 2000; Wilson et al., 2009). Hanseth (1996) uses this theory to analyse information structure development and applications. Network theory has proven to be a useful theoretical framework to analyse structural conditions of technology and other enabling systems such as flexible learning environments (Roberts, 2004), e-learning technologies (Tatnall & Lepa, 2003), co-evolution of object and network collaboration in an innovative process of product realization (Lehenkari, 2006; Miettinen, 1998), the collaborative-based learning environment (Fjuk, 1998) or institutional networks for policy making (Wilson et al., 2009). Network theory explores power differentials within networks which states that actors are not in equilibrium due to difference in power, position or ability (Camerer, 2004) and that hierarchies and peer relations form part of the networks, coexisting and interacting (Heckscher, 2007).

Network theory often exemplifies the use of social network analysis (SNA) (Scott, 2000; Wasserman & Faust, 1997) to examine nodes which represent individual actors (or employees) within the networks and ties to illustrate the interrelationships among individual actors and introduces ‘structural variables’ to measure them (Martínez et al., 2006, p. 384) such as degree of network centrality, patterns, size and density (Belanger & Allport, 2008). Cohen and Prusak (2001) and Wilson et al. (2009) measure social capita, focusing on the aspects of trust-building and the value that the individual actors get from social networks. They argue that one cannot isolate knowledge from social networks that involve relationships, obligations and commitments. Conversely, centrality in a network is positively associated with satisfaction in team-based learning (Baldwin et al., 1997) and a higher sense of belonging in the network of practice (Haythornthwaite, 1998).

The research on networked learning highlights organizational learning as a cognitive achievement and is about work practices that use computer networks in the accomplishment of an individual’s goals and collective goals. Muller-Prothmann and Frost (2009) claim that the basic element of collaboration in an organization is knowledge sharing which serves as a function for learning, innovation and decision making. When employees collaborate in global virtual teams there will be pressures upon the individuals to optimize results for the overall global function as well for the local unit (Rich & Lukens, 2009). Employees have to adopt collaborative technologies based on the extent to which they perceive themselves as capable of using technology to achieve their goals. However, Araujo (2009) also found that team members are likely to exhibit different personal values, beliefs and attitudes, and cultural diversity that could impact self-efficacy in collaborative technology adoption.

By focusing on collaboration and interpersonal relationships in organizations, academic researches and business practices are led to various conceptualizations of informal knowledge communication in networks of practice and social networks (Muller-Prothmann et al., 2009). This also raises questions of identity and belonging; conflict and cooperation; and change and continuity (Goodyear et al., 2004). Salmons and Wilson (2009), however, recognize that few studies have actually examined communication processes, or organizational or leadership practices that encourage or hinder the development of working relationships needed to build and sustain online collaboration. In short, most studies are still lacking depth in the structure, organization, and the development process of collaboration or the degree of collaboration.

2.5.5 Socio-technical Systems Theory

Research on information systems examines more than just the technological system, or just the social system, or even the two side by side. It investigates the phenomena that emerges when the two interact (Lee, 2001, p. iii). The central principles of socio-technical systems theory were first elaborated by Trist and Bamforth (1951). Luhmann (1993) advances the approach in discussing modelling collaborative work combining new epistemological concepts with system theory. The term socio-technical systems (STS) relates to systems that combine social and technical sub-systems and interactions between complex system infrastructures and human behaviour. In socio-technical systems research, behaviour is often studied using an ethnographic approach, case studies, social network analysis and surveys (Goggins et al., 2011).

According to Herrmann et al. (2004), social systems are defined by: the phenomena of communications and cooperation between employees; emergence of systems; self-referential development of systems, structures and processes; self-descriptions; and responsible autonomy. Technical systems are defined by artefacts, control and anticipation, state-transitions, and pre-programmed adaptability (Herrmann et al., 2004). The relative structure and interactive patterns in the socio-technical context provide a necessary contrast for exploring group behaviour and dynamics of interactions (Goggins et al., 2011). It is assumed that the degree of integration between manufacturing organizations and the CNL infrastructures is closely interrelated.

Variation in the socio-technical context does have an effect on group experience (Dourish, 2004). The conditions affect the success (or failure) in the adoption of collaborative technologies. Socio-technical information systems can be designed to support storage and distribution of data as a basis of knowledge sharing within the organization (Herrmann et al., 2007). In addition, Powell et al. (2004) reviewed 47 studies of virtual teams, and suggested that the development of virtual teams is complex, multivalent and requires extensive study to determine the design based upon the social technical mechanism.

2.6 Framework and Modeling Collaborative Networked Learning

Adamides and Karacapilidis (2006) observe that modelling is predominantly used in process management, improvement, re-engineering and IT implementation initiatives. Although there are a significant number of researches on the modelling of collaborative networked organizations (Camarinha-Matos et al., 2006a; Huan, 2004; Löh et al., 2005), networked learning (Stamatis et al., 1999), computer supported collaborative learning (Weinberger & Fischer, 2006), and computer-supported collaborative work, few have attempted to model CNL for manufacturing (Adamides & Karacapilidis, 2006; Dennis et al., 1999; Taylor, 2001). Most of the models approach networked learning from pedagogical, multi-agent systems, semantics or ontological standpoints. In contrast, the participation framework is influenced by the works of Vygotsky's sociocultural approach and Deweyian pragmatism (Sfard, 1998), which provide appropriate tools for observing and conceptualizing collaborative work in groups and distributed expertise

(Lipponen et al., 2004). Scardamalia and Bereiter (1994) propose a *knowledge building* framework, which draws a theoretical distinction between knowledge building and learning; and between the knowledge used in work practices, and the knowledge that is the object or product of such work. The core of Engeström's (1987) model of *expansive learning* is the creation of a new model, concept and artefact as a consequence of a shared understanding of a collaborative learning activity. Both address the same central question: How is new knowledge created through collaborative activities? (Lipponen et al., 2004).

The nearest constructivist approach to modelling is from Camarinha-Matos and Afsarmanesh (2007) who attempted to design a framework for a *collaborative networked organization* (CNO) using the following four dimensions:

i. *Structural dimension* - addresses the structure or composition of the relationships between all employees or organizations (actors/nodes) and their roles in the network.

ii. *Componential dimension* - focuses on the elements in the organization's network, for example: hardware/software resources, infrastructures and architecture of the network supporting collaboration; information and knowledge; human resources; and ontologies used in the network to facilitate mutual understanding among the network members.

iii. *Functional dimension* - addresses the "base operations" available at the network and the execution of time-sequenced flows of operations (processes and procedures) related to the "operational phase" of the CNO's life cycle.

iv. *Behavioural dimension* - governs the processes involved in collaborative activities, for example, policies, governance, procedures, rules and value. Prescribes normative guidelines or rules for formal behaviour such as principles, strategies, and protocols. Deals with conflict resolution and contractual obligations between the organizations and external parties.

Alavi and Liedner (2001) present a framework for e-learning, which explicitly configures the relationships among technology capabilities, instructional strategy and psychological processes involved in the learning process. Similarly, Gupta (2006) in his doctoral study adapted the framework to model collaborative e-learning and end-users training. The impact of training is mediated through learning and the interaction process to achieve learning outcomes. The learning process is influenced by individual differences and the support provided.

Kamrani (2008) proposes an integrative *collaborative product development* (CPD) framework that provides design insight and a tool to evaluate, optimize and select better alternatives. It consists of an analytical tool, a collaborative environment, an optimization module, CAD modelling, and vendors' catalogues. For the integration of information, at every stage of product development there is a component for collaborative technology. Gronau (2004) explores the idea of *collaborative engineering communities* (CEC) as an application framework that enables Internet supported design of the product development processes through the integration of consumers and independent distributors in the design phase of a product lifecycle (PLC). In another study, Huang, Kristal and Schroeder (2008) propose a model on the effect of *internal and external learning on mass customization capability* (see Figure 2-4). The internal learning generates knowledge within the organization through training and employees' suggestions. The external learning identifies customers and suppliers as important sources of knowledge. Internal and external learning are meta-routines that emphasize problem solving and collaboration (Huang et al., 2008).

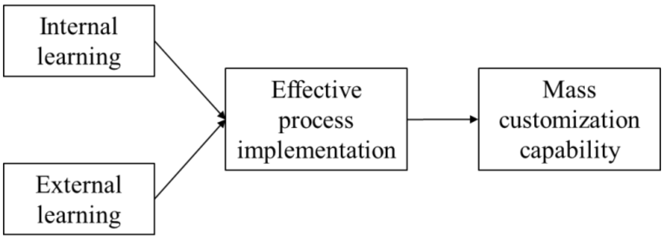

Figure 2-4 Effect of learning on process implementation and mass customization
(Source: Adapted from Huang, Kristal and Schroeder, 2008)

Lin (2007b) examines the impact of online information quality, system quality and service quality and the impact of offline activities on the sustainability of networks of practice and applies the *technology acceptance model* (TAM) as a theoretical framework (see Figure 2-5). Information quality affects perceived usefulness, while system-quality and service quality influence both perceived ease of use and perceived usefulness of virtual communities. Perceived usefulness and ease of use are significant antecedents of an employee's sense of belonging and influence the intention to use a network of practice.

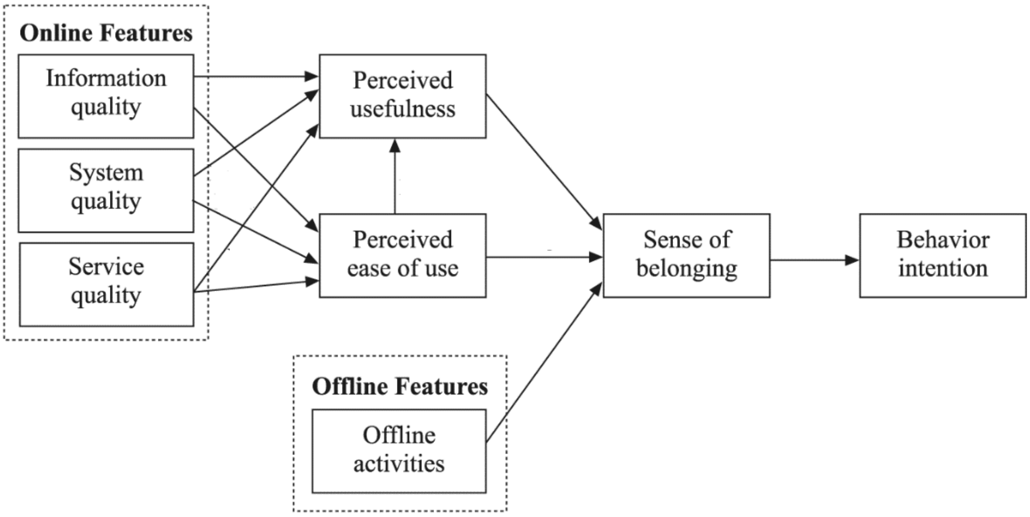

Figure 2-5 Technology Acceptance Model of virtual communities
(Source: Adapted from Lin, 2007b)

Wasson (2007) proposes a framework for the *technology enhanced learning environment*, which postulates the interaction between design and use and demonstrates that the design of a technology enhanced learning scenario requires components of organizational, pedagogical and technological aspects (see Figure 2-6). Huang, Jeng and Huang (2009) use this framework for modelling their research on a mobile blogging system to facilitate the learning activity in a technology enhanced collaborative learning environment from design and use perspectives. The pedagogical view of collaborative learning is regarded as a theoretical model of the design perspective and use perspective where learners' experimental activity influences the design and learning outcome.

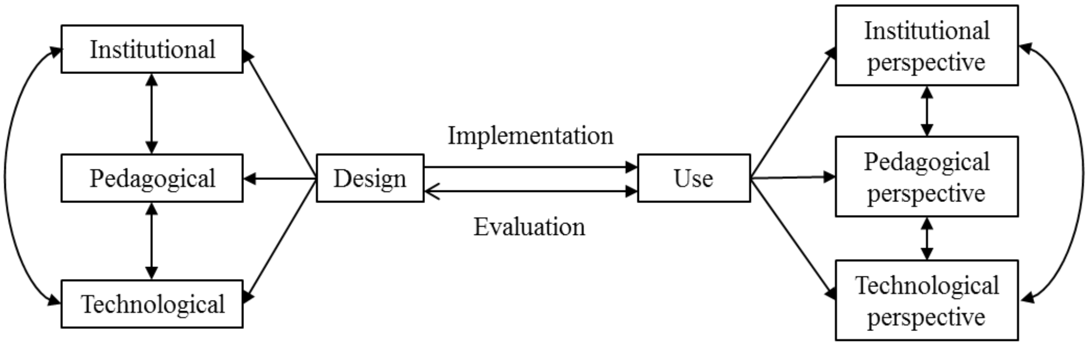

Figure 2-6 Technology Enhanced Learning Environment
(Source: Adapted from Wasson, 2007)

Although these frameworks manifest the model in various forms of collaborative learning, they do not depict the determinants of CNL; neither do they represent the model for the antecedents of CNL. Nevertheless, the study advances from the framework and guidance of socio-technical systems (STS) theory to develop an integrative framework for CNL in manufacturing.

These models describe characteristics of effective group interaction, sharing of information and construction of knowledge, such as organizational support (Scott & Walczak; Mohrman et al., 1995; Harris & Bayerlein, 2003; Fuller et al., 2007, Smith, 2003), positive interdependence (Chatenier et al., 2009; Grant & Baden-Fuller, 2004; Van der Vegt & Van de Vliert, 2001; Johnson & Johnson, 2003; Wageman, 2001; Giuliani, 2007; Lechner et al., 2006; Lusch et al., 2010), promotive interaction (Soller & Lesgold, 2000; Benbunan-Fich & Hiltz, 2003b; Swan, 2005; Whatley et al., 2005), internal-external learning, perceived effectiveness and perceived usefulness.

2.6.1 Organizational Support

Organizational support in information systems is defined in terms of assistance, feedback, encouragement and the provision of procedural support (Scott & Walczak, 2009). A support system is part of the organizational infrastructure that facilitates the necessary processes to manage, control, coordinate and improve work (Mohrman et al., 1995) which must be aligned with the organizational design (Harris & Bayerlein, 2003). Ideally, employees are self-directed and the organization is willing to support their employees' learning goals and engagement with others in the learning networks (Fuller et al., 2007; Smith, 2003) and extrinsic motivation to use technology (Scott et al., 2009).

The organization support is just as important in determining different forms of knowledge construction, and influences different forms of learning using technology as a mediator. Conversely, developing a training system, without organizational readiness and support, may lead to failure (Billet, 2001).

2.6.2 Interdependence

According to Findley (1989) learners share a common purpose, dependent on and accountable to individual and group successes of their work or projects. Learning theories state that interdependencies between team members are necessary for achieving desired learning outcomes (Chatenier et al., 2009). Task interdependence is embedded in the jobs (Van der Vegt & Van de Vliert, 2001), and employees require assistance and support from multiple teams to work collectively (Van der Vegt et al., 2001; Wageman, 2001). Studies have shown that self-managing teams, virtual global teams and other cross functional teams that support joint improvement activities and new product development (Grant & Baden-Fuller, 2004) require positive interdependence for the groups to succeed. “When goal, task, resource and role interdependence are clearly understood, employees realize that their efforts are required for the team to succeed” (Johnson & Johnson, 2003, p. 174). Virtual teams have a higher rate of interaction and higher interdependence between members than ordinary virtual groups (Furst et al., 1999 as cited by Curseu et al., 2008). Interdependencies may shift from communication networks, to collaborative networks involving joint technology development or innovation projects with customers, suppliers and partners (Giuliani, 2007; Lechner et al., 2006). Lusch, Vargo and Tanniru (2010) posit that the most challenging task is not about technology and its intermediary support organizations’ ability to meet the value propositions, but rather in gaining employees participation in a complex and interdependent value network.

2.6.3 Interactions

Without interaction there is no real collaboration (Soller et al., 1999). According to Lowyck and Poysa (2001), knowledge emerges through the network of interactions and is distributed among employees and system that interact. Hence, learning is viewed as a social construct, facilitated by communication, interaction, collaboration and cooperation among employees (Benbunan-Fich & Hiltz, 2003b; Swan, 2005). The degree of collaboration relies on the joint and shared ownership of the outcome and the quality of interaction during the process (Whatley et al., 2005). Kreijns et al. (2003) argue that interaction between the workgroup members will not automatically occur just because the technology used allows social interaction. Engeström (1992) explains that through collaborative activities, employees can focus on re-conceptualizing their own interaction system to create new motives and artefacts. Even interactions with computer-supported social networks (Wellman et al., 2000) should be considered as strongly interactive. Effective collaboration increases interconnections between organizations (Provan & Milward, 1995), increases interactions (Chen, 2011) and fosters learning among employees (Inaba et al., 2000).

2.6.4 Internal-External Learning

According to Paiva, Roth and Fensterseifer (2008), internal knowledge development leads manufacturing organizations to continuously fit their capabilities to environmental changes. Internal learning resides within the organization; embedded in behaviour, manufacturing activities, procedures, data storage, interactions, and repositories of knowledge. Effective internal learning requires: skill in conducting self-appraisals; ability to use appropriate learning standards and curricula; reflecting the assessment of events and personal goals; and willingness to change learning strategies (Cortina et al., 2004). Explicit knowledge is transformed into implicit knowledge through the process of internalization (Curceu et al., 2008). Direct experience and interaction are the only ways tacit knowledge can be transferred from an employee to another employee or workgroups (Nonaka et al., 1995). On the other hand, external learning places an emphasis on learning sources from inter-organizations, suppliers, partners and customers; often in the forms of interactions, procedures, information sharing and inter-organizational alliances. The ability to learn from external knowledge is a function of skills, language and knowledge of the most recent scientific or technological development in the field (Cohen & Levinthal, 2000).

2.6.5 Perceived Effectiveness

Soller and Lesgold (2000) posit that it would be impossible to enumerate and evaluate the effectiveness of all possible interactions from collaboration because the dynamic nature of human communication and interaction accounts for too many variables.

However, researchers are able to measure the perceived effectiveness and impact of knowledge transfer and collaborative technology. Stonebraker and Hazeltine (2004) examine the effectiveness of a virtual learning program managed by a MNC and found that familiarity with the technology is directly associated with virtual learning satisfaction and the positive perception of the relevance of the courses to the job.

2.6.6 Perceived Usefulness

Perceived usefulness reflects employees belief in their ability to obtain information and services, share their experiences with others, and enhance their performance in information exchange (Lin, 2007b). The information is useful only if the online information is accurate, informative and updated (Perkowitz & Etzioni, 1999). Information quality improves the usefulness by enhancing the fit between network content and employees' information requirements (Lin, 2007b). In addition, Lin and Lu (2000) argue that information quality is a valuable predictor of the perceived usefulness. Information quality is affected by its perceived usefulness and the employee's ability to recognise its value so that information can become integrated into experience (Cohen & Levinthal, 1990; Lenox & King, 2004). System quality in online information system measures the functionality of a portal (Lin, 2007b). System reliability, convenience of access, response time and flexibility are qualities valued by users and affect the perceived usefulness (DeLone & McLean, 2003; Nelson et al., 2005).

2.7 Collaborative Technology

Research on CNL has recently paid increasing attention to the rapid development of collaborative technology (Goodyear, 2003; Laurillard, 2009b; Lipponen, 2002a, 2002b; McAndrew et al., 2006; Pereira, 2001; Stonebraker et al., 2004). Collaborative technology supports organizational learning by enabling employees to transfer and exchange ideas and knowledge (Curseu et al., 2008; Laurillard, 2009b) through creative use of multimedia, combined with communication tools (Pereira, 2001) and virtual communities (Bergquist & Liungberg, 2001; de Souza & Preece, 2004; Hall & Graham, 2004). In the study on epistemological and ontological dimensions of human-computer interaction (HCI), Brey (2005) outlines the epistemic[3] and ontic[4] relation between

[3] Epistemic devices extend human cognition by performing information processing tasks.
[4] Ontic devices simulate environments and act as tools to interact with these environments.

humans and computer systems in support of information-processing and problem solving. Computers are becoming ontic devices that generate and sustain new virtual and social realities (Brey, 2005) and offer enormous potentials for collaborative learning by overcoming time and space constraints (Laurillard, 2009a, 2009b; Lipponen, 2002a). Based on the human-computer interaction (HCI) perspective, several studies have noted that web site usability and service quality are the key factors for predicting members' intention to use networks of practice (Kuo, 2003; Lin, 2007b; Preece, 2001; Soller & Lesgold, 2000).

Advancement in the development of information communication technology (Carchiolo et al., 2002; Serce & Yildirim, 2006) and wireless communication technology (Motiwalla, 2005) accelerate the use of CNL through the Internet and provide new opportunities for communication and innovative employee interaction both in and out of the learning setting (Chen et al., 2003; Clough et al., 2007; Lakkala, 2007; Tatar et al., 2003). Technology is easily applied for transmitting and delivering knowledge (Lipponen, 2002b) and since wireless handheld devices support a cooperative and collaborative learning environment, mobility, coordination, communication, and organization of materials, negotiation, and interactivity are greatly enhanced in ways not possible in conventional learning environments (Lai & Wu, 2006; Zurita & Nussbaum, 2004). The CNL leverage on computer technology to provide analytical capabilities, interactivity, and networking support and to organize geographically dispersed teams (Camarinha-Matos et al., 2006a; Suthers et al., 2008; Wasson, 2007), allowing distributed people to communicate, collaborate, and share information over distance and time (Belanger et al., 2008; Curseu et al., 2008; Susman et al., 2003).

In addition, Zakaria, Amelincks and Wilemon (2008) in their study on global virtual teams describe how the heterogeneous workgroups used synchronous and asynchronous technologies to collaborate. Although collaborative technology encompasses a variety of functions to support group work, including information exchange, shared repositories, learning management systems, and groupware systems to facilitate communication and coordination (Bhatt et al., 2005; Cooper, 2003; Orlikowski & Hoffman, 1997), employees must make sense of collaborative technology, each other and the task at hand simultaneously (Goggins et al., 2011; Laffey et al., 2006). A CNL environment should be flexible to promote constant growth and development, following changes in organizational needs, employees' expectations, and technology advancement.

2.7.1 Structured Collaboration

Structured collaboration provides a workspace for individuals and workgroups to communicate or collaborate. Structural mechanisms include communication channels, organizational structure, physical, technical, and work-system infrastructure that enable practice-based learning (Docherty et al., 2008), workspace tools and a workflow management system (Lee & Holmquist, 2009). The establishment of lateral structures enable CNL across organizational units to transform organizational design, organize learning programmes, and establish global virtual teams. Collaborative tools enable employees to share workspace for the authoring and review of documents in a controlled manner, which fit well with organizations that use a team-based approach for work (Lee et al., 2009). A workflow management system represents the movement of information that flows through the sequence of steps or operations. For instance, by analysing the historical data of workflow executions, bottlenecks, workloads, and throughput time, missed datelines can be clearly identified for remediation or further improvement (Haag et al., 2006). Structured collaboration is therefore a crucial component for establishing policies and governance pertaining to CNL, and for ensuring the effectiveness and consistency of the learning programmes.

In a study of manufacturing organizations, Choy et al. (2008) found that effective learning occurs when employees are provided with structured learning experiences and opportunities with graduated access to vocational experiences to achieve a higher level of competency. In manufacturing, work-based learning encompasses a variety of job related skill sets that are needed to perform specific roles and/or tasks. An effective collaboration therefore requires some alignment or integration between the business processes and the information systems. On that basis, Muller-Prothmann (2009) introduced KMmaster®, a software application that is designed to facilitate collaboration and create a platform to support knowledge communication in teams, departments, or inter-organizational networks.

2.7.2 Unstructured Collaboration

Unstructured collaborative technology consists of synchronous and asynchronous systems. Unstructured data includes application files and text data format, and other multimedia or graphic data, which can be stored in personal folders and shared workgroup folders, and multiple file servers (Manwani & Moon, 2004). Both synchronous and asynchronous technologies focus on integrating the unstructured data into useful information. Lee and Holmquist (2009) define this type of unstructured collaboration as computer application and information tools for example, computer-mediated communication (CMC). Some scholars believe the terms asynchronous learning and e-learning are frequently used interchangeably (Levy, 2007). While learning through an online forum constitutes asynchronous e-learning, learning through chat or instant messaging is considered as synchronous e-learning (Bouhnik et al., 2009). However, the notion of e-learning actually constricts the definition of CNL and does not recognize other forms of informal learning and participatory-based learning.

Choosing between synchronous and asynchronous systems depends on the needs and the stage of collaboration. The delay of asynchronous communication, for instance, allows time for reflection in interaction and helps learners to reflect on their own and others' ideas and to share their expertise (Lipponen, 2002a). According to Wasson (2007), before embarking on a project task, the rate of synchronous meetings and frequency of communication are higher than the post decision. The asynchronous nature of the post decision work only takes precedence after the need for synchronous meetings has diminished, or members have been reassigned to their respective area of responsibility. Learning is then transformed into more of a cooperative, rather than a collaborative form of work (Wasson, 2007). While the asynchronous learning has the capability to expand time which allows extended interactions, synchronous learning has the capability to contract time which makes it particularly appropriate for tasks that require interactivity, spontaneity and fast decision-making. Unlike a face-to-face setting, asynchronous communication lacks immediacy of feedback (Strijbos, 2004). On the other hand, synchronous learning provides a sense of immediacy and communicative presence, hence enhances interactions (Haythornthwaite et al., 2000).

2.7.2.1 Asynchronous Learning Network

The asynchronous learning network (ALN) involves the exchange of information between group members at different times. It allows participants to contribute and express ideas (Ingram & Hathorn, 2004) facilitated by emails and discussion forums (Bouhnik et al., 2009; Kildare et al., 2006), while maintaining contact over time and sharing group documents (Bennett, 2004). Coordination in asynchronous collaboration involves the offline data capture of missed messages, traces of interactions, and the historical view of the collaborative outcome (Balmisse et al., 2009) which include email, listservs, newsgroup, chatrooms, Microsoft SharePoint, Lotus Notes/Domino, podcasts and discussion forums. Other office applications (e.g. wordprocessors, spreadsheets and presentations) are part of the collaborative tools that support the co-authoring of electronic documents. Integration of these applications, for example between Acrobat X with Sharepoint and Microsoft Office, delivers an efficient, easily deployed and secure online collaboration solution, complete with document conversion, reviewer notifications, response tracking, comment aggregation and archiving capabilities (Forrester Consulting, 2010). The asynchronous learning network (ALN) provides access to project documentations, accelerates decision making, reduces turnaround time and increases team efficiency.

The development of online collaborative office applications such as Callanos^{TM} (for team document sharing, workplace and project collaboration), and Google applications and Office Web applications enhance wordprocessors, worksheets and presentations to work virtually anywhere with a supported browser. According to Fjuk and Smodal (2001), the Internet provides capabilities for searching, browsing and exchanging information. More recently, wiki has been widely used by organizations as a type of asynchronous web-based collaboration tool.

The use of computer technology in CNL is constantly expanding. The most original applications of computer support collaborative learning (CSCL) [5] and collaborative technology are, perhaps, networked learning environments (or groupware) such as Computer Supported Intentional Learning Environment (CSILE) (Scardamalia et al.,

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[5] According to Strijbos (2004) CSCL involves a simultaneous study of the interaction between cognitive, motivational and social components in an attempt to learn through collaboration.

1994) or Future Learning Environment (FLE-Tools) (Lakkala, 2007; Muukkonen et al., 1999) which are designed for educational use and collaborative knowledge construction (Lipponen, 2002b; Scardamalia et al., 1994). CSCL provides users tools for posting knowledge into a shared workspace and system tools for progressive discourse interaction between employees (Scardamalia et al., 1994). In the same way, the asynchronous learning network (ALN) is organized for members who use computer-mediated communication (CMC) networks to learn, at the time, place and pace suited to support reflective and analytical approaches to interaction (Harasim et al., 1995; McConnell, 2000; Motterham & Teague, 2000). Moreover, Hutchins and Hutchinson (2008) posit that the emphasis on the usability of the asynchronous sources and the immediacy of these sources are crucial. With the increasing number of global collaborations, it is not surprising that the ALN is more frequently used than synchronous communications because they provide flexibility for the dispersed employees (Wilson et al., 2009).

While the ALN enables effective knowledge sharing and allows employees to focus on important tasks and provides freedom to initiate, and respond, it may be problematic to get timely communication and collaboration (Lee et al., 2009). The delay allows time for reflection in interaction (Dillenbourg et al., 1996; Lipponen, 2002b). Group members can carry on lengthy but focused conversations with asynchronous conferencing systems that maintain conversational threads about specific subjects of interest (Sproull & Kiesler, 1991; Turoff, 1991), schedule activities on group calendars (Lange, 1992), track activities through workflow systems (Abbot & Sarin, 1994), and post and retrieve documentation comprising a repository of organizational memory and expertise through hypertext (Ackerman, 1994; Ackerman & Malone, 1990; Conklin, 1992). A study of a mobile blogging system revealed positive and encouraging support for collaborative learning (Huang et al., 2009).

2.7.2.2 Synchronous Learning Network

Synchronous learning network (SLN) occurs when single or multiple parties exchange information concurrently. A synchronous system allows employees to meet online through synchronous discussion and quickly share ideas (Ingram et al., 2004). This includes real-time chatting, exchange of information through group interactive sessions and audio-video conferencing such as Skype, webcast, Vyew (for collaboration and web conferencing), Concept Share (for sharing and feedback on Web and other design products), Twiddla (online whiteboard), instant messaging, and Microsoft's NetMeeting. Other systems that support real-time collaboration over work artifacts include application sharing (Greenberg, 1990), groupware drawing systems (Greenberg et al., 1995), groupware text editors (Baecker et al., 1993), live presentation tools and business meeting tools for brainstorming and idea organization (Valacich et al., 1991). All these systems encourage collaboration and sharing of expertise through conversations and discussions (Hass et al., 2003). Instant messaging is based on peer-to-peer (P2P) technology which requires client application over the Internet protocol. Participating in multi-point and multi-threaded conversations over instant messaging in the virtual workplace may pose issues to employees of older generations who do not have a similar experience to the Internet savvy generation and desire to use the tool in the same way (Lee et al., 2009).

Although teleconferencing and video conferencing has been around since the early 1990s, the advancement of conferencing technologies provides a forum for geographically dispersed teams to collaborate and exchange ideas and information, while virtual customer support centres or helpdesk technicians remotely collaborate, using chat, email, discussion list, or screen sharing to assist and support customers in their homes and offices. Virtual contact centres take advantage of the "anytime", "anywhere" characteristics of the Internet (Irons, 2009). More recent affordability of the broad bandwidth technology further enables video over the internet protocol (VoIP) to deliver voice communications and multimedia sessions over an internet protocol (IP) network such as Skype. The benefits of web-conferencing include increased business efficiencies, speeding up the process of organizing meetings, accelerate the decision making process, and cutting travel expenses. Frequently, technology is used as a marketing tool to give presentations and discussion with customers over the Internet (Lee et al., 2009). Others like network conferencing (in the form of discussion forums, bulletin boards, etc.) create unstructured group discussions.

2.8 Applications of Collaborative Networked Learning

The need to adopt CNL in manufacturing arises from three developments: 1) widespread interest in organizational learning; 2) the present ubiquitous use of ICT for online training and e-learning; and 3) the omnipresence of virtual teams within the organization (Brandon & Hollingshead, 2008). These developments are well supported by scholarly studies on networked learning (de Laat, 2006; Goodyear, 2000, 2005; Goodyear et al., 2004; Goodyear et al., 2006) which conclude that CNL enables organizations to adapt and respond to global demands for rapid change and to have greater agility (Bogenrieder & Nooteboom, 2004; Knight & Pye, 2005; Polito & Watson, 2002; Quik et al., 2006).

In product life cycle (PLC) management, employees use CNL to interact in a dynamic virtual workspace for the entire phases from product conceptualization, design, build and servicing (Sayah & Zhang, 2005). CNL can be applied to accelerate product realization by reducing developmental costs and improving organizational performance and responsiveness to market needs. With global virtual teams, operating costs are further reduced due by cost saving in travelling, relocation and the avoidance of expatriation assignments (Duarte & Snyder, 1999).

CNL helps build an organizational culture that fosters learning and the open sharing of knowledge and innovations. Best practices and transferable processes can be effectively proliferated across the globe, creating new standards and leveraging successes from other organizations or subsidiaries. Learn by doing and guided methodology for problem solving could transform organizational knowledge (Quik et al., 2006). Virtual team collaborations focus on participatory learning facilitates and the sharing of knowledge between employees and workgroups (Valkanos & Fragoulis, 2007). CNL enables geographically dispersed employees and workgroups to document, disseminate and share product information such as product schematics, bill of materials (BOM) and technical specifications over the network. Vital information can be shared and transferred on a secured and accelerated pace or real-time basis.

From an individual’s perspective, an employee is concerned about the need to acquire new sets of knowledge and skills to improve and to simplify his/her work processes, increase productivity and to reduce the cost of reworks (Quik et al., 2006). According to Daradoumis and Marquès (2000), virtual team collaboration creates the potential for cognitive and metacognitive benefits. It reinforces and improves learning of the subject-matter and engages employees in the CNL process. Likewise, employees who are trained on the use of collaborative tools are able to formulate new knowledge and enhance their problem solving skills and innovations (Quik et al., 2006). CNL also leads to extensive learning opportunities, affordance and development in communication and socio-technical skills.

2.9 Summary

The literature review in this chapter underpinned the importance of theoretical and conceptual development in the area of CNL. It argued that better understanding of the inter-relationships between CNL and organizational learning is further required. It also explored the concept of collaborative learning from multiple perspectives and theoretical paradigms. The underlying premise is that CNL is well known and widely used in today's manufacturing organizations. Many have leveraged the use of collaborative technology to share information and to accelerate learning. However, the nature of manufacturing industries is so diverse that there is no cohesive CNL system that could be unilaterally adopted or used by all manufacturing organizations. Although there is a vast literature on collaborative learning in the context of education, there is also lack of research exploring the antecedents of CNL in manufacturing.

This study attempts to fill these gaps by conducting an empirical research that examines various antecedents influencing the adoption and utilization of CNL. The inadequacy of knowledge in the research of CNL in manufacturing has spurred this doctoral study and helped to shape the research propositions in the following chapter. The research questions are presented below:

RQ1. *What are the significant antecedents for a CNL model in manufacturing?*

This research question addresses the need to examine the proposed constructs: organizational support, positive interdependence, promotive interactions, internal-external learning, perceived effectiveness and perceived usefulness in their roles as antecedents influencing the dependent variable CNL in manufacturing.

RQ2. *How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning?*
This question examines the relationships between organizational support, positive interdependence, promotive interaction, and internal-external learning with CNL. This will operationalize the research objective and the antecedents of CNL to establish an integrative framework within the manufacturing context.

RQ3. *What are employees' perceptions of CNL*'s *usefulness and effectiveness in manufacturing?*
This question identifies CNL implementation with employees' perceptions of CNL effectiveness and usefulness. It also relates to RQ2 on the need to establish a solid CNL system within the proposed framework. Perceived effectiveness and usefulness are expected to bear some influences.

RQ4. *What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?*
This question aims to investigate the difference between CNL for MNCs and CNL for SMEs. Although both exist within the manufacturing industry with common operational models, it is of interest to determine the barriers and challenges in implementing CNL programmes. In particular, the frequency and intensity of CNL usage between both organizations is investigated, bearing in mind the likely scarcity of resources in SMEs.

The research questions define the scope of the research and determine what is to be studied, and to some extent how it will be studied (Blaikie, 2000, 2010; Creswell, 2008; Johnson & Onwuegbuzie, 2004). The research questions are derived from and extend the research objectives or purpose (Ridenour & Newman, 2008), as well as representing the direction of the research (Creswell, 2008). The research questions are used to formulate the framework for the research in the next chapter.

CHAPTER 3: RESEARCH FRAMEWORK

3.1 Introduction

From the review of the literature in Chapter 2, the study identified gaps in the literature which lead to an outline of the research questions. This chapter provides a rationale for the model of the study and introduces the conceptual framework. The conceptual framework aims to illustrate the relationships between the independent variables and dependent variables and to operationalize CNL. The relationships are supported by the research propositions.

3.2 Restatement of the Research Questions

The purpose of this study is to establish the antecedents of collaborative networked learning in manufacturing by addressing the following research questions:

RQ1. What are the significant antecedents for a CNL model in manufacturing?

RQ2. How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning?

RQ3. What are employees' perceptions of CNL's usefulness and effectiveness in manufacturing?

RQ4. What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?

3.3 Conceptual Framework

A framework represents a set of basic assumptions or fundamental principles in which discussion and actions can proceed (Popper, 1994). It is closely related to the 'theoretical perspectives' and the 'ontological conceptual' (Blaikie, 2010). The conceptual framework acts as a model to focus on interpreting the phenomena relevant to the research. When the framework is translated into measurable relationships between concepts, then it becomes an operationalized system which eventually develops into theory after it has been tested (Blaikie, 2010).

The initial selection of the constructs was generated from the researcher's self-reflections based upon years of experience as practitioner in the area of study. Following this, a comprehensive list of constructs used in previous empirical researches was drawn from the literature in Chapter 2. This is consistent with Netemeyer's (2003) recommendation that the process of research development starts with a review of the literature in order to extract a solid theoretical definition of the constructs and domains delineated and outlined domains. The result from the extraction of theoretical definition of the constructs and domains from closely related empirical studies is summarized in Table 3-5. Having identified the constructs from the literature the researcher then engaged in consultations on the area of research with experts from manufacturing organizations and with a panel of senior academics and researchers at AUT.

Concepts of CNL are drawn from collaborative learning, cooperative learning and work-based learning. The related constructs are then associated to the CNL environment to ensure compatibility in purpose and functions. The justifications on the selection from a range of constructs to develop the antecedents of CNL are shown in Table 3-6.

The selected constructs are then adopted and developed into a conceptual framework of CNL, as shown in Figure 3-7. These theoretical deductions are then investigated by examining the antecedents that support CNL in manufacturing organizations.

Table 3-5 Empirical studies on related areas

Classification of Scale	Authors	Methodology	Sample size	Related construct(s)
Collaboration technologies	Nikas, Poulymenakou, and Kriaris (2006)	quantitative (survey)	285 companies, response rate 62.5%	Top management support, IT department quality, collaborative work practices, environmental
Implicit knowledge dissemination	Fedor, Ghosh, Caldwell, Maurer and Singhal (2003)	qualititative (semi structured interview) quantitative (survey)	10 companies, 48 teams, 150 members, response rate 62.5%	organizational support, internal-external learning, project success and impact
Cross-functional teams	Chen and Paulraj (2004)	quantitative	954 sample size, 232 responded, response rate 24.3%	top management support, information technology, communication, cross functional teams
Knowledge management system	Vitari, Moro, Ravarini, and Bourdon (2009)	quantitative	103 consultants (response rate 8%), 97 engineers (response rate 20%)	organizational culture, organizational structure, perceived usefulness
Communities of practice	Zboralski (2009)	quantitative (SEM)	1 MNC, 220 active CoP, 222 participants from 36 CoP	management support, interaction frequency, interaction quality
Interdependence (job)	Dean and Snell (1991)	quantitative	512 manufacturing companies, 123 plant managers, 101 operations managers, 109 quality managers, and 97 production managers	Interdependence
Competitive and collaborative learning	Regueras, Verdu, Verdu and Castro (2011)	quantitative	36 students (in pairs)	positive interdependence
Cooperative learning	Janz and Prasarnphanich (2003)	quantitative (SEM)	13 organizations, 28 teams, 231 teams members	positive interdependence, promotive interaction, effectiveness
Continuous improvement/ learning	Anderson, Rungtusanantham, Schroeder, and Devaraj (1995)	quantitative	41 out of 72 plants participate, 60% response rate	Internal and external cooperation, learning
Continuous improvement	Rungtusanantham, Forza, Koka, Salvador, and Nie (2005)	quantitative (secondary data)	110 plants in Round Two WCM database	Internal and external cooperation, learning
Organizational learning scales	Schroeder, Bates and Junttila (2002)	quantitative (SEM)	164 plants, 65% response rate	Internal and external learning
Knowledge transfer effort	Zellmer-Bruhn (2003)	quantitative	3 companies, 158 teams	knowledge acquisition and transfer, external learning
Team learning	Sarin and McDermontt (2003)	quantitative	52 teams, 229 members	team learning, participation

Table 3-5 Empirical studies on related areas (cont')

Classification of Scale	Authors	Methodology	Sample size	Related construct(s)
Virtual teams	Lin, Wang, Tsai, and Hsu (2010)	quantitative (SEM)	40 out of 200 companies, 1000 questionaires, 312 usable response rate 31.2%	perceived job effectiveness, perceived benefits
Computer technology	Lowerison, Sclater, Sshmid, and Abrami (2004)	quantitative	1231 students in 61 classes	perceived effectiveness
Learning management system (LMS)	Ritchie, Drew, Srite, Andrews and Carter (2011)	quantitative (SEM)	388 sales associates, 52% from US, 48% from 31 different countries, response rate 54%	perceived usefulness
Information system	Venkatesh, Speier and Morris (2002)	quantitative (SEM)	not mentioned	perceived usefulness
Organizational knowledge	Bock, Kankanhalli and Sharma (2006)	quantitative (SEM)	44 working professionals	perceived usefulness
Virtual communities	Lin (2007)	quantitative (SEM)	200 questionaires, 165 completed, response rate 82.5%	perceived usefulness, information quality, system quality, service quality
Usage of intranet	Lee, Kim (2009)	quantitative (SEM)	333 intranet users,10 companies	technical support, task interdependence, perceived usefulness
Design-process integration	Droge, Jayaram, and Vickery (2004)	quantitative	150 first-tier suppliers	external integration
Information sharing	Li, Rao, Ragu-Nanthan, and Ragu Nanthan (2005)	quantitative (SEM)	3,137 respondents, 196 useable	supplier partnership, information sharing
Information sharing	Monczka, Peterson, Handfield, and Ragatz (1998)	quantitative	84 companies, response rate 41%	information participants and information sharing
Collaborative learning	Martinez, Dimitriadis, Gomez-Sanchez, Rubia-Avi, Abellan, and Marcos (2006)	qualititative quantitative social network analysis	CA-UVA > 100 students AIB-OUC > 130 students	network centrality, density
Team perception of knowledge sharing	Hoegl, Partoeeah, and Munson (2003)		145 teams, 430 interviews	perception of strength, network preference

Table 3-6 Selection of Constructs for CNL

Classification of Scale	Related construct(s)	Reason for Selection
Collaboration technologies	Top management support, IT department quality, collaborative work practices, environmental	Management support is imperative for collaborative technology e.g. resource allocation, promotions and support structure.
Implicit knowledge dissemination	Organizational support, internal-external learning, project success and impact	Organizational support and internal-external learning supports knowledge dessemination
Cross-functional teams	Top management support, information technology, communication, cross functional	Management support key to success in cross functional teams and IT/IS project management.
Knowledge management system	Organizational culture, organizational structure, perceived usefulness	Organizational structure related to organizational support. Perceived usefulness could be key to adoption of CNL system
Communities of practice	management support, interaction frequency, interaction quality	Management support and promotive interaction are factors that promote workgroups in CNL
Job interdependence	Interdependence	Job interdependence forces employees to use CNL.
Competitive and collaborative learning	positive interdependence	Positive interdependence, promotive interaction, and perceived effectiveness are determinants of competitive, cooperative and collaborative learning.
Cooperative learning	positive interdependence, promotive interaction, effectiveness	
Continuous improvement	Internal and external cooperation, learning	Internal-external learning affects continuous improvement, which is the purpose of CNL
Organizational learning	Internal and external learning	Internal-external learning core to sharing and learning within the organization
Knowledge transfer effort	knowledge acquisition and transfer, external learning	External learning influences knowledge transfer which relates to CNL sharing of information
Team learning	team learning, participation	Out of scope for the study of antecedent of CNL. This construct is more relevant in the study of group dynamics and effect of CNL.
Virtual teams	perceived job effectiveness, perceived benefits (usefulness)	Perceived effectiveness is also to related to CNL as it is dependent on workgroups.
Computer technology	perceived effectiveness	Perceived effectiveness could effect the adoption of CNL system or collaborative technology.
Learning management system (LMS)	perceived usefulness	LMS is part of CNL's sub-system in the use of computer support learning.
Information system	perceived usefulness	Perceived usefulness could effect the adpotion of CNL system or collaborative technology
Organizational knowledge	perceived usefulness	
Usage of intranet	technical support, task interdependence, perceived usefulness	Intranet is a form of collaborative technology. Technical support can be related to organizational support.
Information sharing	supplier partnership, information sharing	Could be measured by interdependence and interactions.
Collaborative learning	network centrality, density	Omitted. Related to Social Network Analysis (SNA) theory and not STT
Team perception of knowledge sharing	perception of strength, network preference	Omitted. Related to Social Network Analysis (SNA) theory and not STT

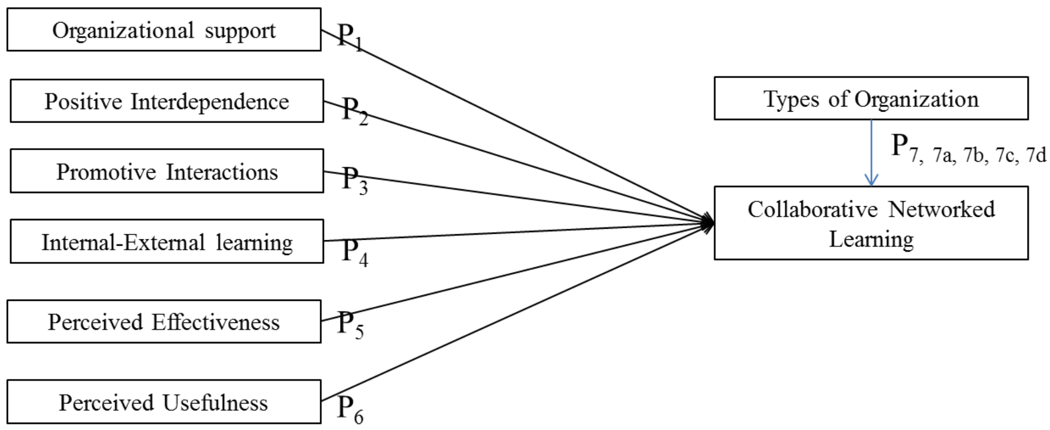


Figure 3-7 Conceptual framework of CNL

The research is driven by the determination to test a provisional supposition about the phenomena of CNL and propositions which state that there is a causal relationship between the dependent variable and independent variables. The relationships among the variables are shown by the following eleven propositions:

P_1 Organizational support is an antecedent of CNL.

P_2 Positive interdependence is an antecedent of CNL.

P_3 Promotive interaction is an antecedent of CNL.

P_4 Internal-external learning is an antecedent of CNL.

P_5 Employees' perceived effectiveness is an antecedent of CNL.

P_6 Employees' perceived usefulness is an antecedent of CNL.

P_7 For MNCs and SMEs, the influence of CNL is different.

P_{7a} The influence of online learning is different between MNCs and SMEs.

P_{7b} The influence of a shared database is different between MNCs and SMEs.

P_{7c} The influence of online meetings is different between MNCs and SMEs.

P_{7d} The influence of email for work is different between MNCs and SMEs.

3.4 Research Propositions (RP)

This research is driven by the desire to test a provisional supposition of antecedents of CNL. Propositions are preferred because of the exploratory nature of the study as previously the theory of CNL had not been developed. Although the terms proposition and hypothesis both refer to the formulation of a possible answer to specific research questions, Whetten (1989) contrasts the two and explains that a proposition states a relationship between two concepts, whereas a hypothesis operationalizes this relationship into an empirically testable form of statement. The notion of hypothesis testing is inappropriate for theory building, since it is "an interpretative exercise designed to produce a theory for later testing" (Flynn et al., 1990, p. 255). The intent of this study is to develop a theory by identifying relationships between the proposed antecedents and their associations with CNL. The propositions suggest relationships between the proposed antecedents and CNL in a condition where at present the relationships can neither be verified nor confirmed by previous empirical research.

Thus this study proposes the following propositions in 3.4.1 to 3.4.7. The first set of propositions (P_1, P_2, P_3, P_4, P_5, and P_6) seeks to identify the antecedents of CNL. The second set of propositions (P_7, P_{7a}, P_{7b}, P_{7c}, and P_{7d}) compares employees' level of engagement in CNL in terms of hours spent using online learning, a shared database, online meetings, and email to perform their work.

The proposed antecedents for this research are selected from prior studies in technology acceptance, collaborative learning and cooperative learning. They are linked to the research questions in Section 3.2 and conceptual framework in Section 3.3. As antecedents, the researcher considers important events, circumstances, or precursors that transpired before employees in manufacturing organizations are likely to adopt CNL. As such, the proposed framework must be well-grounded and supported with a multi-dimensional approach to socio-technical system (STS) theory.

3.4.1 Proposition 1 (P_1) Organizational Support is an Antecedent of CNL

A support system is part of the organizational infrastructure that facilitates the necessary processes to manage, control, coordinate and improve work (Mohrman et al., 1995) and in the case of CNL, the organization would support their employees' learning goals and engagement with others in the learning networks (Fuller et al., 2007; Smith, 2003). Therefore, perceived organizational support is positively related to self-efficacy and the motivation to learn (Chiaburu et al., 2010) and is strongly associated with affective commitment (Aube et al., 2007). Thus, it can be postulated that organizational support through the provision of opportunities for diverse employees to engage in collaborative work and learning is an important antecedent to achieve positive CNL outcomes. Likewise, the greater the extent to which employees perceive that the organization or management is providing support, the more the employees are willing to learn and engage through collaborative network.

3.4.2 Proposition 2 (P_2) Positive Interdependence is an Antecedent of CNL

CNL occurs in interactive groups in which participants actively communicate and negotiate meaning with one another. In a complex problem solving situation, employees are required to collaborate with each other (Chan et al., 2001) resulting in positive interdependence between learners (Hung & Chen, 2001). Although manufacturing organizations may be highly segmented into departments, as operational knowledge becomes more specialized and complex, solutions to problems will require interdependence of employees working together. Positive interdependence refers to the degree to which the performance of a single group member depends on the performance of all other members (Strijbos et al., 2004, p. 197). Positive interdependence also relates to the attainment of individual goals to the success of others in the workgroup (D'eon, 2005; Johnson & Johnson, 1989; Johnson et al., 1998; Kravcik et al., 2004; Kreijns et al., 2003; Young, 2003). Building a CNL system requires employees to think in terms of organized networks of mutual interdependence and to overcome individual differences (Heckscher, 2007). Conversely, employees whose job requires less input from others, requires less information access than those who do (Gray & Meister, 2004). Positive interdependence facilitates the development of new insights and discoveries through promotive interaction (Gabbert et al., 1986; Johnson et al., 2003).

3.4.3 Proposition 3 (P_3) Promotive Interactions is an Antecedent of CNL

Social interaction is the key element in CNL. An interaction in CNL encompasses interactivity between employees and their workgroups, from information sharing to task-oriented discussions, to achieve shared understandings and knowledge construction. Promotive interaction means close, usually synchronous, purposeful activity and joint decision making (D'eon, 2005) where employees participate in workgroups to complete their tasks and goals (Johnson et al., 2003). For CNL to occur, both action and interaction need to be well coordinated within the shared workspace in the manufacturing network. It has to be a deliberate planning by the management or organization to promote interaction. In a review of 168 studies between 1924 and 1997 by Johnson, Johnson and Smith (1998), cooperation among learners improved learning outcomes relative to individual work across the board. Their finding is further supported by Springer et al.'s (1999) review of 37 studies of students in science, mathematics, engineering and technology. Interactions with computer-supported social networks (Wellman et al., 2000) should also be considered as strongly interactive. In addition, effective collaboration increases interconnections between organizations (Provan et al., 1995), increases interactions (Chen, 2011) and fosters learning among employees (Inaba et al., 2000).

3.4.4 Proposition 4 (P_4) Internal-External Learning is an Antecedent of CNL

Wiske, Franz and Breit (2005) also assert that "collaboration with others enriches one's capacity to develop and apply ideas" (p.99). Employees reflect on what they learned, consider ideas from multiple perspectives to provide an interpretive framework (Wiske et al., 2005) and share organizationally relevant experiences and information with others in collaboration (Lin, 2007a). A network of interdependent relationships link the success of an organization with the success of other organizations, leveraging intra-organizational knowledge sharing (Dyer & Nobeoka, 2000; Gutpa & Govindarajan, 2000). Intense global competition and increasing technological dynamism promote the importance of external learning as an element of organizational success (Chesbrough, 2003a). External sources of knowledge are critical to the innovation process and most innovative ideas are learned from competitors, developers, partners or suppliers. For instance, Bierly and Daly (2007) found that smaller firms learn more from suppliers and the scientific community than larger firms, while larger firms learn more from partnerships and consultants. Huang, Kristal and Schroeder (2008) posit that internal-external learning can translate knowledge into manufacturing processes and leads to effective process implementation. Therefore, CNL arises from the need for employees to share, collaborate and learn both internally and externally in order to achieve their goals. In addition, it is assumed that CNL provides easier access to external knowledge and allows for more rapid dissemination of organizational knowledge. Innovation, be it undertaken internally or externally, is a complex process that requires knowledge and information flow between organizations and other employees (Lichtenthaler, 2005;

Meagher & Roger, 2004) and innovation can only happen through interaction with external factors (Chesbrough, 2003b).

3.4.5 Proposition 5 (P_5) Employees' Perceived Effectiveness is an Antecedent of CNL

Effectiveness is operationalized as the usability and usefulness of the information in the repository or through interactivity with other members. A study by Murgolo-Poore, Pitt, Berthon and Prendegast (2003) found a significant relationship between perceived effectiveness and the amount of information disseminated through the organization's intranet. Gray and Meister (2004) also found that employees who perform more intellectual work and who require frequent interactions with others, perceive themselves to be learning more from knowledge sharing networks than those who perform less intellectual work and required less frequent interactions. Frequent communications between workgroups create more opportunities for leveraging competencies, increasing perceived effectiveness and increasing motivation to collaborate and learn (Monteiro et al., 2008; Noorderhaven & Harzing, 2009). Employees who are required to use the network for documenting, accessing vital information and using that information for their work are more likely to have a perceived notion about the effectiveness of CNL as compared to those who are not provided with collaborative technology.

3.4.6 Proposition 6 (P_6) Employees' Perceived Usefulness is an Antecedent of CNL

Perceived usefulness is defined as "the prospective user's subjective probability that using a specific application will increase his or her job performance within an organizational context" (Davis et al., 1989, p. 985). If employees perceive that the results gained from using CNL are useful for their work, then it is quite likely that employees will continue in using CNL. In other words, employees' ability to adopt collaborative technology is dependent on its perceived usefulness (Davis, 1989; Iyer & Ravindran, 2009). However, employees draw on their own experience and prejudice when judging the usefulness of a system (Dasgupta et al., 2002; Iyer et al., 2009). Clearly, if CNL does not provide useful information exchanges, it will not motivate employees to collaborate and contribute to learning. Perkowitz and Etzioni (1999) argue that information is useful only if the user considers the information on the network to be accurate, informative and pertinent. Ritchie et al. (2011) found that those employees who regarded the organization's Angel software as highly useful were more likely to use it. Employees who have positive experiences in collaborative projects and are able to work through the complexity of their jobs are more likely to share and attain information and knowledge from their peers and workgroups.

3.4.7 Proposition 7 (P_7) For MNCs and SMEs, the Influence of CNL is Different.

Proposition 7_a (P_{7a}) The Influence of Online Learning is Different Between MNCs and SMEs.

Proposition 7_b (P_{7b}) The Influence of a Shared Database is Different Between MNCs and SMEs.

Proposition 7_c (P_{7c}) The Influence of Online Meetings is Different Between MNCs and SMEs.

Proposition 7_d (P_{7d}) The Influence of Email for Work is Different Between MNCs and SMEs.

Most studies agree that CNL is most predominant in MNCs and engagement in SMEs is relatively small. The majority of the studies (e.g.Lee, 2004; Roffe, 2004; UNCTAD, 2004) have reported that technology acceptance among SMEs is relatively slow and the adoption is limited to simple applications (Mohamad & Ismail, 2009). Harris (2008) in his study of 24 SMEs found that the SMEs had more innovative business models than MNCs; however, ironically, the SMEs perceived formal qualifications as increasing the propensity for employees to leave the organization. In addition to cost of training as a barrier, none of the participants surveyed had actually undertaken any form of e-learning except those who worked in areas relating to technology (Harris, 2008). Likewise, Nikas, Poulymenakou and Kriaris (2006) found that management commitment in employees training and skill development is the key factor affecting the adoption of information technology. Conversely, Allan and Lawless (2005) note that SMEs are increasingly required to use online collaboration within the organization as a method of working and information exchange. More and more SMEs are turning to virtual teams collaborating online due to business requirements or demands from their MNCs customers.

As organizations grow in capacity and the complexity of their business, the propensity to engage in knowledge-based collaboration and the intention to adopt collaborative technology increases (Goerzen, 2005; Ireland et al., 2002; Nikas et al., 2006). However, employees must be prepared to collaborate and this readiness includes compliance with a common interoperable infrastructure, and mutual agreement on the rules of governance or engagement (Camarinha-Matos et al., 2006b), which most SMEs would find constraining. Similarly, economic pressures on SMEs may put a greater emphasis on treating employees as labourers and not as learners (Choy et al., 2008), reflecting a lack of strategic focus (Riege, 2005) to develop, capture and disseminate or apply knowledge (Beijerse, 2000). SMEs tend to be less effective in recognizing the value of their explicit knowledge and are short of resources, infrastructure and technology (Levy et al., 2003). Therefore, it would be interesting to investigate to what extent SMEs are actively engaging in CNL as compared to MNCs. The literature and empirical studies seem to be divergent in their findings.

3.5 Rationale for the Model Structure

As mentioned in section 1.4, the research objectives are operationalized as the basis on which the scales and measurement are developed to collect data in order to prove the constructs. The development of these scales and measurement are further explained in Chapter 4 of the thesis. Figure 3-7 illustrates the conceptual framework and shows the relationships between the constructs and CNL. The relationships between the research questions, objectives and propositions are inextricably linked in the development of the study as shown in Table 3-7.

Table 3-7 Research questions, objectives and propositions

Research Questions (RQ)	Research Objectives (RO)	Propositions
Research Question RQ_1	Research Objective RO_1	Proposition P_1
	Research Objective RO_4	Proposition P_2
		Proposition P_3
		Proposition P_4
		Proposition P_5
		Proposition P_6
Research Question RQ_2	Research Objective RO_3	Proposition P_1
		Proposition P_2
		Proposition P_3
		Proposition P_4
		Proposition P_5
		Proposition P_6
Research Question RQ_3	Research Objective RO_1	Proposition P_5
		Proposition P_6
Research Question RQ_4	Research Objective RO_2	Proposition P_7
	Research Objective RO_4	Proposition P_{7a}
		Proposition P_{7b}
		Proposition P_{7c}
		Proposition P_{7d}

3.6 Summary

This chapter discussed the conceptual framework of CNL in relation to the set of propositions, and then illustrated the relationships with the research questions and research objectives. The development of the propositions was explained and supported from the literature and past research. The arguments presented in this chapter established the basis for the empirical study and research design which are covered in the next chapter.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

Research is a systematic and methodological process of enquiry and investigation (Collis & Hussey, 2009), which often refers to paradigmatic assumptions (O'Leary, 2004; Walter, 2006) that link with theoretical principles to underpin a research (Grant & Giddings, 2002), while method refers to the practical means or tools for collecting and analyzing data (Bryman, 2008; Grant et al., 2002). A research design is governed by a set of methods or rules, principles, theories and values (Somekh & Lewin, 2005), that guide the researcher on how research is conducted (Bryman, 2008; Grant et al., 2002; Mingers, 1997; Sarantakos, 2000).

This chapter discusses the philosophical position, paradigm and research method used in the study. Given that the 'quantitative-qualitative' debate has been discussed in length in the literature, this thesis has no intention of exacerbating or adding to the debate. Both quantitative and qualitative researches represent different research strategies. This study involves constructing a survey questionnaire that includes reviewing and analysing previous and current literature. A pilot study was tested by colleagues and academic staff of the university and a series of questions addressing the dimensions and key variables of the study were finalised. This chapter explains how the conceptual framework based on constructs (see Figure 3-7) was operationalized to provide clarity and rigor to the theoretical paradigm.

4.2 Philosophical Position

Packer and Goicoechea (2000) enunciate that learning and collaboration are not only a matter of epistemology but also a matter of ontology. Knowledge is not all that is constructed, but a matter of personal learning, social transformation and interaction. This study takes a different paradigmatic approach to research with different assumptions about the nature of knowledge (ontology) and the means of generating knowledge (epistemology). "Knowledge is the meanings people make of it; knowledge is gained through people talking about their meanings" (Creswell, 1998, p. 19). Due to cultural experiences and diverse worldviews, Onwuegbuzie et al. (2009) find that employees are partially biased in their objective perceptions of reality. This study adopts an idealist ontological assumption that accepts multiple realities; constantly shifting due to the nature of interactions and development in collaborative and communication technology. Social realities are made up of shared interpretations produced and reproduced by employees as they continue to practice CNL in their daily routines.

The social and behavioural sciences have traditionally fallen into two schools with scholars taking different views; for example, Guba and Lincoln (1988) use the terms "scientific" and "naturalistic" and Tashakkori and Teddlie (1998) adopt "positivist" and "constructivist". This study adopts the constructivist epistemological assumption and posits that knowledge is an outcome of manufacturing employees interacting with their work environment and dependent on how or if employees perceive opportunities to profit from CNL learning environments and whether the organizations are considered as learning environments (Bauer et al., 2004).

Brown et al. (1989) posit the situation as a co-construction of knowledge through interactivity. The fundamental epistemological approach surrounding this study is not about emulating the research of physical or natural sciences. Post-positivistic reconstruction of scientific processes is founded on a coherence theory of reality that emphasizes the temporarily bounded character of knowledge (Stockman, 1983) that "incorporates a multiplicity of theoretical perspectives" on a particular phenomenon (Fischer, 1998, p. 136). Objectivity remains as an elusive ideal and though replicated findings are probably true, they can be subjected to falsification. This study agrees with Blakie's (2010) postulation that it is quite impossible for fallible humans to observe an external world unencumbered by concepts, theories, past knowledge and experiences, and so all social enquiry reflects the standpoint of the researcher and observation will be theory-ladened.

4.3 Research Paradigm

This study subscribes to a pragmatic paradigm that provides the underlying philosophical framework for mixed methods research (Somekh et al., 2005;

Tashakkhori & Teddlie, 2003) as well as different forms of data collection and analysis (Creswell, 2003). A pragmatic paradigm is in-line with socio-technical systems (STS) theory that shares a distinctive ontological flexibility between social and technical aspects leading to the emergence of CNL. It also assumes that “human activity is highly nuanced and contextualized” and there is a fundamental gap between “what is required socially and what we can do technically” (Ackerman, 2000, p. 17). Rather than a commitment to any single system of philosophy (Mackenzie & Knipe, 2006) or a single scientific method (Mertens, 2005), the pragmatist centres on the research problem and applies mixed methods approaches to understanding the phenomena (Creswell, 2003; Johnson et al., 2004; Tashakkori & Teddlie, 1998) and to draw multiple realities of CNL (Armitage, 2007; Creswell & Plano-Clark, 2007; Zhu, 2011). When reporting, the pragmatist combines languages from both positivism and constructivism in order to stress the pragmatic paradigm (Creswell & Plano-Clark, 2007).

4.4 Research Approach

This study combines a mixed methods and auto ethnographic approach. Using mixed methods, the research was approached in a sequential manner using both quantitative and qualitative techniques that best address the research questions (Creswell, 2003). Sources of primary data from questionnaires and semi-structured interviews include an ‘ethnographic’ dimension “where the author is both informant and investigator” (Cunningham & Jones, 2005, p. 2) and the approach presents a balanced insight into the phenomenon from the perspective of the user as well as the researcher (Hackley, 2003).

4.4.1 Mixed Methods

In recent years, research that involves the integration of quantitative and qualitative research is becoming increasingly common (Bryman, 2006) with operational research (Zhu, 2011) for the “purpose of breadth and depth of understanding and corroboration” (Johnson et al., 2007, p. 123). The mixed methods approach is appropriate for this study which has both exploratory and confirmatory questions (Bryman, 2006; Teddlie & Tashakkhori, 2009) and employs both inductive and deductive logic (Creswell et al., 2003; Patton, 2002). Similar areas of study in collaborative learning increasingly apply mixed method strategies (e.g. Barron, 2003; Benbunan-Fich et al., 2003a; de Laat et al., 2006a; Hakkinen et al., 2003; Hiltz et al., 2000; Hmelo-Silver, 2003; Macgregor &

Thomas, 2005; Martínez et al., 2006; Schrire, 2006b; Strijbos & Fischer, 2007a; Strijbos et al., 2007b; Weinberger et al., 2006). CNL reflects a complex reality where multiple variables interact and influence each other in a rich empirical and ecological setting (de Laat, 2006). The mixed methods approach is likely to produce a complete study of networked learning and CNL (Benbunan-Fich et al., 2003a; de Laat, 2006; Hakkinen et al., 2003). It has the ability to reveal high quality and complex inferences (Rauscher & Greenfield, 2009), it is valuable in capturing individuals' experiences and beliefs (Kristensen et al., 2008) and it opens new ways of contextualizing and building up understanding of CNL activities that participants are engaged in (de Laat et al., 2006).

According to Daradoumis, Martinez-Mones and Xhafa (2004), evaluating CNL is a very complex task which requires extensive consideration on a variety of aspects, as well as the integration of several analysis techniques, data and tools into a mixed evaluation method. For instance, De Laat (2006) used content analysis, critical event recall and social network analysis (SNA) to examine the interaction patterns within a networked learning community and the ways members shared and co-constructed knowledge. "There is a philosophical grounded a priori commitment to using mixed methods to reach the same utility and accuracy goals held by pragmatists, but through complementary rather than compatibility" (Rocco et al., 2003, p. 22). In the same manner, this study uses mixed methods to complement the findings in achieving objective interpretations of CNL.

4.4.2 Ethnographic

Auto ethnography is increasingly used as a research method of inquiry, pushing the qualitative boundaries by focusing on a phenomenon in the life of the researcher as the central aspect of study (Keefer, 2010, p. 207). The goal is to use analytic perspectives in constructing multi-layered accounts of the social world (Atkinson & Delamont, 2008). The researcher was completely immersed in several CNL manufacturing environments for nineteen years, engaged in developing, learning, sharing and transferring organizational knowledge. The researcher interviewed participants on CNL issues by making sense of both the organizational cultural and technological contexts. From 1991 until 2010, the researcher served in various positions in MNCs and SMEs:

i. Assistant Manager, Human Resources, Quality Assurance, and Engineer in Echolac Malaysia (subsidiary of Mitsubishi, Japan-based MNC). Developed a CNL system for a quality management system for 185 employees. Master in lean manufacturing.

ii. Material Analyst, Outsource Manufacturing Program in Intel Products Malaysia (United States-based MNC). Power user for SAP/R3 system run by Intel worldwide for material management and supply chain management. Super user on teleconferencing, emails, e-learning and shared database; leader/member of virtual teams and networks of practice. Started-up and managed three manufacturing facilities and a virtual factory (VF) within 2 years.

iii. Factory Manager in Conplamas, Malaysia (local SME). Developed a CNL system for the documenting and sharing of product and process information, including an MRP system using Microsoft Access for 150 employees.

iv. Operations Manager in Eurospan, Malaysia (local SME). Initial stage of development for learning management system (LMS).

v. Plant Manager, Production Manager & Operational Excellence, and Manufacturing Manager in Eaton Electrical Switchgear (United States based MNC). Mapics and Oracle System Project Leader for Enterprise Common Platform, Lean Coordinator and Six Sigma Green-belt. Superuser on teleconferencing, emails, and shared database. Power user of Oracle, leader/ member of networks of practice and user of Eaton's Learning Management System (LMS).

vi. Senior Operations Manager, SAP/R3 Project Leader in Honeywell Aerospace (United States-based MNC). Power user and master trainer of SAP and Lean Six Sigma Green-belt. Superuser on teleconferencing, emails, e-learning and shared database. Leader/member of virtual teams and networks of practice. Started-up and managed a manufacturing facility for avionic aerospace.

The researcher was engaged with a genuine situational identity as a member of the organization and positioned as an active researcher (Adler & Adler, 1994) on collaborative social interaction (Angrosino & Mays de Perez, 2003; Nardi et al., 2002). The researcher reflected upon his experience in using CNL and seeks to reduce influence on the research by "allowing a variety of voices to be expressed" (Blaikie, 2000, p. 54).

Currently, the researcher serves as a Lecturer in AUT University (from 2011 until the present). The researcher has been directly engaged in CNL planning, designing and implementation, as well as being a power user himself. The researcher is also teaching

Project Management, Operations Management and Advance Operational Performance at undergraduate and postgraduate levels. As an ethnographer, the researcher leveraged his knowledge and experience to make sense of the interviews by asking for more clarification and evidence of CNL engagements. Based on this background, the researcher was able to test the competency or credibility of his sources with a degree of confidence. The researcher was also able to reflect and consider the phenomena as a participant from his own perspective with reference to his own values and practices (Hackley, 2003).

4.5 Unit of Analysis

A unit of analysis is the primary entity or element for collecting and analyzing data (Nardi, 2006). Nardi et al. (2002) regard the unit of analysis for computer-supported cooperative learning (CSCL) and computer-supported collaborative work (CSCW) as the collective social network level or activity system (see also Engestrom, 1987). Stahl (2005) posits learning as a blend of processes and therefore the analysis of learning should be done with both the individual and group. Dillenbourg et al. (1996) claim that "the group itself has become the unit of analysis and the focus has shifted to more emergent, socially constructed, properties of interaction" (p.1). There is no consensus whether the unit should be individuals, dyads, groups or communities as it is dependent on the theoretical background and definition of 'collaboration' used (Lipponen, 2002b).

In this study, the researcher seeks for major themes that could explain the CNL phenomenon and its hidden dimensions or antecedents with individual employees' engagement in CNL as the focus for the unit of analysis. This study seeks to understand the antecedents of CNL from the perspective of the individuals; the unit of analysis being the manufacturing employees' experience in group collaboration and their perceptions of effectiveness and usefulness of CNL. The unit of analysis also covers the difference between MNCs and SMEs.

4.6 Research Strategy and Process

The research process for this study is illustrated in Figure 4-8, with cross references provided for the respective sections of the thesis. The research process serves as a guide for conducting a well-grounded research and aligning the research questions with research strategies and research paradigms. According to Blaikie (2010), an abductive research strategy fits well with a combination of idealist ontological assumption and the epistemology of constructivism. An abductive research strategy can be used to answer the ‘what’ and ‘why’ questions, and therefore generates some “understanding rather than explanation, by providing reasons rather than causes” (Blaikie, 2010, p.89). An abductive research strategy incorporates what the inductive and deductive research ignore, such as meanings and interpretations, the motives and intentions (Blaikie, 2010), that would influence the decisions and direct behaviour of employees in manufacturing organizations to use CNL in their routines.

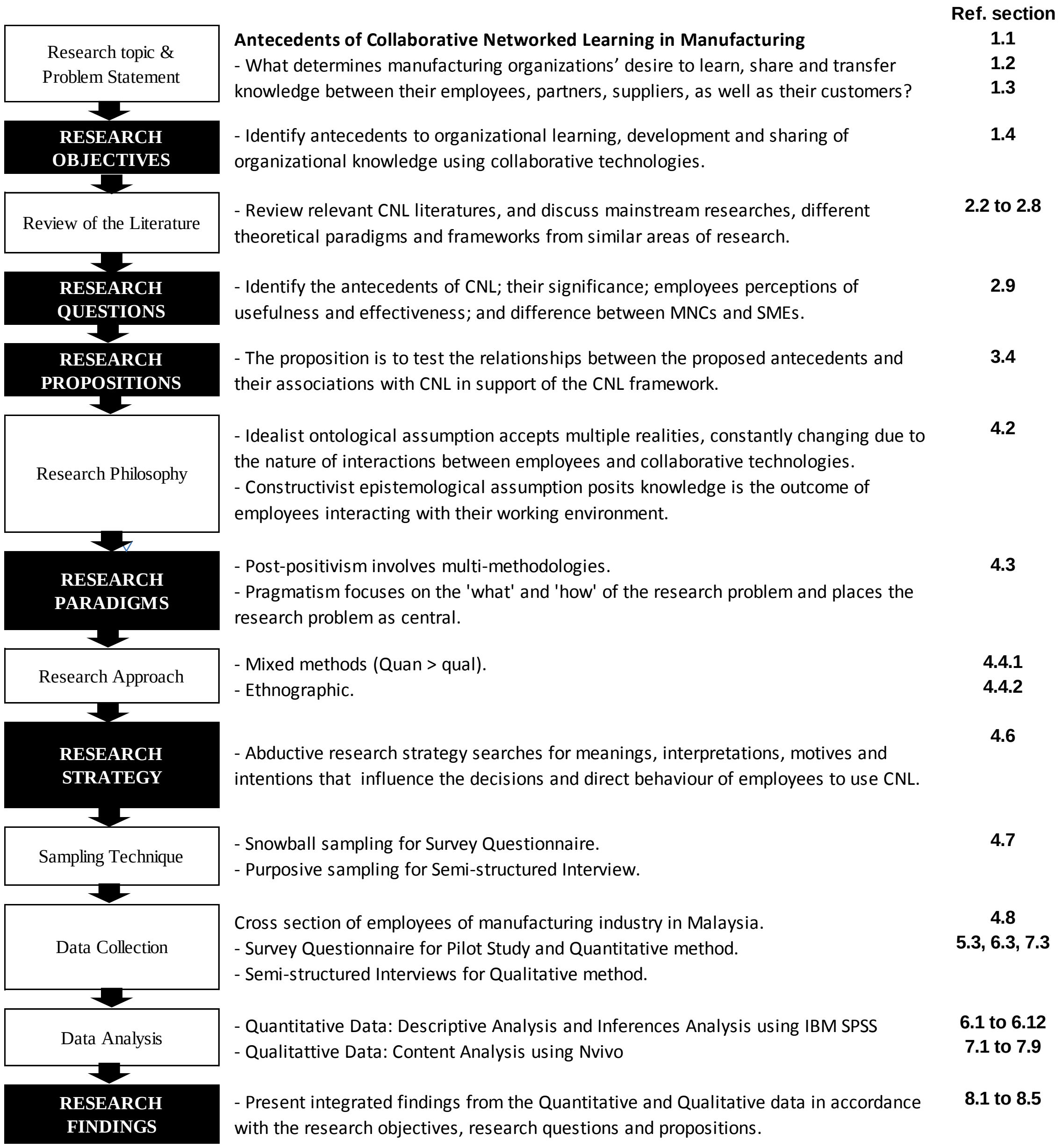


Figure 4-7 Systematic approach to empirical research design

According to Creswell (2003), a pragmatic paradigm implies that the overall approach to research is that of mixing data collection methods and data analysis procedures within the research framework. The quantitative approach employs the strategy of the survey questionnaire as the data collection method with pre-determined measures that result in numeric data. In contrast, the qualitative approach employs the strategy of the interview as the data collection method that results in open-ended textual data. The qualitative approach which uses interview transcripts for subjective assessment of attitudes, opinions and behaviour, aims to discover employees' underlying motives, motivations and perceptions in their use of CNL. Although qualitative results are regenerated and are not subjected to rigorous quantitative analysis, when combined with quantitative results, they can provide a holistic perspective.

Similar research on collaborative technology cited the used of quantitative and qualitative data for complementarity purposes. Burdett (2000) conducted a comparison study of women's perceptions of satisfaction and participation using an Electronic Meeting System (EMS). The quantitative results from the questionnaire were compared using qualitative data collection and analysis strategies. In this study, a qualitative approach was used to develop and test proposed questions for the quantitative phase of the study. Questions drawn from the literature and from researcher's own experience (19 years as a practitioner) were tested with colleagues and contacts in industry and subsequently were presented to a panel of 12 senior academics and researchers at AUT.

4.6.1 Quantitative Research Strategy and Data Analysis

The framework for quantitative research was adapted from Menor and Roth's (2007a, 2007b) two-stage approach which is built on Churchill's (1979) paradigm. The step-by-step procedure in the development of the survey questionnaire is illustrated in Figure 4-9 of the quantitative research model to ensure that the scale is valid and reliable.

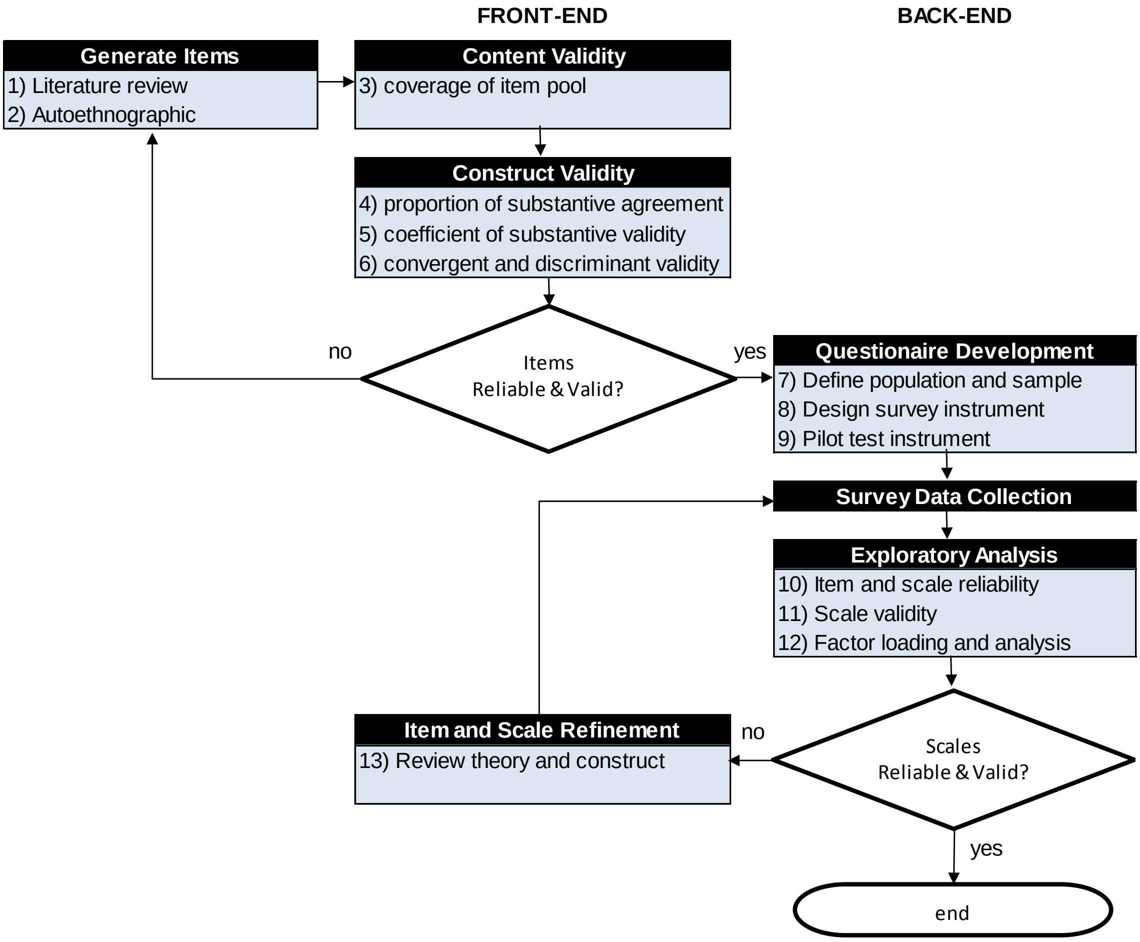


Figure 4-8 Framework of research for quantitative phase
Adapted from Menor and Roth (2007a, 2007b)

The quantitative research began with generating items based upon past research in the areas of cooperative learning, collaborative learning and workplace learning. Details of the development of the measurement and scale are discussed in Section 5.2. Using an ethnographic approach, the list of items was then expanded based upon the researcher's past experience and knowledge of CNL. The items were reworded, added or deleted, in order to make sense of CNL's activities, events, interdependent tasks and outcomes. In the front-end stage, content validity and construct validity were both determined using exploratory factor analysis (EFA). During the questionnaire development stage, Bryman (2008) suggests conducting a pilot study before administering the survey questionnaire in order to ensure the research instrument functions well. Therefore, a pilot study was conducted and tested using exploratory analysis. Subsequently, some items were reworded in order to provide clarity and to improve validity and reliability of the instrument. Nardi (2006) argues that the pilot study will assess whether the instructions are adequate, the wording of the items and format are clear, and the time required for completion of the survey.

Questionnaires from the pilot study were disseminated through online surveys with the objective of soliciting self-reported backgrounds and information pertaining to perceptions and experiences in using CNL systems and tools. The survey used a mix of multiple-choice questions and a structured questionnaire. For multiple-choice questions, a 5-point Likert scale was used for indicating a level of disagreement or agreement (1= strongly disagree; 5= strongly agree). This approach overcame ambiguity in the survey questionnaire and increased the validity of the research instrument.

4.6.2 Qualitative Research Strategy and Data Analysis

The semi-structured interview produces “rich and illuminating data and can be used to gather both qualitative and quantitative data” (Cameron & Price, 2009, p. 252). It allows the researcher to explore how participants respond to complex issues pertaining to participants’ personal experience of CNL. Semi-structured interviews use questions that form a general frame of reference (Bryman, 2008). The questions can vary in sequence and the researcher can probe further by asking significant questions based upon the replies, in order to provide better perspectives. It was the conjecture of this study that semi-structured interviews would provide better cross-examination of the motivational factors, while a web-based survey would compare the relationship of these variables to employees’ work experiences, in particular with the use of CNL. Therefore, the phenomena were studied using web-based surveys and semi-structured interviews to confirm findings through the convergence of different perspectives. Interviews were conducted bi-lingually (in English, Malay, or both) to ensure participants were able to comprehend the questions and were able to better articulate their thoughts and ideas using the language with which they were comfortable.

Denzin and Lincoln (2000) define qualitative research as gathering and interpreting narrative or textual information regarding an individual’s experience. Creswell (2007) defines it as an inquiry “to understand the contexts or settings in which participants in a study address a problem or issue” (p. 40). The following framework for qualitative research was adapted from Onwuegbuzie, Johnson and Collins' (2009) qualitative research model as illustrated in Figure 4-10.

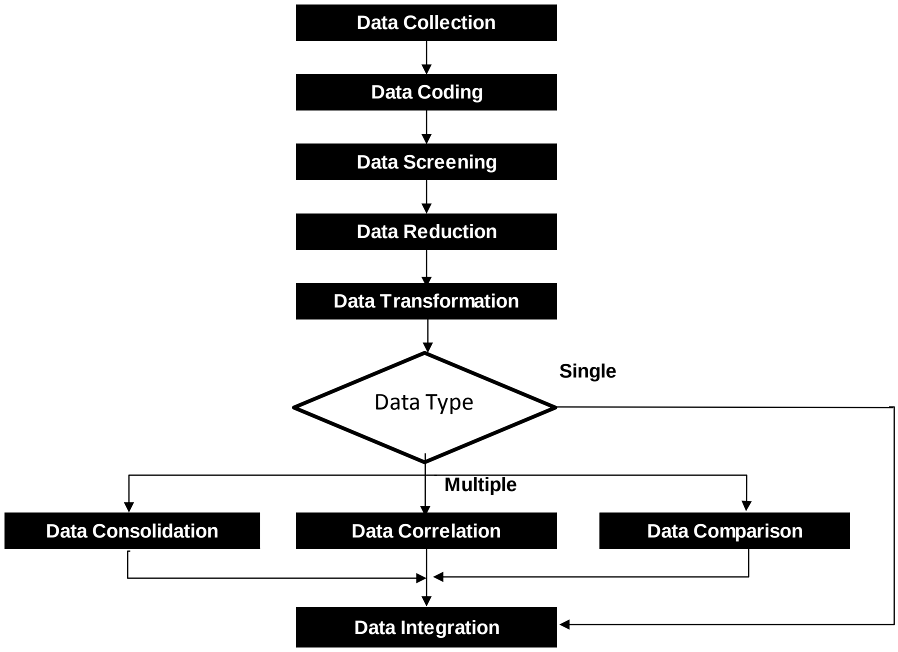


Figure 4-9 Framework of research for qualitative phase
Adapted from Onwuegbuzie, Johnson and Collins (2009)

After **data collection** was completed, the data was **coded** and **screened**. The study followed the process recommended by Anfara, Brown and Mangione (2002) in which the data were analysed for generic content and organized into manageable segments. Bogden and Biklen (2003) suggest clustering similar topics and concepts together, before recoding and refining them. This helped to reduce the data into themes and key ideas. The underlying similarities and associations were first compared to the explanatory model, which led to clusters that shared similar characteristics or themes (Huberman & Miles, 1994). The final data focused on the key ideas and themes relating to the research questions (Anfara et al., 2002). The descriptive codes were analysed according to the conceptual framework of this study and developed into a detailed account of the antecedents of CNL, including all influencing and contributing factors which built the case.

Data reduction techniques are commonly used with typology construction when using an abductive research strategy (Blaikie, 2010). Blaikie (2010) further reiterates that in the case of an abductive research strategy (see section 4.4), data collection, data reduction and data analysis tend to blend into one another in a cyclical process. **Data correlation** is used to correlate qualitative data with quantitative data and/or quantitative data with qualitative data (Johnson et al., 2004; Onwuegbuzie & Teddlie, 2003) and is followed by **data consolidation**, wherein both quantitative and qualitative data are combined to create new or consolidated variables (Johnson et al., 2004). Data comparison is used to compare qualitative and quantitative data/findings (Onwuegbuzie et al., 2003). **Data integration** characterizes the final stage, whereby both quantitative and qualitative data are integrated into either a coherent whole or into two separate sets of coherent wholes (Johnson et al., 2004). This is demonstrated in Chapter 8.

4.7 Development of Sample for the Study

A sample is a selection of observations from a reference set (Blaikie, 2010; Kinnear & Gray, 2009; Tashakkori & Teddlie, 2003) to be used to make inferences about the whole population (Blaikie, 2010) and to address the research questions (Tashakkori et al., 2003). “A population is an aggregate of all cases that conform to some designated set of criteria” (Blaikie, 2010, p. 172). The target population of the CNL investigation was chosen based on the number of users in the manufacturing organizations and the use of resources involved. Depending on the nature of the networked learning environment, this population organized themselves through virtual teams, online-learning, and information sharing using computer networks.

Malaysia was chosen due to the diversified nature of the industries with a high number of manufacturing organizations. According to the Economic Census 2011 released by the Department of Statistics Malaysia, in 2010, the Malaysia manufacturing sector posted positive growths with the gross output expanded by RM181.0 billion or a growth rate of 5.0% between 2005 and 2010. The employment rate increased by 137,197 persons or 1.6%. The contribution of the manufacturing sector to Gross Domestic Product (GDP) in 2010 was 24.6%. Overall, the manufacturing sector engaged 1,812,360 persons in 2010, with male employees accounted for 1,179,024 persons (65.1%) and female 633,336 persons (34.9%).

According to Collins (2010), the process of selecting a sampling design for a sequential mixed methods approach requires two distinct yet interrelated decisions on sampling schemes and sample sizes. The choice of using snowball sampling in the quantitative phase and purposive sampling in the qualitative phase expanded the sampling schemes available to the researcher, thereby enhancing the diversity of the mixed methods research design. However, the sample survey only investigated a subset of the target population, which is the Northern part of Malaysia. The participants for this study were mainly working in high density integrated industrial areas, for example, Bayan Lepas, Seberang Perai, and Kulim.

4.7.1 Snowball Sampling for Survey Questionnaire

For the survey questionnaire, it was considered that a sample size of 384 participants from a population of 1.8 million manufacturing employees would statistically provide a confidence level of 95% with a degree of accuracy of plus or minus 5% (Krejcie & Morgan, 1970). The size of the sample was required to be large enough so that the results could be generalized to the employees of manufacturing in Malaysia. Snowball sampling, also known as network, chain referral or reputational sampling (Blaikie, 2010) was used to locate employees in the manufacturing network to enable a web-based survey of 384 participants from various manufacturing organizations.

According to Black (2005), snowball sampling recruits subjects with the desired traits or characteristics, who then recruit others with similar traits to participate. Regardless of the types of industries, snowball sampling from diverse industries and organizational sizes provided better representation of the target population in manufacturing, and therefore eliminated any confirmatory and sampling bias. In this instance, participants were also asked to recruit individuals from their organizations or anyone that worked in manufacturing organizations to participate in the research. Participants were given an option of using either a web-based survey questionnaire or a hardcopy survey form. The web-based surveys were self-administered by participants at their preferred time and location. The hardcopies of the survey forms were distributed and collected by former colleagues, suppliers and friends of the researcher.

4.7.2 Purposive Sampling for Semi-Structured Interview

When using purposive sampling, the goal is to generate new theories by obtaining new perspectives about the phenomenon being studied (Miles & Huberman, 1994). Purposive sampling allows the researcher to recruit participants on the basis of specific characteristics of the unit of analysis (Nardi, 2006), thus ensuring "balanced group sizes when multiple groups are to be selected" (Black, 2005, p. 124). It also permits the researcher to intentionally choose key participants based on the researcher's perception that the participants will yield a depth of information or a unique perspective (Maxwell, 1997; Miles et al., 1994; Patton, 2002). The aim of using a purposeful sample in this instance was to capture the major variations rather than to identify a common core of MNCs and SMEs.

In "studies that use semi-structured interviews that are analysed using content analysis, sample size is justified on the basis of interviewing participants until data saturation is reached" (Francis et al., 2010, p. 1229). Qualitative research typically focuses in depth on relatively small samples selected purposefully (Patton, 2002). This study followed the recommendation of Francis et al. (2010) that there should be an initial sample of 10 interviews, followed by 3 more interviews if there is no emerging theme. The size of the sample is determined by informational considerations and the sample is terminated when no new information is found (Lincoln & Guba, 1985). There is no deterministic number on the sample size for purposive sampling, except when it has reached saturation (Collins, 2010; Guest et al., 2006). In this study, the researcher implemented a predetermined criterion of managerial staff, supervisory exempts, technical/quality exempts, and non-exempts, such as production operators. The researcher established this criterion in order to observe or assess any difference between the participants' characteristics or their roles and responsibilities with regards to the conceptual framework that structures the investigation.

4.8 Data Collection Process

As the "research problem is central" (Creswell, 2003, p. 11), data collection and analysis methods were chosen to provide insights into the research questions. As such, this study concurs with Gorard (2004) who posits that the mixed methods approach can lead to "less waste of potentially useful information" (p.7). The mixed-methods approach involves both qualitative and quantitative procedures of data collection. Brewer and Hunter (2006) focus upon data collection approaches within the research process and posit the notion of “multi-methods”, while Bryman (1988, 2004) alludes to the “mixed strategy” approach whereby he suggests that qualitative as well as quantitative research strategies can be used within the same study. According to Mackenzie and Knipe (2006), the paradigm and research question determine the appropriate data collection and analysis methods. This approach leads to broader data collection rather than being restricted to any one method, which may potentially diminish and unnecessarily limit the depth and richness of the study.

According to Biesta (2010) the combination of both “does not raise any particular problems neither of a philosophical nor of a practical nature” (p.101). They are two forms of information, which provide two modes of representation on the research of interest. This study used a sequential mixed analysis [QUAN → qual] which means the quantitative phase was conducted before the qualitative phase, with a stronger emphasis on quantitative data. Quantitative analysis was used to study the occurrence of events and the general tendencies in CNL, followed by a qualitative analysis to study participatory attributes (see Morse & Niehaus, 2009; Morse, 1991).

4.9 Ethical Considerations

Although participation was voluntary, participants were properly informed and their consents for interviews were obtained. Respect for privacy and confidentiality was imperative and the identities of the participants were protected at all stages of the research. The survey and interview protocols were approved by the Auckland University of Technology Ethics Committee (AUTEC) after some revisions were incorporated based upon the suggestions and recommendations of the committee (see Appendix A). Ethical considerations were prescribed into the research questionnaire (see Appendix B) and participants were presented with details about the purpose of the study, confidentiality, and contact details in case any participant required clarification on any issues relating to the study. Collected survey data and other information pertaining to the research samples have been kept confidential and no propriety information has been transmitted outside the scope of the study. Every attempt has been made to minimise any risks involved in the study.

4.10 Summary

The study adopts a constructivist epistemological assumption and idealist ontological assumption that accepts multiple realities. The underlying pragmatic paradigm supports a mixed methods approach. In this chapter, the research design and framework using both quantitative and qualitative approaches, incorporating Onwuegbuzie and Teddlie's (2003) conceptualization and data analysis process of mixed-methods research was presented. The research process and the process of developing the measurement and scales in support of the constructs were described. Snowball sampling for the survey questionnaire and purposive sampling for the semi-structured interviews was also discussed and rationalized. Finally, data collection methods for both quantitative and qualitative measurements were explained. The results of the pilot study were used to develop the measurement scale, which is discussed in detail in Chapter 5.

CHAPTER 5: DEVELOPMENT OF MEASUREMENT SCALE

5.1 Introduction

As outlined in section 4.6.1, this study aimed to develop a measurement scale for the antecedents of CNL in manufacturing. This chapter begins with defining the measurements and explaining the development for the scales used for measuring the constructs. A pilot study was carried out for the 44-item scales. An online questionnaire was offered through www.Qualtrics.com that required a self-reported background and information pertaining to perceptions and experiences in using CNL. The survey used a mix of multiple-choice questions and a structured questionnaire. The dataset was transferred from Qualtrics online survey to IBM SPSS Statistics Release 19.0 for data analysis, and assessed for normality. The aim of this section is to establish a strong analytical basis for construct validity and reliability of the measurement scale that is used in the main study.

5.2 Measurement of Constructs

Where parsimony is concerned in measurement the number of items required to test a construct depends on the domain and dimension of the construct itself (Cortina, 1993). This study did not require a large number of items as the constructs for the antecedents of CNL have a narrow domain and few dimensions. If the scales are self-administered and participants' response bias is considered, scale brevity is often an advantage (Churchill & Peter, 1984; Cortina, 1993; Nunnally & Bernstein, 1994). A self-administered questionnaire is not only convenient to the participants, it also eliminates interviewer variability when interviewers or researcher ask questions in a different order or in different ways (Bryman, 2008) and is best designed for measuring variables with numerous values or response categories (Nardi, 2006).

5.2.1 Scale Development

Scale development and validation is a time-consuming endeavour and the literature review indicated past attempts at measuring the constructs as well as the strengths and weaknesses of these attempts (Netemeyer et al., 2003). The adoption of existing measures of organizational support, promotive interaction, positive interdependence, internal-external learning, and perceived usefulness help to avoid the redundancy of developing new scales to measure a similar construct. The approach to CNL espouses both positive interdependence and promotive interaction. Kreijns, Kirschner and Jochems (2003) define "positive interdependence" as team members being closely linked to each other in a way that members cannot succeed unless the other members in the team succeed. "Promotive interaction" requires individual members to support each other's effort in order to achieve the team's goals. Johnson, Johnson and Smith (1998) introduce scales for measuring cooperative learning: mutual interdependence, face-to-face promotive interaction, appropriate practice of interpersonal skills, and regular assessment of team functioning.

Netemeyer et al. (2003) suggest consulting several sources on item generation and how previous studies have operationalized the constructs. By employing existing items, a researcher may understand the measurement qualities of the existing questions or items and compare the findings with past studies (Bryman, 2008). Using the same questions or items allows the study to explore whether the context of the study appears to make any difference to the findings (Bryman, 2008). The final measurement items were consolidated and adapted for use in the survey questionnaire as shown in Table 5-8.

Table 5-8 Final development of constructs and measures

Constructs		Measurements
ORGSUP perceived organizational Support	B1	Access to a computer workstation to perform job
	B2	Access to networked computer/email for work
	B3	Access to training through computer network
	B4	Access to online shared databases to facilitate work
	B5	Support from supervisor/manager to collaborate with others
POSIDP positive interdependence	C1	Job requires to work in teams
	C2	Job requires to hold tele-conferences with members from other sites
	C3	Job requires to share ideas, work and information with others
	C4	Job can only be completed if other members complete theirs
	C5	Performance depends on the results of team
PROINT Promotive interaction	D1	Frequently share ideas, work and information with others
	D2	Frequently interact with peers and members in the team online
	D3	Easily obtain help and support from team/peers online
	D4	Frequently share information in online meetings or discussions
	D5	Members in the team help each other to learn and engage
LEARN internal-external Learning	E1	Learn from shared information from the network
	E2	Receive training to collaborate effectively
	E3	Participate in improvement projects
	E4	Learn from suppliers/customers or external parties
	E5	Learn from peers and members in the team
PEREFF perceived effectiveness	F1	Work efficiently through use of information from the network
	F2	Work interdependently using the computer network
	F3	Use computers to share information effectively with others
	F4	Team achieves goals for projects by using information from the network
	F5	Team produces good quality collaborative work
PERUSE perceived usefulness	G1	The network systems/tools are useful for work
	G2	The shared databases are useful for work
	G3	The online meetings/discussions with external parties are useful
	G4	The network systems are useful for sharing information
	G5	The online learning system or training are useful
COLLRN collaborative Learning	H1	Access knowledge and information through the computer system/network
	H2	Update work through the computer system/network
	H3	Learn by sharing and exchanging information with others
	H4	Participate in e-learning or online courses
	H5	Participate in workgroups to complete projects or tasks

The final development for the measurements identified 35 items in support of the seven constructs: organizational support (5), positive interdependence (5), promotive interactions (5), internal-external learning (5), perceived effectiveness (5), perceived usefulness (5) and collaborative networked learning (5). Netemeyer et al. (2003) recommend large items for the initial pool that are "over inclusive of the domain" (p.101), but depending on the "dimensionality and complexity of the construct definition" (p.116). They further suggest considering other issues like item redundancy, level of internal consistency and participants' cooperation, when deciding on the number of items for the initial pool. There is no consensus on the number of items required to support each construct. Netemeyer, et al. (2003) suggest four or more; Clark and Watson (1995) suggest four to five items for narrow constructs and up to 35 items for broad concepts. Given that the scales were self-administered, and taking into account the possibility of participants' fatigue and non-cooperation, this study considered scale brevity (Churchill et al., 1984; Clark et al., 1995; Cortina, 1993; Nunnally et al., 1994).

This study chose to limit the number of items, and to use simple, concise and non-biased wordings and statements. The wording of the items reflected the education level and the language abilities of the participants, and refrained from jargon, acronyms, technical terms and obscure phrases (Nardi, 2006). As suggested by Nardi (2006), demographic questions were placed at the end of the self-administered questionnaire. Demographic questions were also designed to be mutually exclusive and exhaustive, for example, the category "others" for department. The final version of the questionnaire was then used in the pilot study.

5.2.2 Scale Validation

According to Bryman (2008), validity is concerned with the integrity of the conclusions that are generated from the research. Validity refers to the credibility of the research results, measuring what it is designed to measure and the degree to which the results can be applied to the general population of interest. Items on the questionnaire must relate to the constructs being measured.

Internal validity refers to the credibility of the study and is determined by the degree to which conclusions drawn from the items correctly related to participants' experience and perception of CNL. For quantitative data, the internal validity of a study is judged by the degree to which its outcomes can be attributed to manipulation of independent variables and not to the effects of confounding variables (Black, 2005). Therefore, the study protocol must be designed to minimise the effect of extraneous factors so that any potential cause-and-effect relationship between variables can be accurately measured. However, for qualitative data, the researcher is constantly seeking for "any cause-effect relationship that can offer a plausible explanation of the phenomenon under study" (Diaz Andrade, 2009, p. 49), which adds credibility to the analysis and findings (Guba

& Lincoln, 1994). Comparison was made between different groups of employees: those who use CNL and those who do not.

External validity refers to whether (and to what degree) the results of a study can be representative of a larger population or situation to which the results are to apply (Black, 2005; Diaz Andrade, 2009). The researcher includes temporal and spatial dimensions of the phenomenon under study in the analysis in order to produce theoretical generalizations (Walsham, 1995 as cited by Diaz Andrade). External validity is primarily determined by the selection of participants through the use of snowball sampling procedures that limit potential bias and limit direct contact with the researcher. Participants in this study represented a general population of manufacturing employees from diverse industries, both MNCs and SMEs. Both MNCs and SMEs were separated to provide a comparison between different settings or contexts but with the same treatment of variables in order to test the consistency of the findings.

Content validity implies that the measures used are practical, pertinent and related to the purpose of the research (Bryman & Cramer, 2005; Nevo, 1985). This is a basic requirement for a good measure, which means that the measurement items in an instrument should cover the major content of a construct (Churchill, 1979). A content valid instrument enhances the use of practical situations and induces the cooperation of participants through comprehensible, clarity, clear instructions and easy-to-use response formats (Netemeyer et al., 2003). Content validity concerns with the inspection of instrument of measure (Nunnally et al., 1994). Content validity for this study was achieved through a comprehensive literature review and interviews with practitioners and scholars from multi-disciplines as well as members of the AUT University Ethics Committee (AUTEC) for practical purpose, relevance to the research objectives, mitigation of response bias, ease of use, easily read instructions, and clarity of the questionnaire. In the pre-pilot study, these items were reviewed and re-evaluated through structured interviews with practitioners who were asked to comment on the appropriateness of the research constructs. Based upon the feedback, redundant and ambiguous items were either modified or removed.

5.2.3 Development of Instrument

The questionnaires were designed to accomplish two basic goals: (1) to translate the research objectives into specific questions that the participants could respond to, and (2) to encourage the participants to cooperate and provide answers that best reflected their feelings, opinions, perceptions of CNL in an accurate and unbiased manner. A survey questionnaire is useful to test propositions and to generalise findings (Hair et al., 2006). It is a widely used data collection method for organizational research (Zikmund, 2000) and for operations management research (Forza, 2002). Structured questionnaires gather quantitative data which can be used to produce descriptive and inferential statistical data (Cameron et al., 2009). The web-based survey used multiple-choice questions with a 5-point Likert scale for indicating the level of disagreement or agreement with declarative statements (1= strongly disagree; 5= strongly agree). According to Lissitz and Green (1975) and Cavana et al. (2001) a 5-point scale is recommended because any increment above the scale does not improve the reliability of ratings. Therefore, a 5-point scale is more appropriate to generate sufficient responses and was chosen for this study. To further improve the validity of the questionnaire, all the participants were able to undertake this study in their local language (see Appendix D).

5.3 Data Collection for Pilot Study

The questionnaire was pre-tested during the development phase, before the online version was released for use. The pilot study checked the procedure and questionnaire to determine if the instrument was working as it was intended. A survey questionnaire generation, administration and reporting system was deployed on Qualtrics that allowed the researcher to setup web-based surveys with questions having multiple response options. The pilot study administered the preliminary questionnaire to a small group of participants in Malaysia and the instrument was extended to other participants in the main study based on the results. After the pilot study, the questionnaire was revised in order to ensure the “validity and reliability of the measures, as well as making it more user-friendly” (Flynn et al., 1990, p. 262). The pilot study provided essential feedback on how participants had answered a range of questions and concepts within the participants’ knowledge and experience of using CNL, either in their past or present places of work. The summary of responses from the web-based survey also provided a partial quantitative assessment and preliminary understanding of key issues in how the information was being shared and collaborated. The findings of the pilot study also formed the basis for the semi-structured interviews.

5.4 Data Preparation

Data preparation was necessary to ensure that data have been correctly recorded in SPSS and the distributions of data to be used in the analysis are normal. Preliminary analysis generated descriptive statistics and examined for missing data, outliers, and the normality of data. Any missing data needs to be clearly identifiable to prevent misrepresentation during data analysis. Outliers cause data non-normality and effect the validity of the statistical analysis. Normality is a fundamental issue in statistical analysis that could influence the validity of the results (Coakes, 2006).

5.4.1 Missing Data, Multiple Responses and Data Entry

There was no missing data as the participants answered all items in the questionnaire using the web-based survey. The Qualtrics system forced the participants to response to every item in the questionnaire, hence prevented missing data. It also prevented participants from submitting an incomplete questionnaire by ignoring the error message (due to incompleteness of the response). There was no missing data or multiple responses in the hardcopies of the survey.

The dataset was directly extracted and transferred from Qualtrics database to IBM SPSS without any need for reformatting. However, the numerical coding of data was screened using SPSS's Data Editor and Variable View windows to ensure the consistency and accuracy of the codes for further analysis. All variable property descriptive values were checked for accuracy and translated into numeric codes (e.g. 0 = male; 1 = female) and measurement level (nominal, ordinal, or scale) as described in Appendix E. These variable properties were correctly assigned in variable view in the data editor. In the case of the web-based survey, the data did not generate any multiple responses sets as all the responses were well controlled and participants were obliged to provide a single response for each item. The data was retrievable from Qualtrics database since all participants in the pilot study used the web-based survey. No hardcopies were necessary in the pilot study, therefore eliminating the risk of data entry error.

5.4.2 Outliers

According to Hair et al. (2006) outliers are "observations with an unique combination of characteristics identifiable as distinctly different from the other observations" resulting in non-normality (p.64). Initial analysis using scatterplots identified few outliers across the items. While this study acknowledges the importance of filtering the outliers, the researcher decided to accept the outliers "as-is" for normality analysis (see section 5.3.3). It was considered that any attempt to eliminate or forfeit the outliers may affect the validity of the results due to a small sample size (n =44).

5.4.3 Assessment of the Normality

The dataset was assessed for normality by testing the skewness and kurtosis. West et al. (1995) suggest an approach to significance tests of normality by interpreting the absolute values of the skewness and kurtosis indices. Skewness refers to the "measure of symmetry of a distribution" and kurtosis refers to the "measure of the peakedness or flatness of distribution when compared with a normal distribution" (Hair et al., 2006, p. 37). The normal distribution is symmetric and has a skewness value of 0. Kurtosis is a measure of the extent to which observations cluster around a central point. A normal distribution has a kurtosis value of 0. It is considered to be moderately non-normal if the skewness index value is greater than 3.0 and the kurtosis index value is greater than 10.0. Kurtosis values greater than 20.0 indicate a more serious normality problem (Kline, 2005). Forty four items from the pilot study were tested (see Table 5-9) and all showed normality ranging between 0.0 to 1.4 for skewness (level < 3.0) and 0.0 to 2.7 (level < 10.0) for kurtosis.

Table 5-9 Normality test for pilot study (n=44)

	skewness	kurtosis
B1 Access to a computer workstation to perform job	-0.81	-1.41
B2 Access to networked computer to work	-1.06	-0.93
B3 Access to training and learning through computer network	-1.13	1.40
B4 Access to on-line shared databases to facilitate work	-1.05	0.94
B5 Support from supervisor/manager to collaborate	-0.08	-0.28
C1 Job requires to work in teams	0.00	-2.10
C2 Job requires to tele-conference with other sites	-0.71	-0.30
C3 Job requires to share ideas, work and information	-0.81	0.86
C4 Job can only be completed if other members complete theirs	-0.34	-0.92
C5 Performance depends on the results of the team	-0.46	-0.01
D1 Frequently share ideas, work and information	-0.11	-0.43
D2 Frequently interact online with peers and team	-0.47	0.06
D3 Easily obtained help and support on-line	-0.01	0.08
D4 Frequently share on-line meetings	-0.40	-0.14
D5 Team help each other to learn	-0.02	-0.62
E1 Learn from shared information from the network	-1.21	2.71
E2 Receive training to collaborate effectively	-0.57	0.32
E3 Participate in improvement projects	-0.68	0.59
E4 Learn from external parties	-0.47	0.38
E5 Learn from peers/team	0.07	0.26
F1 Work efficiently through use of information from the network	-0.81	4.05
F2 Work interdependently using the computer network	1.35	-0.19
F3 Use computers to share information effectively	-0.79	2.16
F4 Team achieves goals using information from the network	-0.71	0.62
F5 Team produces good quality collaborative work	-0.64	1.57
G1 The network system/tool is useful	-0.76	0.47
G2 The shared database is useful	-0.73	0.99
G3 The on-line meetings with external parties are useful	-1.34	2.65
G4 The network system is useful for sharing information	-0.72	1.72
G5 The on-line learning system is useful	-0.70	0.75
H1 Online knowledge and information	-0.04	-1.39
H2 Work using online system/network	-0.83	0.11
H3 Sharing and exchanging information	-0.43	-0.02
H4 Participate in e-learning	-0.30	-0.81
H5 Participate in workgroup activities	-0.30	-0.53

a skewness standard error 0.36
b kurtosis standard error 0.70

5.5 Profile of Participants

For the pilot study, the participants were recruited from various manufacturing organizations using snowball sampling. The initial group of participants was known to the researcher and mostly had worked with the researcher in the past. From a total of 61 participants invited, 44 participants responded. In addition, the study also examined the patterns and participations of CNL by demographic profiling using frequency and descriptive statistics.

Response Rate: The web-based survey was completed by 44 participants out of 51 participants solicited from Malaysia manufacturing organizations between December

2011 and February 2012 (86.3% response rate) with a completion rate of 100%. The high survey response rate suggested enthusiasm to participate in the pilot study. Seven participants who declined to participate indicated that they were either non-employees of any manufacturing organization or had no interest in the subject area of research.

Demographics: Out of the 44 participants 24 (54.5%) were male and 20 (45.5%) were female (Table 5-10). The majority of the participants were aged between 30-39 years (68.2%, n= 30), compared to those aged between 20-29 years (18.2%, n= 8) and those aged between 40-49 years (13.6%, n= 6), which is relevant to the general population of manufacturing employees in Malaysia. The majority of the participants possessed at least a diploma or a bachelor degree (75%, n= 33), while others possessed a postgraduate degree (22.7%, n= 10) and 1 participant (2.3%) possessed only a high school qualification. This shows that the majority of the participants were exempt staff, supervisors or managers, who possessed a higher qualification compared to production operators, line workers, store hands or general workers. The age and gender of participants also suggested a fairly typical distribution found in the present manufacturing environment. This indicated that there would be a general interest and knowledge concerning collaborative technology available at their respective organizations.

Table 5-10 Demographic profile for pilot study (n=44)

		Frequency	Percent	Cumulative Percent
Gender:	Male	24	54.5	54.5
	Female	20	45.5	100.0
	Total	**44**	**100.0**	
Age:	20-29 years	8	18.2	18.2
	30-39 years	30	68.2	86.4
	40-49 years	6	13.6	100.0
	Total	**44**	**100.0**	
Education:	Postgraduate/masters/doctorate	10	22.7	22.7
	Bachelor degree/diploma	33	75.0	97.7
	High School/STPM/SPM	1	2.3	100.0
	Total	**44**	**100.0**	

Background: The overall demographic as shown in Table 5-11 provides a wide range of participants from diverse backgrounds across organizations and departments. Out of 44 participants, the majority were from MNCs (90.9%, n=40), while the rest were from SMEs (9.1%, n=4). The majority of the participants were from Technical or

Engineering (22.7%, n =10); Management and Leadership (20.5%, n =9); and a diverse mix from Purchasing, Procurement, Sourcing or Materials (13.6%, n =6) and Planning, Sales and Marketing (11.4%, n =5). The demographic of participants suggests that CNL has appeal to a broad mix of employees in manufacturing organizations.

Table 5-11 Pilot study - Participants by organizations and departments (n=44)

	Frequency	Percent	Cumulative Percent
Organizations			
Multinationals (MNCs)	40	90.9	90.9
Small medium enterprises (SMEs)	4	9.1	100.0
Total	**44**	**100.0**	
Departments			
Management/Leadership	9	20.5	20.5
Technical/Engineering	10	22.7	43.2
Human Resources/Administration/Security	1	2.3	45.5
Purchasing/Procurement/Sourcing/Materials	6	13.6	59.1
Planning/Sales/Marketing	5	11.4	70.5
Production/Operations/Manufacturing/Assembly	2	4.5	75.0
Quality/Safety	1	2.3	77.3
Logistics/Warehouse/Store	1	2.3	79.5
Others	9	20.5	100.0
Total	**44**	**100.0**	

5.6 Assessment of Dimensionality

Factor analysis is a general linear model (GLM) technique used for establishing instrument validity (Black, 2005; Flynn et al., 1990) and to discover clusters of items with similar concepts, based on correlations or covariance between items (Field, 2005). Although this study attempted to produce factor analysis, it was considered that it would be inappropriate to interpret the result due to the small sample size (n =44). Exploratory factor analysis (EFA) was carried out for a larger sample size (n=246) for the main study as discussed in Section 6.7.

5.7 Assessment of Internal Consistency

Reliability measures the extent to which the measurement has a consistent effect from sample to sample (Black, 2005; Bryman, 2008; Bryman et al., 2005; Flynn et al., 1990; Nardi, 2006; Netemeyer et al., 2003). Reliability is the ability of the questionnaire to produce the same results under the same conditions. Careful consideration is given to the development of the scale. Psychometric theory demonstrates that reliability of the test increases with multiple items (Kinnear et al., 2009) that represent multiple aspects of the construct. When several questions are grouped and averaged, the potential error that might occur in a single question can be reduced (Hair et al., 2006). Although, constructs with multiple dimensions require more items (Netemeyer et al., 2003), scale brevity is often an advantage (Churchill, 1979; Nunnally et al., 1994).

Another test of internal consistency is Cronbach's coefficient alpha, which is the most widely used method in operations management research (Davis, 1995) and for questionnaires using Likert scales (Oppenheim, 1992). Cronbach's coefficient alpha is based on the degree of inter-relatedness among a set of items that comprise a measure, with higher correlations among the items associated with high alpha coefficients (Bryman, 2008; Netemeyer et al., 2003; Nunnally, 1978; Pedhazur & Schmelkin, 1991). Cronbach's alphas were calculated for all constructs and dimensions, and the results are presented in Table 5-12.

Table 5-12 Pilot study - Cronbach's alpha for first test (n=44)

Constructs	Cronbach's Alpha	N of Items
Organizational Support	0.77	5
Positive Interdependence	0.72	5
Promotive Interactions	0.78	5
Internal-External Learning	0.74	5
Perceived Effectiveness	0.82	5
Perceived Usefulness	0.88	5
Collaborative Networked Learning	0.87	5

The Cronbach's coefficient alpha as shown in Table 5-11 were ≥0.72 which is generally considered to be reliable in any empirical research (Hair et al., 2006; Nunnally, 1978; Nunnally et al., 1994). The closer the α is to 1.00, the greater the internal consistency of items in the instrument being assessed (George & Mallery, 2009; Sekaran, 2003). The newly developed scale for CNL registered 0.87 (>0.6), and the adapted constructs had reliabilities ranging from 0.72 to 0.88 (>0.7) for the pilot study. This suggest that the measure's constituent scales were internally reliable (Bryman, 2008, p. 155). However, Cortina (1993) cautions against use of such a general guideline because the value of α depends on the numbers of items on the scale. Therefore, the reliability test was repeated for the main study, which consisted of a larger sample size but with fewer items after purification and factor analysis.

5.8 Assessment of External Consistency

External consistency assesses the items degree of consistency of a measure over time (Bryman et al., 2005; Netemeyer et al., 2003). This is done by administering the pilot test on two occasions to the same group of participants. However, this procedure has to be carefully considered because the intervening events between test-retest may account for a high significance between two results. The retest was administered to 44 participants approximately two weeks after the first test which was deemed to be a sufficient time elapse between tests so as to avoid artificial consistency. Participants who had participated in the pilot study were identifiable in Qualtrics. Email invitations and few rounds of reminders were also sent to the same group of participants to complete the same survey for the second time. However, only 32 (72%) participants successful completed the re-test after the end of the second week. The results of test-retest show consistent reliability between the first (see Table 5-12) and the re-test (see Table 5-13).

Table 5-13 Pilot study - Cronbach's alpha for re-test (n =32)

Constructs	Cronbach's Alpha	N of Items
Organizational Support	0.80	5
Positive Interdependence	0.68	5
Promotive Interactions	0.69	5
Internal-External Learning	0.71	5
Perceived Effectiveness	0.80	5
Perceived Usefulness	0.85	5
Collaborative Networked Learning	0.91	5

For the re-test of the pilot study, the reliabilities for the scale items range from 0.7 to 0.9 (>0.7) and are considered to be externally consistent. The result of reliability test shows consistent scores between the test and re-tests.

5.9 Summary

This chapter discussed the approach used to develop the measurements and scales for the study, and described the rationale for the procedures used to test the validity and reliability. The result of the internal consistency test demonstrated that the instrument was consistent and good for use in the data collection for the main study. Exploratory factor analysis (EFA) was not carried out at this stage due to the small sample size of the pilot study. Nonetheless, the result from Cronbach's coefficient alpha showed that the measures were internally reliable and externally consistent, and could therefore be used in the main study. Chapter 6 presents the results from the main study; tabulated and analysed to answer the research questions and propositions.

CHAPTER 6: QUANTITATIVE DATA ANALYSIS AND RESULTS

6.1 Introduction

Descriptive procedures of SPSS were used to calculate basic univariate statistics to summarize data and get a description of the responses to questions, including demographic data such as age, gender, education and department. This provided frequency tables, cross-tabulations found mean differences between groups and correlations between factors. The measures were analysed and compared using frequency tables with each response to variables represented as a mean and standard deviation of the total responses. Factor analysis examined items for convergence into valid and reliable measure of constructs. Bivariate analysis was used to examine the relationships between two variables and to prove that they did not happen by chance. Multivariate analysis was used to demonstrate the degree of correlation between multiple factors which influence manufacturing employees' decisions and perceptions in using CNL.

6.2 Restatement of the Research Questions

To achieve the purpose of the study, the following research questions were addressed in the quantitative data analysis:

RQ1. What are the significant antecedents for a CNL model in manufacturing?

RQ2. How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning?

RQ3. What are employees' perceptions of CNL's usefulness and effectiveness in manufacturing?

RQ4. What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?

6.3 Data Collection for Survey Questionnaire

The questionnaire was made available through a Qualtrics web-based survey and through mailed out hardcopies. The questionnaire solicited self-reported background, and information pertaining to perceptions and experiences in using CNL. Compared to conventional mail surveys, the cost of Qualtrics web-based surveys for sending questionnaires and coding data is relatively low, and has a short turnaround time. Potential errors due to data transfer and codification are eliminated (Nardi, 2006). The Qualtrics generated electronic dataset from responses were pre-coded in SPSS format. See Appendix D for the questionnaire. Both types of questionnaire (online and hardcopy) consisted of 44 questions categorized into 3 sections: type of manufacturing organizations (item A1), experience with CNL (items B1 to H5), and number of hours using CNL systems and tools (items I1 to I4) and demographic data (items J1 to J4). Participants were requested to answer all questions.

Biased samples and biased returns are a common problem with a web-based survey. Participants using web-based surveys are most likely to be employees who have access to computer networks, have some skills and feel comfortable with a Qualtrics web-based survey tool. Nardi (2006) notes that variation in computer use and accessibility based on roles, positions, types of organization, and education may affect the generalizability of findings from online surveys. To mitigate this issue, hardcopies were also distributed to those who did not have access to a computer network or who indicated a preference for hardcopies of the survey questionnaire.

Mouton and Marais (1993), and Bryman (2008) describe various factors that could affect the reliability of a test. A self-administered web-based survey and anonymous administration lessen socially desirable responding (SDR) bias involving an individual's self-description but not self-deceptive bias (Nederhof, 1985; Netemeyer et al., 2003). SDR can be reflected in responses with tendencies to provide a favourable position for the participants in terms of norm and organizational practices. To mitigate the risk of SDR, the following questions were designed to complement others:

i. Item C1 "My job requires me to work in teams" with item C5 "My performance depends on the results of my team".
ii. Item G2 "The shared database is useful" with item I2 "Numbers of hours using a shared database or network information per week".
iii. Item G3 "The online meetings with external parties are useful" with item E4 "I learned from suppliers, customers or external parties".
iv. Item H4 "I participated in e-learning or online courses" with item I1 "Numbers of hours using e-learning or online learning per year".

In order to reduce duplicate submissions from the same respondent, the researcher conducted verification on the IP addresses which prevented any repeated or duplicated responses. The Qualtrics web-based survey automatically prompted the participants, should any of the questions not be answered. Hardcopies of the survey were checked for accuracy before they were entered into the Qualtrics online database.

6.4 Data Preparation

Data preparation is necessary to ensure that data has been correctly recorded in SPSS and the distributions of data to be used in the analysis are normal (Coakes, 2006). Preliminary analysis generated descriptive statistics and examined the normality of data, missing data and multicollinearity. Normality is the most fundamental assumption in statistical analysis which could influence the validity of the results. Multicollinearity is to be avoided if the unique contribution variables to a factor are to be ascertained. Outliers can result in non-normality data and affect the validity of the statistical analysis (Hair et al., 2006).

6.4.1 Missing Data, Multiple Responses and Data Entry

There was no requirement for treatment of missing data or value for both the web-based survey and the hardcopy survey as participants answered all items in the questionnaire. Frequency tables containing counts for each value of the scales was also used to check and validate the data to ensure there was no missing data, data duplication or multiple response data. The Qualtrics prevented participants from submitting an incomplete questionnaire. However, to ensure integrity, special attention was given to hardcopies of the survey with every response being verified to ensure no missing value or multiple values before the data was transferred into the database. This was to ensure that all participants' responses were correctly entered into the system. The web-based survey did not generate any multiple responses in any single item as all the responses were controlled by Qualtrics. Similarly, no multiple responses were detected in the hardcopies. This helped in the process of accumulation and consolidation of all data and enabled ease of transfer of the formatted database directly into IBM SPSS for data analysis, without any need for conversion or reformatting. The data was directly extracted and transferred from Qualtrics database to IBM SPSS in the data editor. Using SPSS variable view, the descriptive value labels for numeric codes and measurement level (nominal, ordinal, or scale) were checked.

6.4.2 Outliers

Scatter plots were used to identify extreme outliers as they can impact regression analysis (Norusis, 2008). The scatter plots gave no response with extreme outliers that exceeded ± 2.5 of the standardised variable value (Hair et al., 1998; Pallant, 2001). Outliers that are not too extreme are retained and careful consideration given not to recode the value, in order to maintain the integrity of the study. The researcher did conduct verification on outlier items to ensure correct data entry or data coding, and found no anomaly.

6.4.3 Assessment of the Normality

Normality of distribution is achieved when there is a mean of 0 and standard deviation of 1 for samples (confidence interval ≥ 95%). This is required because confirmatory factor analysis (CFA) and multiple regressions require data to be normally distributed. However, Hair et al. (2006) posit that when the sample size is more than 80, the effect of non-normality is minimised. The dataset for the main study with 246 participants was assessed for normality by testing the skewness and kurtosis (see Table 6-13). Although the size of 246 participants could be considered small, Hair et al. (2006) argue that this number is adequate for quantitative analysis and therefore serves the purpose of initial exploration of CNL. The central limit theorem also states that in a sample of a sufficiently large size, the distribution of sample means is approximately normal (Norusis, 1999). It is considered to be normal if the data demonstrated skewness index values less than 3.0 and kurtosis index values less than 10.0. Kurtosis values greater than 20.0 indicate a more serious normality problem (Kline, 2005).

Thirty five items from the main study were tested (see Table 6-14) and all showed normality ranging between -0.43 to -2.36 for skewness (level < 3.0) and ±0.01 to 5.14 (level < 10.0) for kurtosis. The data demonstrated normal distribution.

Table 6-14 Testing skewness and kurtosis (n= 246)

	skewness	kurtosis
B1 Access to a computer workstation to perform job	-2.36	5.14
B2 Access to networked computer/email for work	-2.13	4.04
B3 Access to learning through computer network	-1.30	0.94
B4 Access to on-line shared databases to facilitate work	-1.26	0.51
B5 Support from supervisor/manager to collaborate	-1.27	1.79
C1 Job requires to work in teams	-1.45	1.48
C2 Job requires to tele-conference with other sites	-0.43	-1.27
C3 Job requires to share ideas, work and information	-1.18	0.36
C4 Job can only be completed if other members complete theirs	-0.56	-0.80
C5 Performance depends on the results of the team	-0.77	-0.31
D1 Frequently share ideas, work and information	-1.10	0.33
D2 Frequently interact online with peers/team	-0.80	-0.53
D3 Easily obtained help and support on-line	-0.77	-0.52
D4 Frequently share on-line meetings	-0.50	-1.06
D5 Team helps each other to learn	-1.12	0.63
E1 Learn from shared information from the network	-0.91	-0.07
E2 Receive training to collaborate effectively	-0.78	-0.27
E3 Participate in improvement projects	-.988	0.39
E4 Learn from external parties	-.215	-1.21
E5 Learn from peers/team	-1.29	1.25
F1 Work efficiently through use of information from the network	-1.00	-0.01
F2 Work interdependently using the computer network	-0.94	0.01
F3 Use computer to share information effectively	-1.18	0.54
F4 Team achieves goals using information from the network	-0.84	-0.26
F5 Team produces good quality collaborative work	-0.96	0.09
G1 The network system/tool is useful	-1.21	0.78
G2 The shared database is useful	-1.21	0.92
G3 The on-line meetings with external parties are useful	-0.66	-0.67
G4 The network system is useful for sharing information	-1.17	0.51
G5 The on-line learning system is useful	-0.75	-0.17
H1 Online knowledge and information	-0.88	-0.04
H2 Work using online system/network	-1.14	0.43
H3 Share and exchange information	-0.99	0.09
H4 Participate in e-learning	-0.09	-1.21
H5 Participate in workgroup activities	-0.62	-0.58

Note: standard error for skewness = 0.16
standard error for kurtosis = 0.31

6.5 Profile of Participants

For the main study, the participants were again randomly recruited from various manufacturing organizations using snowball sampling. The main study was conducted from July 2012 until the end of November 2012 and 292 responses were obtained. The response were analysed and were useful for the development of questions in the follow-up with semi-structured interviews with 12 of the participants engaged in the survey.

Of the 63 potential participants identified for the initial stage, 12 were unreachable due to change in employment. This reduced the sample size of the initial target group of participants to 51. After the cut-off date of November 22, 246 usable responses were attained, out of which 150 were from the web-based survey and another 96 replied through hardcopies. Forty six potential participants declined to participate giving a non-response rate of 14% (46 of 338). In total, 292 participants responded to the survey, of which 246 completed responses were usable. With 63 survey invitations and 400 hardcopies printed and distributed, the overall response rate was 63% (292 of 463), and the usable rate was 84% (246 of 292). Table 6-15 shows the profile of the 246 participants.

Table 6-15 Main study - Participants by gender, age and education (n=246)

		Frequency	Percent	Valid Percent	Cumulative Percent
Gender:	Male	112	45.5	45.5	45.5
	Female	134	54.5	54.5	100.0
	Total	**246**	**100.0**	**100.0**	
Age	20-29 years	86	35.0	35.0	35.0
	30-39 years	128	52.0	52.0	87.0
	40-49 years	29	11.8	11.8	98.8
	Above 50 years	3	1.2	1.2	100.0
	Total	**246**	**100.0**	**100.0**	
Education:	Post graduates	27	11.0	11.0	11.0
	Bachelor degree/diploma	145	58.9	58.9	69.9
	High school/STPM/SPM	69	28.0	28.0	98.0
	Junior/SRP/PMR	4	1.6	1.6	99.6
	Others	1	.4	.4	100.0
	Total	**246**	**100.0**	**100.0**	

The majority of the participants were aged between 30-39 years (52.0%, n =128), followed by those aged between 20-29 years (35.0%, n =86), and possessed at least a diploma or a bachelor degree (58.9%, n =145). The participants came from MNCs (72%, n =177) and SMEs (28%, n = 69). The majority of the participants were from Production/Operations/Manufacturing/Assembly (26.8%, n =66), followed by Technical/ Engineering (19.9%, n =49) as shown in Table 6-16.

Table 6-16 Main study – Participants by organizations and departments (n=246)

	Frequency	Percent	Valid Percent	Cumulative Percent
Organization :				
Multinational (MNC)	177	72	72	72
Small-medium enterprise (SME)	69	28	28	100
Total	**246**	**100.0**	**100.0**	
Departments:				
Management/Leadership	22	8.9	8.9	8.9
Technical/Engineering	49	19.9	19.9	28.9
Human resources/Administration /Security	9	3.7	3.7	32.5
Purchasing/Procurement /Sourcing /Materials	30	12.2	12.2	44.7
Planning/Sales /Marketing	21	8.5	8.5	53.3
Production/Operations/Manufacturing/Assembly	66	26.8	26.8	80.1
Quality/Safety	24	9.8	9.8	89.8
Logistic/Warehouse/Store	11	4.5	4.5	94.3
Finance/Accounts/Costing	4	1.6	1.6	95.9
Others	10	4.1	4.1	100.0
Total	**246**	**100.0**	**100.0**	

6.6 Preliminary Investigations

Preliminary investigations were carried out for Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The communalities test for variables represented the amount of variance accounted for by the factor solution. These tests were carried out before examining the factor loading for each item and its construct.

6.6.1 Measurement of Sampling Adequacy and Sphericity

Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were carried out. Measure of sampling adequacy is a measure which calculates the entire collection matrix and each individual variable, and evaluates the appropriateness of applying factor analysis. The KMO represents the ratio of the squared correlation between variables to the squared partial correlation between variables (Field, 2005, p. 640). The KMO value >0.50 indicates appropriateness and fulfils the required sampling adequacy (Field, 2005; Hair et al., 2006; Kaiser, 1974). Values between 0.5 and 0.7 are mediocre, values 0.7 to 0.8 are good, values between 0.8 and 0.9 are great, and values above 0.9 are superb (Hutchenson & Sofroniou, 1999 as cited by Field, 2005). Table 6-17 shows the result of Kaiser-Meyer-Olkin and Barlett's test for sampling adequacy and sphericity.

Table 6-17 Kaiser-Meyer-Olkin and Barlett's test

Factors	Measure of Sampling Adequacy	Test of Sphericity		
		Approx. Chi-Square	d.f.	Sig.
Organizational Support	0.85	1206.82	10	0.000
Positive Interdependence	0.84	682.62	6	0.000
Promotive Interactions	0.85	1088.88	10	0.000
Internal-External Learning	0.80	619.35	6	0.000
Perceived Effectiveness	0.87	1493.24	10	0.000
Perceived Usefulness	0.89	1177.02	10	0.000
Collaborative Networked Learning	0.89	1065.80	10	0.000

In this study, the KMO value for 33 items ranged highly between 0.80 and 0.89 (Table 6-4) which is considered as great. The Bartlett test of sphericity tests for the overall significance of all correlations within the correlation matrix (Hair et al., 2006) and these were found to be significant ($p<0.001$), hence suggesting that the correlation matrix demonstrates significant correlations (Field, 2005; Hair et al., 2006).

6.6.2 Assessment of Communalities

The proposition of common variance present in a variable is known as communality (Field, 2005). In factor analysis, the researcher is interested in finding a common dimension within the data. Correlation coefficients fluctuate sample to sample depending on the sample size and the communality of the variable should be more than 0.5 (Field, 2005). That is why this study chose to test communality using the main study with a larger sample size (n=246) as compared to the pilot study (n=44). The communality for a variable represents the amount of variance accounted for by the factor solution. A general rule is to consider that at least one-half of the variance of each variable must be taken into account. Table 6-18 shows item communalities extraction.

Table 6-18 Item communalities

	communalities
B1 Access to a computer workstation to perform job	0.88
B2 Access to networked computer/email for work	0.88
B3 Access to learning through computer network	0.84
B4 Access to on-line shared databases to facilitate work	0.67
B5 Support from supervisor/manager to collaborate	0.67
C1 Job requires to work in teams	0.75
C2 Job requires to tele-conference with other sites	0.48
C3 Job requires to share ideas, work and information	0.83
C4 Job can only be completed if other members complete theirs	0.72
C5 Performance depends on the results of the team	0.80
D1 Frequently share ideas, work and information	0.79
D2 Frequently interact online with peers/team	0.87
D3 Easily obtained help and support on-line	0.86
D4 Frequently share on-line meetings	0.72
D5 Team helps each other to learn	0.71
E1 Learn from shared information from the network	0.79
E2 Receive training to collaborate effectively	0.78
E3 Participate in improvement projects	0.67
E4 Learn from external parties	0.43
E5 Learn from peers/team	0.72
F1 Work efficiently through use of information from the network	0.85
F2 Work interdependently using the computer network	0.88
F3 Use computers to share information effectively	0.87
F4 Team achieves goals using information from the network	0.90
F5 Team produces good quality collaborative work	0.84
G1 The network system/tool is useful	0.86
G2 The shared database is useful	0.88
G3 The on-line meetings with external parties are useful	0.64
G4 The network system is useful for sharing information	0.87
G5 The on-line learning is useful	0.77
H1 Online knowledge and information	0.85
H2 Work using online system/network	0.82
H3 Share and exchange information	0.85
H4 Participate in e-learning	0.70
H5 Participate in workgroup activities	0.75

Extraction Method: Principal Component Analysis

Items C2 and E4 that registered a communalities value of 0.48 and 0.43 respectively (< 0.5) were removed. In this study, exploratory factor analysis (EFA) was used to examine the dimensionality of the constructs and factor loading. It was used in the purification stage of the 35-items scale development. The factors extracted should account for 50% to 60% of the total variance explained and should be attributable to those factors (Hair et al., 1998). Field (2005) advocates retaining items with loadings of no less than 0.4. All items that do not have an absolute loading of at least 0.4 on any factor are recommended for elimination (Churchill et al., 1974; Field, 2005).

Eigenvalues are designed to show the proportion of variance accounted by each factor (George et al., 2009). This study followed the recommendation by Kaiser (1960) to retain all factors with an Eigenvalue >1.0, although Jolliffe (1972) rejects Kaiser's criterion on the ground that it is too strict and suggests an Eigenvalue >0.7. However, the rationale for Eigenvalue >1.0 is that a given factor must account for at least as much variance by a single item or variable (Netemeyer et al., 2003). Therefore, Eigenvalue >1.0 was also chosen for the purpose of this study.

6.7 Exploratory Investigation and Item Reduction

Exploratory factor analysis (EFA) is used for establishing instrument validity (Black, 2005; Flynn et al., 1990). EFA is also used in item reduction to identify a small number of factors that explain most of the observed variance in the manifest variables. According to Field (2005) “by reducing a data set from interrelated variables into a smaller set of factors, factor analysis achieves parsimony by explaining the maximum amount of common variance in a correlation matrix using a smaller number of explanatory concepts” (p.620). EFA attempts to identify underlying factors that account for the pattern of correlations within the set of observed variables in multiple indicator measures. The correlation between each pair of variables can be arranged in the *R*-matrix, which is a table of correlation coefficients between variables (Field, 2005), and classifies the tests in terms of the relatively few latent dimensions (Kinnear et al., 2009). Therefore, the factors can be described in the following equation 6.1:

$$Y_i = b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n + \varepsilon_i \qquad \text{.....equation 6.1}$$

where Y is the factor of i and b is the factor loading of variable X_1, X_2, X_3 and X_n. In factor analysis, the principle component for data extraction procedure helps to create compound measures by integrating several items (Hair et al., 2006) and explained variance and covariation among the measures (Green et al., 2000). The rotated components show the loading between each item and the extracted factors (see section 6.7.1 to 6.7.7).

Field (2005) suggests factors with 10 or more loadings greater than 0.4 are only reliable if the sample size is greater than 150. However, there is no consensus on what is deemed as the appropriate sample size for factor analysis. Kass and Tinsley (1979) suggest between 5 to 10 per variable. This study used 7 participants per variable (246 of 35).

The principle component method with oblique rotation was chosen for dimension analysis because there is theoretical ground that the latent factors are correlated to each other (Field, 2005). Field (2005) argues that the oblique rotation is more suitable and meaningful than orthogonal rotation. The pattern matrix produced by oblique rotation contains factor loadings comparable to the factor matrix for the orthogonal rotation. All the items were measured using a 5-point Likert scale that ranged from 1 (Strongly disagree) to 5 (Strongly agree). The principal component analysis with Oblimin rotation with Kaiser normalization was not rotated because only one factor was extracted for organizational support, promotive interaction, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness. The scree plot test (Figure 6-11) also identified one factor. No item was cross-loaded and none was eliminated from the analysis.

6.7.1 Factor Analysis – Organizational Support

Table 6-19 shows that one factor was identified: B1, B2, B3, B4 and B5. Factor organizational support with Eigenvalue 3.94 was extracted and accounted for 78.75% of the variance. The factor analysis of organizational support turned out to be significant (approx. chi-square =1206.82, df = 10, Sig. =0.000).

Table 6-19 Factor loading for organizational support

	Component
	1
B1 Access to a computer workstation to perform job	0.94
B2 Access to networked computer/email for work	0.94
B3 Access to learning through computer network	0.92
B4 Access to on-line shared databases to facilitate work	0.82
B5 Support from supervisor/manager to collaborate	0.82

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.2 Factor Analysis – Promotive Interaction

Table 6-20 shows that one factor was identified: C1, C3, C4 and C5. Factor promotive interaction with Eigenvalue 3.17 was extracted and accounted for 79.36% of the variance. The factor analysis of promotive interaction turned out to be significant (approx. chi-square =682.62, df = 6, Sig. =0.000).

Table 6-20 Factor loading for promotive interaction

	Component
	1
C3 Job requires to share ideas, work and information	0.91
C5 Performance depends on the results of team	0.92
C1 Job requires to work in teams	0.87
C4 Job can only be completed if other members complete theirs	0.87

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.3 Factor Analysis – Positive Interdependence

Table 6-21 shows that one factor was identified: D1, D2, D3, D4 and D5. Factor positive interdependence with Eigenvalue 3.94 was extracted and accounted for 78.89% of the variance. The factor analysis of positive interdependence turned out to be significant (approx. chi-square =1088.88, df = 10, Sig. =0.000).

Table 6-21 Factor loading for positive interdependence

	Component
	1
D2 Frequently interact online with peers/team	0.93
D3 Easily obtained help and support on-line	0.93
D1 Frequently share ideas, work and information	0.89
D4 Frequently share on-line meetings	0.85
D5 Team help each other to learn	0.84

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.4 Factor Analysis – Internal-External Learning

Table 6-22 shows one factor was identified: E1, E2, E3 and E5. Factor internal-external learning with Eigenvalue 3.05 was extracted and accounted for 76.20% of the variance. The factor analysis of internal-external learning turned out to be significant (approx. chi-square =619.35, df = 6, Sig. =0.000).

Table 6-22 Factor loading for internal-external learning

	Component
	1
E1 Learn from shared information from the network	0.91
E2 Receive training to collaborate effectively	0.89
E5 Learn from peers/team	0.87
E3 Participate in improvement projects	0.83

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.5 Factor Analysis – Perceived Effectiveness

Table 6-23 shows one factor was identified: F1, F2, F3, F4 and F5. Factor perceived effectiveness with Eigenvalue 4.35 was extracted and accounted for 86.93% of the variance. The factor analysis of perceived effectiveness turned out to be significant (approx. chi-square =1493.24, df = 10, Sig. =0.000).

Table 6-23 Factor loading perceived effectiveness

	Component
	1
F4 Team achieves goals using information from the network	0.95
F2 Work interdependently using the computer network	0.94
F3 Use computers to share information effectively	0.93
F1 Work efficiently through use of information from the network	0.92
F5 Team produces good quality collaborative work	0.92

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.6 Factor Analysis – Perceived Usefulness

Table 6-24 shows one factor was identified: G1, G2, G3, G4 and G5. Factor perceived usefulness with Eigenvalue 4.02 was extracted and accounted for 80.39% of the variance. The factor analysis of perceived usefulness turned out to be significant (approx. chi-square =1177.02, df = 10, Sig. =0.000).

Table 6-24 Factor loading for perceived usefulness

	Component
	1
G2 The shared database is useful	0.94
G4 The network system is useful for sharing information	0.93
G1 The network systems/tool is useful	0.93
G5 The on-line learning system is useful	0.88
G3 The on-line meetings with external parties are useful	0.80

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.7.7 Factor Analysis – Collaborative Networked Learning

Table 6-25 shows one factor was identified: H1, H2, H3, H4 and H5. Factor collaborative networked learning with Eigenvalue 3.97 was extracted and accounted for 79.36% of the variance. The factor analysis of Collaborative Networked Learning turned out to be significant (approx. chi-square =1065.80, df = 10, Sig. =0.000).

Table 6-25 Factor loading for collaborative networked learning

	Component
	1
H3 Share and exchange information	0.92
H1 Online knowledge and information	0.92
H2 Work using computer system/network	0.91
H5 Participate in work groups	0.87
H4 Participate in e-learning	0.84

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

6.8 Development of a Measurement Model

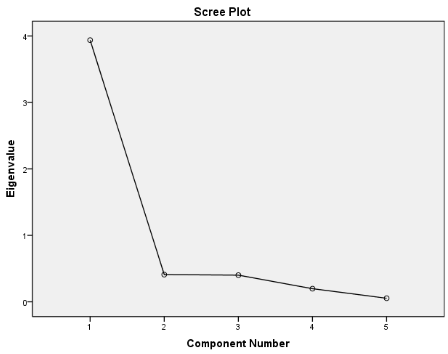
Measurement consists of rules for numerically representing quantities of attributes (Netemeyer et al., 2003) and includes evaluating numbers to reflect the differing degrees of the attributes being accessed (Nunnally et al., 1994). According to Nunnally and Bernstein (1994), the rules of measurement must be clear, practical, not demanding of the researcher or participant and the results do not depend on the researcher. This will ensure the measure is reliable and the results can be easily being interpreted or analyzed. However, the measurement and scale can only be used if it is reliable and valid, especially for the newly developed constructs for this study. After purification, all 33 items were accepted as all factors loaded between 0.80 and 0.95 and met the loading > 0.4. All the factors extracted were between 76.2% and 86.9% exceeded 50% of the total variance explained (as shown in section 6.7.1 until 6.7.7).

6.8.1 Assessment of Unidimensionality

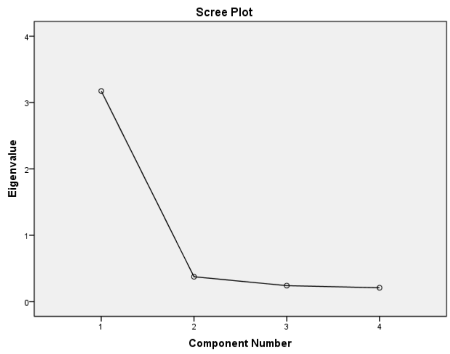
Unidimensionality is a pre-requisite to validity and reliability (Cortina, 1993; Gerbing & Anderson, 1988). A measure's dimensionality is concerned with the homogeneity of items (Netemeyer et al., 2003, p. 9). Netemeyer et al. (2003) further define a measure as unidimensional when it has "statistical properties demonstrating that its items underlie a single construct or factor" (p.9). Unidimensionality indicates that all of the scale is measuring a single underlying factor or construct (Field, 2005). Using exploratory factor analysis (EFA), the unidimensionality test provides evidence of a single latent construct (Flynn et al., 1990).

Using the Eigenvalue >1.0 rule, any construct with more than a single factor should be segregated and/or the items should be removed. However, as was demonstrated in sections 6.7.1 to 6.7.7, all constructs rotated with only a single factor and therefore they were unidemensional. This technique was further complemented with the use of scree plots (see Figure 6-11), which showed the Eigenvalues against the number of factors. For this study, measurement items had factor loadings between 0.80 and 0.95, exceeding the minimum value of 0.60 (Nunnally et al., 1994). All the antecedents are unidimensionals with items representing a single factor for each construct.

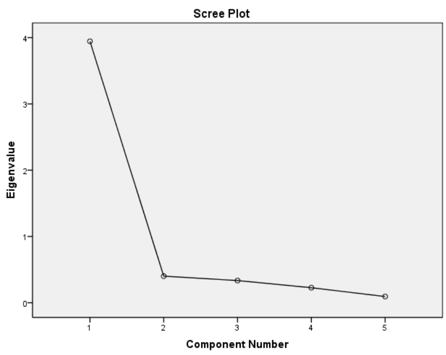
Organizational Support



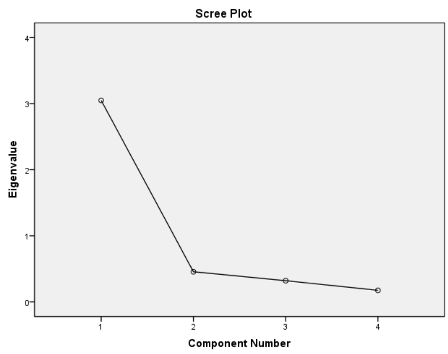
Promotive Interactions



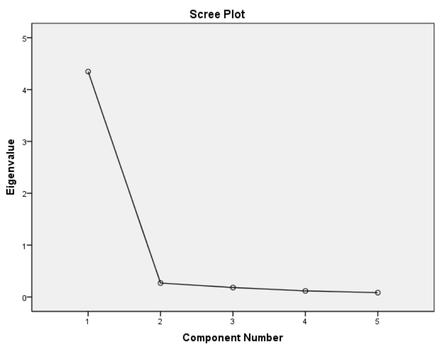
Positive Interdependence



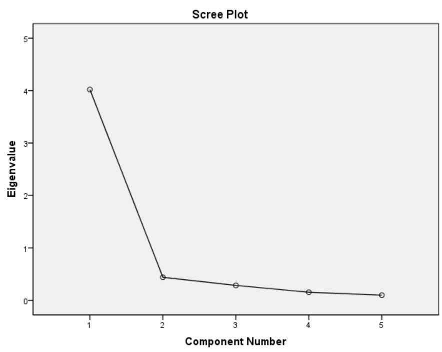
Internal-external Learning



Perceived Effectiveness



Perceived Usefulness



Collaborative Networked Learning

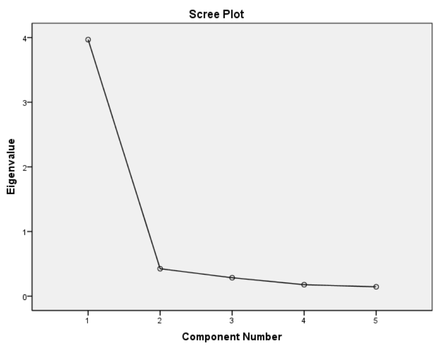


Figure 6-10 Scree plots after items purification

6.8.2 Assessment of Multicollinearity

Multicollinearity occurs when the correlations among multiple independent variables of regressors or predictors in a multiple regression model are highly correlated. Apart from seeking to understand the relationships between the constructs and CNL, it is also imperative to determine which constructs are good predictors of CNL and to answer to *RQ1: What are the significant antecedents for a CNL model in manufacturing?*

By performing collinearity diagnostics (tolerence level > 0.1), any constructs with a high level of collinearity increases the probability of a good predictor (Field, 2005). Singularity or multicollinearity must be avoided because calculation of the regression coefficients is done through matrix inversion. Multicollinearity or singularity may affect the independent variables to become redundant with one another and weaken the analysis. In general, two variables should not be highly correlated with one another at >0.7.

According to Field (2005), although mild multicollinearity is not a problem for factor analysis, it is important to avoid variables that are very highly correlated (R > 0.9) and perfectly correlated (R=1.0) as it will become difficult to ascertain the unique contribution to a factor of the variables. He further points out that multicollinearity can be detected by first scanning the significance of values >0.05 when the determinant of the *R*-matrix (or correlation matrix) is < 0.0001, and only then examine the correlations of R > 0.9 (Field, 2005). In Appendix F, the significance values were <0.05 and the determinants of the *R*-matrix were range from 0.02 to 0.78 (> 0.0001) and as a result it can be established that there is no problem with multicollinearity, except for items B1 and B2 with R = 0.94. It was therefore decided to remove item B1.

6.8.3 Assessment of Internal Consistency

Internal consistency assesses items for their interrelatedness with their scale. According to De Vellis (2003) internal consistency is the measure of homogeneity, where the relationships among items within the scale are logically connected to the latent variable. The internal consistency of the scale is measured using inter-item correlations (Table 6-26), items-to-total correlations (Table 6-27) and Cronbach’s coefficient alpha (Table 6-28 and Table 6-29).

There is no clear guideline to what constitutes moderate inter-item correlations. Robinson, Shaver, and Wrightsman (1991) advocate average inter-item correlations of >0.30 and Peterson suggests 0.31. Table 6-26, shows that the inter-item correlation for this study rated between moderate to high of 0.6 to 0.9.

Table 6-26 Inter-item correlation matrix

	B2	B3	B4	B5	
B2 Access to networked computer/email for work	1.00				
B3 Access to learning through computer network	0.82	1.00			
B4 Access to on-line shared databases to facilitate work	0.70	0.68	1.00		
B5 Support from supervisor/manager to collaborate	0.67	0.72	0.60	1.00	
	C1	C3	C4	C5	
C1 Job requires to work in teams	1.00				
C3 Job requires to share ideas, work and information	0.74	1.00			
C4 Job can only be completed if other members complete theirs	0.63	0.71	1.00		
C5 Performance depends on the results of team	0.73	0.77	0.77	1.00	
	D1	D2	D3	D4	D5
D1 Frequently share ideas, work and information	1.00				
D2 Frequently interact online with peers/team	0.81	1.00			
D3 Easily obtained help and support on-line	0.75	0.89	1.00		
D4 Frequently share on-line meetings	0.65	0.73	0.76	1.00	
D5 Team help each other to learn	0.73	0.69	0.71	0.63	1.00
	E1	E2	E3	E5	
E1 Learn from shared information from the network	1.00				
E2 Receive training to collaborate effectively	0.82	1.00			
E3 Participate in improvement projects	0.63	0.61	1.00		
E5 Learn from peer/team	0.71	0.65	0.67	1.00	
	F1	F2	F3	F4	F5
F1 Work efficiently through use of information from the network	1.00				
F2 Work interdependently using the computer network	0.90	1.00			
F3 Use computers to share information effectively	0.79	0.85	1.00		
F4 Team achieves goals using information from the network	0.83	0.86	0.87	1.00	
F5 Team produces good quality collaborative work	0.80	0.78	0.84	0.86	1.00
	G1	G2	G3	G4	G5
G1 The network system/tool is useful	1.00				
G2 The shared database is useful	0.90	1.00			
G3 The on-line meetings with external parties are useful	0.62	0.66	1.00		
G4 The network system is useful for sharing information	0.85	0.85	0.70	1.00	
G5 The on-line learning is useful	0.75	0.77	0.65	0.76	1.00
	H1	H2	H3	H4	H5
H1 Online knowledge and information	1.00				
H2 Work using online system/network	0.84	1.00			
H3 Share and exchange information	0.85	0.82	1.00		
H4 Participate in e-learning	0.67	0.67	0.69	1.00	
H5 Participate in workgroup activities	0.72	0.69	0.74	0.71	1.00

The item-to-total correlation examines the correlations between each item and the total score from the questionnaire and "in a reliable scale all items should correlate with the total" (Field, 2005, p. 672). Items-to-total correlation < 0.3 is considered weak (de Vaus, 2002; Field, 2005). However, there is no consensus on the decision rules for item-to-total correlation. Tian et al. (2001) suggest deleting items < 0.5; Obermiller and

Spangenberg (1998) suggest < 0.5; Bearden et al. (2001) suggest < 0.35; while Netermeyer et al.(1996) suggest retaining item-to-total correlations in the 0.5 to 0.8 range. In this study the researcher followed the recommendation by Tian et al. (2001) and Obermiller and Spangenberg (1998). Table 6-27 shows that all items exceeded item-to-total correlation 0.5 and therefore all items were retained for further analysis. The correlations within dimensions show all items were highly correlated and the items which were within dimensions were internally consistent, with the corrected item-total correlations values registered between 0.7 to 0.9.

Table 6-27 Item-to-total correlation

	Item-Total Correlation
B2 Access to networked computer/email for work	0.89
B3 Access to learning through computer network	0.86
B4 Access to on-line shared databases to facilitate work	0.73
B5 Support from supervisor/manager to collaborate	0.73
C1 Job requires to work in teams	0.77
C3 Job requires to share ideas, work and information	0.82
C4 Job can only be completed if other members complete theirs	0.78
C5 Performance depends on the results of the team	0.85
D1 Frequently share ideas, work and information	0.82
D2 Frequently interact online with peers/team	0.88
D3 Easily obtained help and support on-line	0.88
D4 Frequently share on-line meetings	0.77
D5 Team help each other to learn	0.76
E1 Learn from shared information from the network	0.83
E2 Receive training to collaborate effectively	0.79
E3 Participate in improvement projects	0.70
E5 Learn from peers/team	0.76
F1 Work efficiently through use of information from the network	0.88
F2 Work interdependently using the computer network	0.90
F3 Use computers to share information effectively	0.89
F4 Team achieves goals using information from the network	0.92
F5 Team produces good quality collaborative work	0.87
G1 The network system/tool is useful	0.87
G2 The shared database is useful	0.89
G3 The on-line meetings with external parties are useful	0.71
G4 The network system is useful for sharing information	0.89
G5 The on-line learning system is useful	0.81
H1 Online knowledge and information	0.87
H2 Work using online system/network	0.84
H3 Share and exchange information	0.87
H4 Participate in e-learning	0.75
H5 Participate in workgroup activities	0.79

From the analysis, the researcher also sought to increase the reliability of the Cronbach's α. Field (2005) recommends that when items result in significant values of α, the overall α should be deleted from the scale in order to improve its reliability. Deletion of item B4 only increased α from 0.928 to 0.933 and item G3 from 0.935 to

0.945. These increases were not deemed to be significant and thus these items were not deleted.

The Cronbach's α reliability test in the pilot study was repeated to ensure consistency in the measurement with the results previously indicated in the pilot study. The result from the main study ranged from 0.90 to 0.96 (Table 6-28) and as this was >0.7, they were considered to be reliable. The split-half reliability was also used to further validate this result, since "Cronbach's alpha would calculate the average of all possible split-half reliability coefficients" (Bryman et al., 2005, p. 77) to clearly dictate the measurement instrument is both reliable and valid. Cronbach's Coefficient Alpha, using the split-half reliability test further proved the scales to be effective (see Table 6-29) with results ranging between 0.73 to 0.95 (level > 0.7). The closer the correlation coefficient is to 1.0 the more reliable it is (Nardi, 2006, p. 63).

Table 6-28 Main study - Cronbach's alpha

Constructs	Cronbach's Alpha	N of Items
Organizational Support	0.90	4
Positive Interdependence	0.91	4
Promotive Interactions	0.93	5
Internal-External Learning	0.90	4
Perceived Effectiveness	0.96	5
Perceived Usefulness	0.94	5
Collaborative Networked Learning	0.93	5

Table 6-29 Main study - split-half reliability

Constructs	Cronbach's Alpha 1st Half	N of Items	Cronbach's Alpha 2nd Half	N of Items
Organizational Support	0.90	2	0.73	2
Positive Interdependence	0.84	2	0.87	2
Promotive Interactions	0.93	3	0.77	2
Internal-External Learning	0.90	2	0.80	2
Perceived Effectiveness	0.94	3	0.92	2
Perceived Usefulness	0.88	3	0.87	2
Collaborative Networked Learning	0.93	3	0.83	2

6.8.4. Validity of Measurement

Construct validity is related to what the instrument is measuring (Churchill, 1979). The construct validity assessment involves examining the convergent and divergent validity of the scale items to ensure the construct variables yield good fit to the quantitative survey data. Validity is concerned with the extent that a scale accurately represents the construct of interest (Hair et al., 2006). Construct validity determines how well the instrument measures or can measure the underlying constructs (Black, 2005; Campbell & Fiske, 1959; Cooper & Schindler, 1998; Cronbach & Meehl, 1955; Netemeyer et al., 2003). The study deduced propositions from the literature and theories that are relevant to the concept of CNL. Furthermore, the assessment of construct validity is a continuous process, which may require a series of refinement after multiple tests over a period of time. Factor loading >0.4 is considered as significant for convergent and divergent validity (Hair et al., 1998). All items had a factor loading range from 0.80 to 0.95 (>0.4), and fulfilled the requirement for convergent and divergent validity (as demonstrated in section 6.7.1 to 6.7.7).

Convergent validity is achieved when two items designed to measure the same scale converge or load together in a single construct to provide the same results (Bryman et al., 2005; Churchill, 1979; Garver & Mentzer, 1999; Hair et al., 2006; Netemeyer et al., 2003). Convergent validity is about the extent to which there is consistency in measurements across multiple operationalization (Campbell et al., 1959). In order to test the convergent validity of the model, the research used exploratory factor analysis (EFA), and the correlation matrix. The high values of item communalities also supported convergent validity. In Table 6-5, items C2 and E4 had low communalities values of 0.48 and 0.43 respectively and were removed. Cronbach's coefficient alpha of >0.7 for all items tested (as demonstrated in Table 6-27 and Table 6-28) also indicated internal consistency and convergent validity.

Divergent validity refers to the independence of the dimensions, assesses the degree to which measures of different latent variables are unique (Hensley, 1999). The CNL constructs are considered to have divergent validity when the scale items are distinctly different from each other and the measures are not related (Bryman et al., 2005; Hair et al., 2006; Netemeyer et al., 2003) or have low correlations (Spector, 1992) because they are supposed to represent other concepts (Bryman et al., 2005). In terms of measure development and validation, evidence of convergent validity in this study was provided from correlation between the measures. The method considered the estimated correlations between the factors < 0.85 (Kline, 2005) and no items that indicated a lack of discriminant validity were deleted.

6.9 Univariate Statistics

Univariate statistics refers to the analysis of one variable at a time (Bryman, 2008, p.322). Descriptive procedure in the SPSS helped to calculate basic univariate statistics. Univariate descriptive procedures focus on single variables to report the distributions of a sample of population, which may include frequency counts; measure of central tendency; and measure of dispersion of distribution. Table 6-30 compares descriptive statistics on the level of agreement (Likert scale from 1= strongly disagree to 5 = strongly agree) and the results between MNCs (n = 177) and SMEs (n = 69).

Table 6-30 Descriptive statistics MNC (n =177) and SME (n = 69)

	MNCs		SMEs	
	Mean	s.d.	Mean	s.d.
B2 Access to networked computer/email for work	4.72	0.61	3.46	1.38
B3 Access to learning through computer network	4.52	0.77	2.97	1.24
B4 Access to on-line shared databases to facilitate work	4.28	1.10	3.19	1.33
B5 Support from supervisor/manager to collaborate	4.36	0.76	3.39	1.10
C1 Job requires to work in teams	4.56	0.73	3.29	1.19
C3 Job requires to share ideas, work and information	4.45	0.75	2.72	1.33
C4 Job can only be completed if other members complete theirs	4.07	0.98	2.35	1.08
C5 Performance depends on the results of team	4.18	0.88	2.65	1.19
D1 Frequently share ideas, work and information	4.37	0.82	2.83	1.28
D2 Frequently interact online with peers/team	4.15	0.96	2.42	1.31
D3 Easily obtained help and support on-line	4.10	0.97	2.45	1.28
D4 Frequently share on-line meetings	3.86	1.23	2.38	1.26
D5 Team helps each other to learn	4.28	0.86	3.04	1.30
E1 Learn from shared information from the network	4.11	0.93	2.80	1.34
E2 Receive training to collaborate effectively	4.01	0.97	2.75	1.32
E3 Participate in improvement projects	4.25	0.90	3.14	1.15
E5 Learn from peers/team	4.27	0.79	3.10	1.27
F1 Work efficiently through use of information from the network	4.19	0.95	2.94	1.39
F2 Work interdependently using the computer network	4.20	0.90	2.83	1.29
F3 Use computer to share information effectively	4.31	0.83	2.93	1.39
F4 Team achieves goals using information from the network	4.12	0.94	2.77	1.32
F5 Team produces good quality collaborative work	4.24	0.85	2.88	1.29
G1 The network system/tool is useful	4.35	0.81	3.01	1.30
G2 The shared database is useful	4.31	0.78	3.00	1.32
G3 The on-line meetings with external parties are useful	3.88	1.20	2.65	1.24
G4 The network system is useful for sharing information	4.34	0.85	2.90	1.32
G5 The on-line learning system is useful	4.06	0.87	2.61	1.23
H1 Online knowledge and information	4.21	0.85	2.84	1.35
H2 Work using online system/network	4.36	0.78	2.81	1.36
H3 Share and exchange information	4.25	0.83	2.84	1.37
H4 Participate in e-learning	3.64	1.14	1.87	0.98
H5 Participate in workgroup activities	4.14	0.94	2.71	1.10

This study depicts the broad experience, activities and tasks that manufacturing employees encounter on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). The majority of the participants stated their preferences as follows:

- Access to networked computer/email for work: MNCs (M = 4.72; s.d. = 0.61) and SMEs (M = 3.46; s.d. = 1.38).
- Access to learning through computer network: MNCs (M = 4.52; s.d. = 0.77) and SMEs (M = 2.97; s.d. = 1.24).
- Job requires to work in teams: MNCs (M = 4.56; s.d. = 0.73) and SMEs (M = 3.29; s.d. = 1.19).
- Job requires to share ideas, work and information: MNCs (M = 4.45; s.d. = 0.75) and SMEs (M = 2.72; s.d. = 1.33).

This clearly demonstrates that the majority of the employees in manufacturing organizations are provided with infrastructure and hardware which enable them to collaborate. Moreover, the observed result also implies that employees in manufacturing organizations are expected to work in teams. However, it would be premature to conclude that employees in manufacturing actually use CNL. This study only depicts the high significant of employees provided with the necessary systems and tools which may support them to engage in CNL.

Bar charts in Figures 6-12, 6-13, 6-14 and 6-15 are used to depict hours spent on online learning, sharing databases, attending online meetings and using email for work among employees in manufacturing organizations.

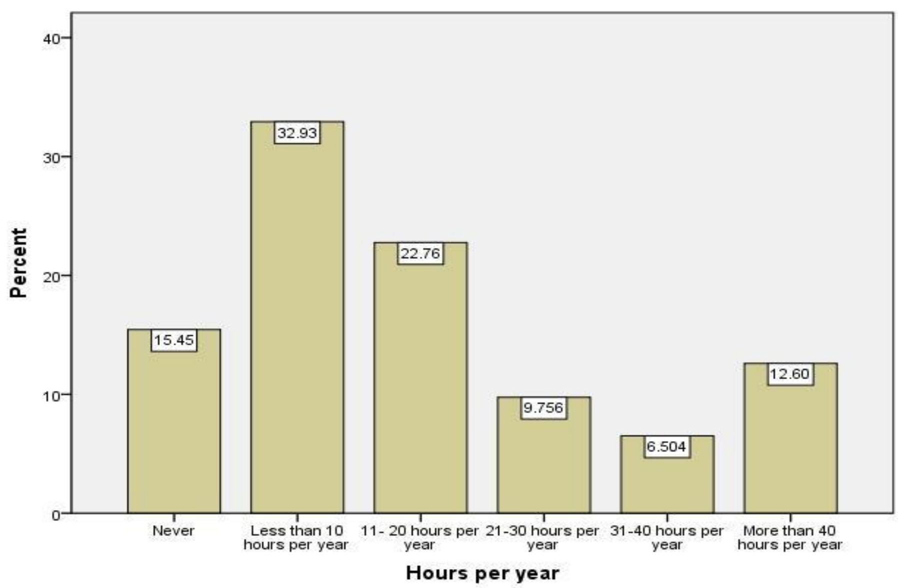


Figure 6-11 Hours spent using online learning per year

In Figure 6-12 it is interesting to note that 48.4% (n=119) of the participants spent 10 hours or less using online learning as compared with 12.6% (n=31) of those who actually spent more than 40 hours per year. This shows that online learning is not a main source of learning in manufacturing and not everyone has the privilege to access the online courses.

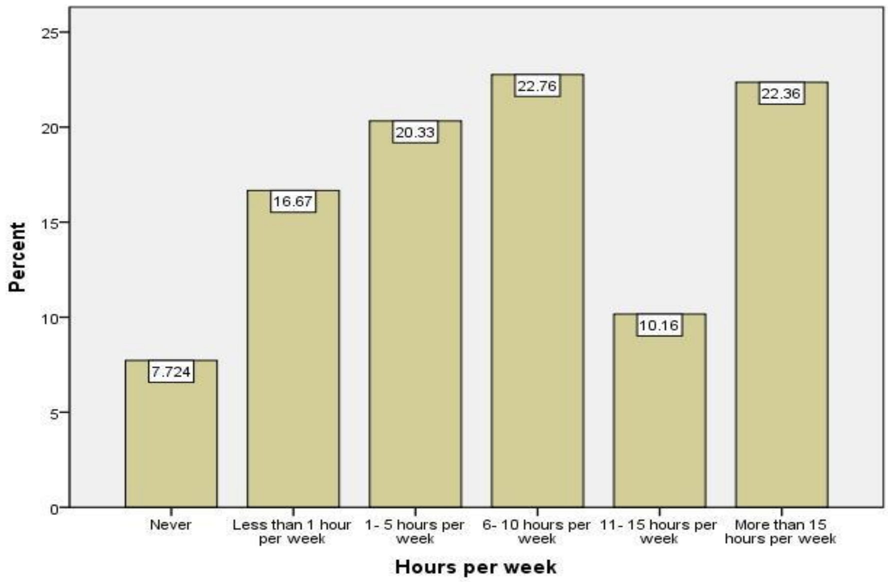


Figure 6-12 Hours using shared database or network information per week

In Figure 6-13, 22.8% (n=56) of the participants spent between 6 to 10 hours per week on a shared database or network information compared to 22.4% (n=55) of those who spent more than 15 hours. Only 7.7% (n=19) had neither used nor had access to any shared database. This shows a significant number of participants had access to a shared database and had actually used shared information in their daily work.

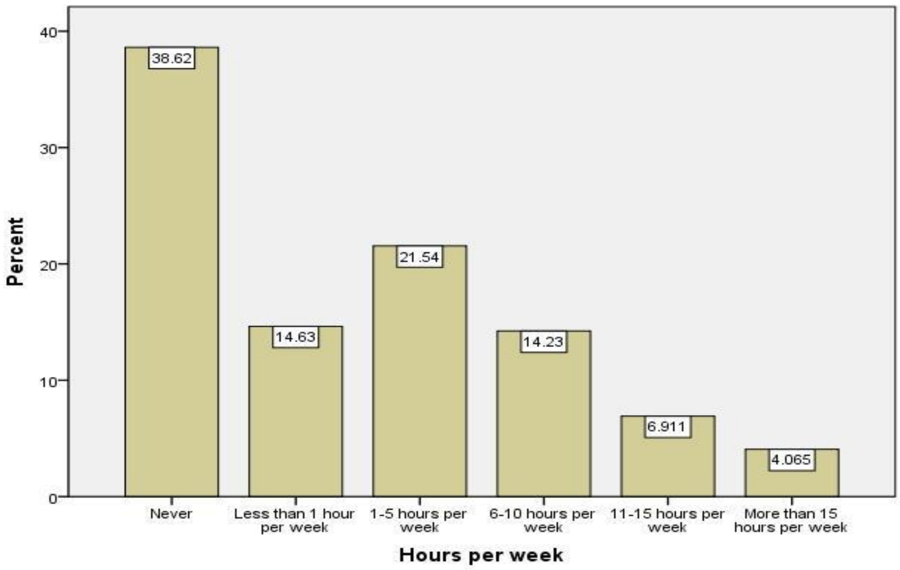


Figure 6-13 Hours using online meetings per week

In Figure 6-14, it is interesting to note that 53.3% (n =131) of the participants said that they had never used online meetings or had used them less than an hour per week. Only 4.1% (n=10) spent more than 15 hours per week using online meetings. This shows that online meetings were not a popular mode of information sharing for all participants.

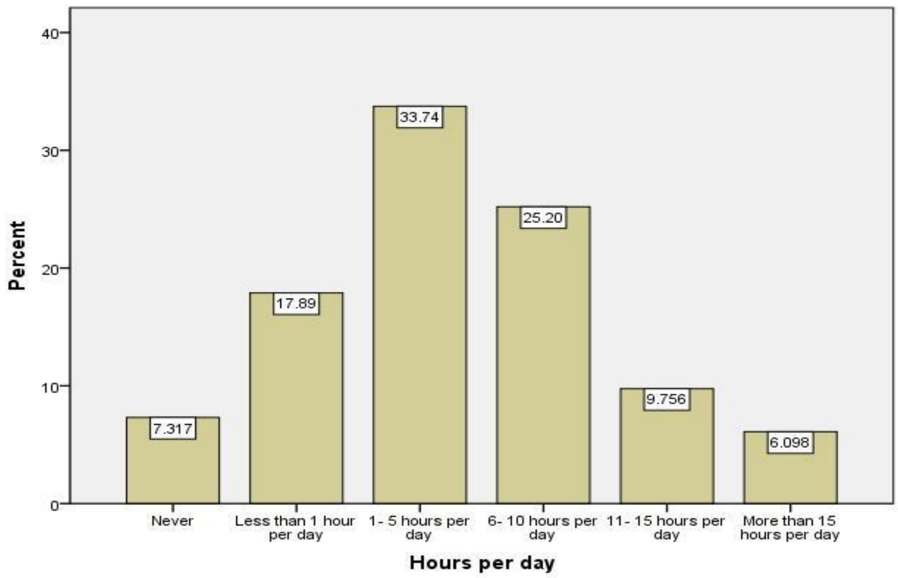


Figure 6-14 Hours using emails per day

In Figure 6-15, 25.2% (n=62) of the participants spent less than an hour per day using emails for work. The majority, at 33.6% (n=83), spent between 1 to 5 hours, while the rest, 41.2% (n=101), spent more than 6 hours per day using emails for their work. The figure is quite significant considering a large percentage of participants were engaged in the work of manufacturing, assembling or testing. Apparently, email was a common mode of communication and possibly an effective mode for sharing information among the participants.

Aside from looking at the hours spent on using CNL by manufacturing employees, this study was also interested in examining the difference between employees in MNC and SME organizations. The independent *t*-test was used to test the results from different groups of participants. Samples from MNCs and SMEs were considered as independent because there was no relationship between the participants from both groups. When comparing two groups with a different number of participants, the pooled variance estimate *t*-test is used by weighting the variance of each sample (Field, 2005). Table 6-31 shows descriptive statistics for hours spent on using different collaborative tools between MNCs and SMEs.

Table 6-31 Comparing mean hours spend using collaborative tools

	Manufacturing organization	N	Mean	Std. Deviation	S.E. Mean
Online learning	MNCs	177	3.35	1.45	0.11
	SMEs	69	1.99	1.41	0.17
Shared database	MNCs	177	4.17	1.41	0.11
	SMEs	69	2.78	1.60	0.19
Online meetings	MNCs	177	2.80	1.48	0.11
	SMEs	69	1.68	1.21	0.15
Work emails	MNCs	177	3.60	1.07	0.08
	SMEs	69	2.54	1.38	0.17

The pair of scores was expected to differ because of a different source of variance, such as perceptions and motivations to use CNL. For the independent *t*-test, the researcher looked at differences between participants from MNCs and SMEs and so the result needed to divide the standard deviation of differences between the two groups. If the standard deviation was high, then a large difference between samples could have occurred by chance. To overcome this, the standard error of the sampling distribution is used to assess whether the difference between samples is statistically meaningful (Field, 2005). If the observed significance level of the Levene's test is small at $p \leq 0.05$, then the study can conclude that the variances are significantly different (Norusis, 1999) and the assumption of homogeneity of variances has been violated (Field, 2005). Appendix G depicts the descriptive statistics for the both groups, while Table 6-32 further reports the result of the independent sample *t*-test. It can be noted that homogeneity of variances had not been violated.

Table 6-32 Independent sample test

		Levene's Test		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	S.E. Difference
Online learning	Equal variances assumed	4.35	0.04	6.67	244	0.00	1.37	0.21
	Equal variances not assumed			6.76	127.71	0.00	1.37	0.20
Shared database	Equal variances assumed	1.65	0.20	6.68	244	0.00	1.39	0.21
	Equal variances not assumed			6.32	111.42	0.00	1.39	0.22
Online meetings	Equal variances assumed	7.29	0.01	5.59	244	0.00	1.12	0.20
	Equal variances not assumed			6.11	150.53	0.00	1.12	0.18
Work emails	Equal variances assumed	7.37	0.01	6.48	244	0.00	1.07	0.17
	Equal variances not assumed			5.80	101.34	0.00	1.07	0.18

Participants from MNCs (n=177) spent more hours using CNL as compared to participants from SMEs (n =69) and the results can be summarized as follows:

i. Hours spent on using online learning or e-learning per year – MNCs (M = 3.35, s.d. = 1.45, S.E. = 0.11) and SMEs (M = 1.99, s.d.= 1.41, S.E. = 0.17). The difference was significant ($t(127.71) = 6.76$, $p< 0.05$).

ii. Hours spent on using a shared database or network information per week – MNCs (M = 4.17, s.d. =1.41, S.E. =0.11) and SMEs (M = 2.78, s.d. = 1.60, S.E. = 0.19). The difference was not significant ($t(244) = 6.68$, $p> 0.05$).

iii. Hours spent on online meetings or tele-conferencing per week – MNCs (M = 2.80, s.d. = 1.48, S.E. =0.11) and SMEs (M = 1.68, s.d. = 1.21, S.E. =0.15). The difference was significant ($t(111.42) = 6.32$, $p< 0.05$).

iv. Hours spent on sending/replying to emails for work per day – MNCs (M =3.60, s.d. = 1.07, S.E. = 0.80) and SMEs (M = 2.54, s.d. = 1.38, S.E. =0.17). The difference was significant ($t(101.34) = 5.80$, $p< 0.05$).

6.10 Bivariate Statistics

Bivariate analysis refers to the analysis of two variables at a time to examine the relationships between and to recognize when "variation in one variable coincides with variation in another variable" (Bryman, 2008, p.325). Cross-tabulation is used to demonstrate the relationships between two or more categorical (nominal or ordinal) variables, when the distribution of one variable is associated with the other variable (Bryman, 2008; Bryman et al., 2005; Norusis, 1999) and it did not happen by chance.

By using cross-tabulation, the study examined the count of the number of cases in each cell of the tables (Table 6-33, Table 6-34, Table 6-35, and Table 6-36). Again, the test was repeatedly used to compare the frequencies of a dichotomous variable from two groups of participants (i.e. MNCs and SMEs).

The chi square (χ^2) test is used in conjunction with cross-tabulation to test the significance level that the observed relationship between the two variables could have arisen by chance (Bryman, 2008; Bryman et al., 2005) and to test the propositions on data that are counts (Norusis, 1999). As a general rule, if the observed significance level is $p < 0.0005$, then the assumption is to reject the two variables as being independent (Norusis, 1999, 2008). The χ^2 test is only appropriate if less than 20% of the cells have expected values of less than 5, or if the expected frequency is less than 1 (Norusis, 1999, 2008). The χ^2 tests in this study met the requirement with 0% to 16.7% of the cells having expected values of less than 5, as stipulated in the results below:

- Online learning - 1 cell (8.3%) had expected count less than 5. The minimum expected count was 4.49.
- Shared database - 0 cell (0%) had expected count less than 5. The minimum expected count was 5.33.
- Online meetings - 2 cells (16.7%) had expected count less than 5. The minimum expected count was 2.80.
- E-mailing - 1 cell (8.3%) had expected count less than 5. The minimum expected count was 4.21.

Table 6-33 shows a cross-tabulation of two categories of manufacturing organizations and six categories of hours spent on sending/replying to work emails (χ^2 = 68.87, df =5, sig =0.000).

Table 6-33 Cross-tabulation of manufacturing organization and email at work

		Type of manufacturing organization: MNC	Type of manufacturing organization: SME	Total
Never	Count	1	17	18
	% within Hours spent on sending/replying to emails	5.6%	94.4%	100.0%
	% within Type of manufacturing organization	.6%	24.6%	7.3%
Less than 1 hour per day	Count	20	24	44
	% within Hours spent on sending/replying to emails	45.5%	54.5%	100.0%
	% within Type of manufacturing organization	11.3%	34.8%	17.9%
1- 5 hours per day	Count	71	12	83
	% within Hours spent on sending/replying to emails	85.5%	14.5%	100.0%
	% within Type of manufacturing organization	40.1%	17.4%	33.7%
6- 10 hours per day	Count	53	9	62
	% within Hours spent on sending/replying to emails	85.5%	14.5%	100.0%
	% within Type of manufacturing organization	29.9%	13.0%	25.2%
11- 15 hours per day	Count	20	4	24
	% within Hours spent on sending/replying to emails	83.3%	16.7%	100.0%
	% within Type of manufacturing organization	11.3%	5.8%	9.8%
More than 15 hours per day	Count	12	3	15
	% within Hours spent on sending/replying to emails	80.0%	20.0%	100.0%
	% within Type of manufacturing organization	6.8%	4.3%	6.1%
Total	Count	177	69	246
	% within Hours spent on sending/replying to emails	72.0%	28.0%	100.0%
	% within Type of manufacturing organization	100.0%	100.0%	100.0%

Pearson Chi-Square = 69.870, df = 5, Asymp. Sig. (2-sided) = .000

A total of 85.5% (n =71) of the participants from MNCs, as compared to 14.5% (n=12) from SMEs, said that they spent between 1 to 5 hours a day using emails for work. This was followed by another 85.5% (n =53) of participants from MNCs, as compared to 14.5% (n=9) from SMEs, who spent between 6 to 10 hours a day using their emails for work. The majority of participants from SMEs, at 94.4% (n =14), said that they had never used emails, as compared to 5.6% (n =1) of participants from MNCs. Those who spent more than 15 hours per day using emails for work were from MNCs at 80.0% (n=12) as compared to SMEs at 20.0% (n =3). The observed significance level for the Pearson chi-square value of 69.87 was less than 0.0005, which showed that participants from MNCs and SMEs did not give the same responses to the question (independent). It was evident that participants from MNCs spent more hours using email for work as compared to participants from SMEs.

Table 6-34 shows a cross-tabulation of two categories of manufacturing organizations and six categories of hours using on-line meetings or tele-conferencing (χ^2 = 37.85, df =5, sig =0.000).

Table 6-34 Cross-tabulation of manufacturing organization and on-line meeting

		Type of manufacturing organization		
		MNCs	SMEs	Total
Never	Count	49_a	46_b	95
	% within Hours spent on on-line meetings or tele-conferencing	51.6%	48.4%	100.0%
	% within Type of manufacturing organization	27.7%	66.7%	38.6%
Less than 1 hour per week	Count	25_a	11_a	36
	% within Hours spent on on-line meetings or tele-conferencing	69.4%	30.6%	100.0%
	% within Type of manufacturing organization	14.1%	15.9%	14.6%
1-5 hours per week	Count	48_a	5_b	53
	% within Hours spent on on-line meetings or tele-conferencing	90.6%	9.4%	100.0%
	% within Type of manufacturing organization	27.1%	7.2%	21.5%
6-10 hours per week	Count	32_a	3_b	35
	% within Hours spent on on-line meetings or tele-conferencing	91.4%	8.6%	100.0%
	% within Type of manufacturing organization	18.1%	4.3%	14.2%
11-15 hours per week	Count	14_a	3_a	17
	% within Hours spent on on-line meetings or tele-conferencing	82.4%	17.6%	100.0%
	% within Type of manufacturing organization	7.9%	4.3%	6.9%
More than 15 hours per week	Count	9_a	1_a	10
	% within Hours spent on on-line meetings or tele-conferencing	90.0%	10.0%	100.0%
	% within Type of manufacturing organization	5.1%	1.4%	4.1%
Total	Count	177	69	246
	% within Hours spent on on-line meetings or tele-conferencing	72.0%	28.0%	100.0%
	% within Type of manufacturing organization	100.0%	100.0%	100.0%

Pearson Chi-Square = 37.854, df = 5, Asymp. Sig. (2-sided) = .000

A total of 91.4% (n =32) of the participants from MNCs said that they spent between 6 to 10 hours a week using online meetings or tele-conferencing for work, as compared to 8.6% (n=3) from SMEs. This was followed by 90.6% (n =48) from MNCs and 9.4% (n=5) from SMEs who spent between 1 to 5 hours a week. The observed significance level for the Pearson chi-square value of 37.85 was less than 0.0005, which shows that participants from MNCs and SMEs did not give the same responses to the question (independent). It is evident that participants from MNCs spent more hours using online meetings as compared to participants from SMEs.

Table 6-35 shows a cross-tabulation of two categories of manufacturing organizations and six categories of hours using a shared database or network information (χ^2 = 56.38, df =5, sig. =0.000).

Table 6-35 Cross-tabulation of manufacturing organization and shared database

			Type of manufacturing organization		
			MNCs	SMEs	Total
	Never	Count	3_a	16_b	19
		% within Hours using shared database or network information	15.8%	84.2%	100.0%
		% within Type of manufacturing organization	1.7%	23.2%	7.7%
	Less than 1 hour per week	Count	19_a	22_b	41
		% within Hours using shared database or network information	46.3%	53.7%	100.0%
		% within Type of manufacturing organization	10.7%	31.9%	16.7%
	1- 5 hours per week	Count	39_a	11_a	50
		% within Hours using shared database or network information	78.0%	22.0%	100.0%
		% within Type of manufacturing organization	22.0%	15.9%	20.3%
	6- 10 hours per week	Count	48_a	8_b	56
		% within Hours using shared database or network information	85.7%	14.3%	100.0%
		% within Type of manufacturing organization	27.1%	11.6%	22.8%
	11- 15 hours per week	Count	20_a	5_a	25
		% within Hours using shared database or network information	80.0%	20.0%	100.0%
		% within Type of manufacturing organization	11.3%	7.2%	10.2%
	More than 15 hours per week	Count	48_a	7_b	55
		% within Hours using shared database or network information	87.3%	12.7%	100.0%
		% within Type of manufacturing organization	27.1%	10.1%	22.4%
Total		Count	177	69	246
		% within Hours using shared database or network information	72.0%	28.0%	100.0%
		% within Type of manufacturing organization	100.0%	100.0%	100.0%

Pearson Chi-Square = 56.382, df = 5, Asymp. Sig. (2-sided) = .000

Surprisingly, a high percentage of participants from MNCs, at 87.3% (n =43), said that they spent more than 15 hours a week using a shared database or network information for work as compared to just 12.7% (n=7) of those from SMEs. Another 87.7% (n =48) from MNCs, as compared to 14.3% (n=8) from SMEs, spent between 6 to 10 hours a week. A high percentage of participants from SMEs, at 84.2% (n=16), said that they did not have access to a shared database or networked information. The observed significance level for the Pearson chi-square value of 56.38 was less than 0.0005, which shows that participants from MNCs and SMEs did not give the same responses to the question (independent). It is evident that participants from MNCs spent more hours using a shared database as compared to participants from SMEs.

Table 6-36 shows a cross-tabulation of two categories of manufacturing organizations and six categories of hours using online learning or e-learning (χ^2 = 91.33, df =5, sig. =0.000).

Table 6-36 Cross-tabulation of manufacturing organization and online learning

		Type of manufacturing organization		Total
		MNCs	SMEs	
Never	Count	4_a	34_b	38
	% within Hours using e-learning	10.5%	89.5%	100.0%
	% within Type of manufacturing organization	2.3%	49.3%	15.4%
Less than 10 hours per year	Count	60_a	21_a	81
	% within Hours using e-learning	74.1%	25.9%	100.0%
	% within Type of manufacturing organization	33.9%	30.4%	32.9%
11- 20 hours per year	Count	51_a	5_b	56
	% within Hours using e-learning	91.1%	8.9%	100.0%
	% within Type of manufacturing organization	28.8%	7.2%	22.8%
21-30 hours per year	Count	20_a	4_a	24
	% within Hours using e-learning	83.3%	16.7%	100.0%
	% within Type of manufacturing organization	11.3%	5.8%	9.8%
31-40 hours per year	Count	16_a	0_b	16
	% within Hours using e-learning	100.0%	.0%	100.0%
	% within Type of manufacturing organization	9.0%	.0%	6.5%
More than 40 hours per year	Count	26_a	5_a	31
	% within Hours using e-learning	83.9%	16.1%	100.0%
	% within Type of manufacturing organization	14.7%	7.2%	12.6%
Total	Count	177	69	246
	% within Hours using e-learning	72.0%	28.0%	100.0%
	% within Type of manufacturing organization	100.0%	100.0%	100.0%

Pearson Chi-Square = 91.328, df = 5, Asymp. Sig. (2-sided) = .000

The majority of those who had engaged in more than 40 hours per year in e-learning were from MNCs at 83.9% (n =26). Participants from SMEs, at 89.5% (n=34) and MNCs, at 10.5% (n=4) said that they had never engaged in any form of online learning or e-learning. The observed significance level for the Pearson chi-square value of 91.33 was less than 0.0005, which shows that participants from MNCs and SMEs did not give the same responses to the question (independent). It is evident that participants from MNCs spent more hours using online learning as compared to participants from SMEs.

6.11 Multivariate Statistics

Although the bivariate statistics in Section 6.10 show evidence of correlation between CNL and different groups, they provide limited information and an oversimplified view of an actual multivariate reality. Multiple factors influence manufacturing employees' decisions and perceptions in using CNL. In such a case, multivariate procedures are best used to demonstrate the degree of correlations between three or more variables and to examine the strength of the relationships between those variables (Bryman et al., 2005) in making a prediction of the dependent variable (Bryman & Cramer, 2005). This study identified a set of independent variables (e.g. organizational support, promotive interaction, positive interdependence, internal-external learning, perceived effectiveness, and perceived usefulness) with estimated likely scores in predicting the scores of CNL. However, it is important that the level of measurement is more than ordinal (Hair et al., 2006), observations are independent, and the dependent variable is normally distributed and has the same variability at each of the independent variables in a linear relationship (Green et al., 2000; Hair et al., 2006; Pallant, 2001). This is achieved by the composition of multiple linear regression equation 6-2:

$$Y = a + b_1x_1 + b_2x_2 + \ldots + b_nx_n \qquad \text{…..equation 6.2}$$

where Y is the outcome score for the variable, b_1, b_2, b_n are the regression coefficients of the predictors x_1, x_2, x_n and intercept a is the regression constant. The independent variables were entered into the regression in a specified order as a means of determining their individual and joint contributions to the dependent variable CNL, predicted from a combination of variables multiplied by their respective coefficients and a residual term. The multiple regression analysis procedure is used to create the predictive power of the antecedents against CNL that include multiple predictor variables (Pallant, 2001). It enables a study to identify a set of predictors, so that other research can focus on its use in future studies.

All predictors were entered into the model using the “enter” method to identify “which predictors contributed substantially to the model’s ability to predict the outcome” (Field, 2005, p. 184). R measured the correlation between the observed value and the predicted value of the dependent variable CNL and all of the independent variables. The coefficient of determination (R^2) measured the amount of variability in the dataset in the context of statistical models for the purpose of predicting the future outcome. The adjusted R^2 value took into consideration the variation in the dependent variable CNL that can be explained by the combined effect of the independent variables (Nardi, 2006). The adjusted R^2 provided a useful measure of the accuracy of the models H1, H2, H3, H4 and H5 in section 6.11.7. The high value of adjusted R^2 means that the variable is a good predictor of the dependent variable (Nardi, 2006; Field, 2005).

Dublin-Watson statistics inform a study whether the assumption of independent errors is tenable and conservatively suggests that a value less than 1 and greater than 3 should be avoided (Field, 2005). In all the cases (Tables 6-36, 6-38, 6-40, 6-42, 6-44 and 6-46) the results registered between 1.31 and 2.02 ($1 < x < 3$) which clearly showed that the assumption of independent errors had been met.

The analysis of variance (ANOVA) is used to test whether the differences between categories are larger or smaller than those other categories. The categories should be mutually exclusive (Nardi, 2006). If the between groups variation is the same as the within groups variation, then the F value will be 1 and there is no influence of the independent variables on the dependent variable. In all the cases (Table 6-37, 6-39, 6-41, 6-43, 6-45 and 6-47) the results registered between 67.22 and 363.10 (> 1) with $p < 0.05$ which suggests that there was a statistical significance in the effect the independent variables had on the dependent variable (Nardi, 2006).

Collinearity diagnostics provide information about multicollinearity. The tolerance statistic is derived from 1 minus R^2 for each independent variable. Tolerance directly measures the amount of variability of the selected independent variable not explained by other independent variables (Hair et al., 2006). A tolerance value close to 1 indicates that the independent variable has little of its variability explained by other independent variables. When tolerance is low (close to 0), it indicates that the variable is almost a linear combination of other independent variable (Norusis, 1999), or the multiple correlation is high and there is a possibility of multicollinearity (Bryman et al., 2005). “As multicollinearity rises, the ability to define any variables effect is diminished” (Hair et al., 2006, p. 186.). Tolerance below 0.1 indicates a problem (Field, 2005; Norusis, 1999). The variance inflation factor (VIF) indicates whether a predictor has a strong linear relationship with the other predictors (Field, 2005). VIF for each independent variable is calculated as 1 divided by the tolerance level and it is useful to assess the impact of multicollinearity on the precision of the estimates from the regression equation (Bryman et al., 2005). If the largest VIF is greater than 10, then there is a cause for concern (Myers, 1990 as cited by Field, 2005).

6.11.1 Multiple Regression – Organizational Support

Table 6-37 demonstrates the fit of the model and provides the value of *R*, R^2 and the adjusted R^2. Table 6-38 shows the ANOVA in construct organizational support. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.85 and 3.54 (< 10), and there were no substantial correlations (R>0.9) between predictors.

Table 6-37 Model fit for organizational support

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.79	0.62	0.61	0.74	1.54
H2 Work using online system/network	0.74	0.54	0.54	0.81	1.46
H3 Share and exchange information	0.75	0.56	0.56	0.80	1.77
H4 Participate in online learning	0.60	0.36	0.35	1.09	1.35
H5 Participate in workgroup activities	0.67	0.46	0.45	0.87	1.58

Table 6-38 ANOVA for organizational support

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	212.56	3	70.85	130.96	0.00
	Residual	130.93	242	0.54		
	Total	343.48	245			
H2	Regression	191.29	3	63.76	96.29	0.00
	Residual	160.25	242	0.66		
	Total	351.53	245			
H3	Regression	195.18	3	65.06	103.01	0.00
	Residual	152.84	242	0.63		
	Total	348.02	245			
H4	Regression	160.30	2	80.15	67.22	0.00
	Residual	289.73	243	1.19		
	Total	450.02	245			
H5	Regression	154.46	2	77.23	101.25	0.00
	Residual	185.36	243	0.763		
	Total	339.83	245			

In model H1, 62% of the observed variability in accessing online knowledge and information is explained by the 3 independent variables. The adjusted R^2 is 61% and the observed value of 0.79 indicates that the linear regression model predicts well.

In model H2, 54% of the observed variability in work using the online system/network is explained by the 3 independent variables. The adjusted R^2 is 54% and the observed value of 0.74 indicates that the linear regression model predicts moderately.

In model H3, 56% of the observed variability in sharing and exchanging information is explained by the 3 independent variables. The adjusted R^2 is 56% and the observed value of 0.75 indicates that the linear regression model predicts moderately.

In model H4, 36% of the observed variability in participating in e-learning is explained by the 2 independent variables. However, the adjusted R^2 is 35% and the observed value of 0.60 indicates that the linear regression model predicts poorly.

In model H5, 46% of the observed variability in participating in workgroup activities is explained by the 2 independent variables. The adjusted R^2 is 45% and the observed value of 0.67 indicates that the linear regression model predicts moderately.

6.11.2 Multiple Regression – Promotive Interactions

Table 6-39 demonstrates the fit of the model and provides the value of R, R^2 and the adjusted R^2. Table 6-40 shows the ANOVA in construct promotive interaction. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.00 and 3.69 (< 10), and there were no substantial correlations (R>0.9) between predictors.

Table 6-39 Model fit for promotive interactions

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.74	0.55	0.55	0.80	1.64
H2 Work using online system/network	0.75	0.56	0.56	0.80	1.89
H3 Share and exchange information	0.75	0.56	0.56	0.80	1.73
H4 Participate in online learning	0.61	0.37	0.36	1.08	1.31
H5 Participate in workgroup activities	0.71	0.51	0.50	0.83	1.65

Table 6-40 ANOVA for promotive interactions

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	188.85	1	188.85	298.00	0.00
	Residual	154.63	244	0.63		
	Total	343.48	245			
H2	Regression	197.20	2	98.60	155.25	0.00
	Residual	154.33	243	0.64		
	Total	351.53	245			
H3	Regression	193.62	1	193.62	305.97	0.00
	Residual	154.40	244	0.63		
	Total	348.02	245			
H4	Regression	164.98	1	164.98	141.22	0.00
	Residual	285.04	244	1.17		
	Total	450.02	245			
H5	Regression	171.44	2	85.72	123.71	0.00
	Residual	168.38	243	0.69		
	Total	339.83	245			

In model H1, 55% of the observed variability in accessing online knowledge and information is explained by the 1 independent variable. The adjusted R^2 is 55% and the observed value of 0.74 indicates that the linear regression model predicts moderately.

In model H2, 56% of the observed variability in work using the online system/network is explained by the 2 independent variables. The adjusted R^2 is 56% and the observed value of 0.7 indicates that the linear regression model predicts moderately.

In model H3, 56% of the observed variability in sharing and exchanging information is explained by the 1 independent variable. The adjusted R^2 is 56% and the observed value of 0.75 indicates that the linear regression model predicts moderately.

In model H4, 37% of the observed variability in participating in e-learning is explained by the 1 independent variable. However, the adjusted R^2 is 36% and the observed value of 0.61 indicates that the linear regression model predicts poorly.

In model H5, 51% of the observed variability in participating in workgroup activities is explained by the 2 independent variables. The adjusted R^2 is 50% and the observed value of 0.71 indicates that the linear regression model predicts moderately.

6.11.3 Multiple Regression – Positive Interdependence

Table 6-41 demonstrates the fit of the model and provides the value of *R*, R^2 and the adjusted R^2. Table 6-42 shows the ANOVA in construct positive interdependence. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.67 and 3.69 (< 10), and there were no substantial correlations (R>0.9) between predictors.

Table 6-41 Model fit for positive interdependence

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.82	0.67	0.66	0.69	1.80
H2 Work using online system/network	0.81	0.66	0.66	0.70	1.81
H3 Share and exchange information	0.83	0.69	0.68	0.67	2.02
H4 Participate in online learning	0.68	0.46	0.46	1.00	1.44
H5 Participate in workgroup activities	0.72	0.52	0.51	0.82	1.68

Table 6-42 ANOVA for positive interdependence

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	229.24	4	57.31	120.89	0.00
	Residual	114.25	241	0.47		
	Total	343.48	245			
H2	Regression	231.65	3	77.22	155.87	0.00
	Residual	119.88	242	0.50		
	Total	351.53	245			
H3	Regression	238.33	3	79.45	175.28	0.00
	Residual	109.69	242	0.45		
	Total	348.02	245			
H4	Regression	207.25	2	103.63	103.73	0.00
	Residual	242.77	243	1.00		
	Total	450.02	245			
H5	Regression	176.13	2	88.07	130.73	0.00
	Residual	163.69	243	0.67		
	Total	339.83	245			

In model H1, 67% of the observed variability in accessing online knowledge and information is explained by the 4 independent variables. The adjusted R^2 is 66% and the observed value of 0.82 indicates that the linear regression model predicts well.

In model H2, 66% of the observed variability in work using the online system/network is explained by the 3 independent variables. The adjusted R^2 is 66% and the observed value of 0.81 indicates that the linear regression model predicts moderately.

In model H3, 69% of the observed variability in sharing and exchanging information is explained by the 3 independent variables. The adjusted R^2 is 68% and the observed value of 0.83 indicates that the linear regression model predicts well.

In model H4, 46% of the observed variability in participating in e-learning is explained by the 2 independent variables. The adjusted R^2 is 46% and the observed value of 0.58 indicates that the linear regression model predicts moderately.

In model H5, 52% of the observed variability in participating in workgroup activities is explained by the 2 independent variables. The adjusted R^2 is 51% and the observed value of 0.72 indicates that the linear regression model predicts moderately.

6.11.4 Multiple Regression – Internal-External Learning

Table 6-43 demonstrates the fit of the model and provides the value of R, R^2 and the adjusted R^2. Table 6-44 shows the ANOVA in construct internal-external learning. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.36 and 3.63 (< 10) and there were no substantial correlations (R>0.9) between predictors.

Table 6-43 Model fit for internal-external learning

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.82	0.67	0.66	0.69	1.80
H2 Work using online system/network	0.76	0.57	0.57	0.79	1.72
H3 Share and exchange information	0.80	0.63	0.63	0.73	1.94
H4 Participate in online learning	0.63	0.40	0.40	1.05	1.34
H5 Participate in workgroup activities	0.68	0.47	0.46	0.86	1.73

Table 6-44 ANOVA for internal-external learning

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	228.61	3	76.20	160.54	0.00
	Residual	114.87	242	0.48		
	Total	343.48	245			
H2	Regression	200.83	3	66.94	107.50	0.00
	Residual	150.70	242	0.623		
	Total	351.53	245			
H3	Regression	220.28	3	73.43	139.11	0.00
	Residual	127.74	242	0.53		
	Total	348.02	245			
H4	Regression	180.30	2	90.15	81.22	0.00
	Residual	269.73	243	1.11		
	Total	450.02	245			
H5	Regression	158.49	2	79.25	106.20	0.00
	Residual	181.33	243	0.75		
	Total	339.83	245			

In model H1, 67% of the observed variability in accessing online knowledge and information is explained by the 3 independent variables. The adjusted R^2 is 66% and the observed value of 0.82 indicates that the linear regression model predicts well.

In model H2, 57% of the observed variability in work using the online system/network is explained by the 3 independent variables. The adjusted R^2 is 57% and the observed value of 0.76 indicates that the linear regression model predicts moderately.

In model H3, 63% of the observed variability in sharing and exchanging information is explained by the 3 independent variables. The adjusted R^2 is 63% and the observed value of 0.80 indicates that the linear regression model predicts well.

In model H4, 40% of the observed variability in participating in e-learning is explained by the 2 independent variables. The adjusted R^2 is 40% and the observed value of 0.63 indicates that the linear regression model predicts moderately.

In model H5, 47% of the observed variability in participating in workgroup activities is explained by the 2 independent variables. The adjusted R^2 is 46% and the observed value of 0.68 indicates that the linear regression model predicts moderately.

6.11.5 Multiple Regression – Perceived Effectiveness

Table 6-45 demonstrates the fit of the model and provides the value of *R*, R^2 and the adjusted R^2. Table 6-46 shows the ANOVA in construct perceived effectiveness. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.00 and 3.59 (< 10), and there were no substantial correlations (R>0.9) between predictors.

Table 6-45 Model fit for perceived effectiveness

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.86	0.74	0.74	0.61	1.85
H2 Work using online system/network	0.77	0.60	0.60	0.76	1.78
H3 Share and exchange information	0.83	0.69	0.68	0.67	2.01
H4 Participate in online learning	0.65	0.42	0.41	1.04	1.37
H5 Participate in workgroup activities	0.69	0.48	0.48	0.85	1.57

Table 6-46 ANOVA for perceived effectiveness

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	253.53	3	84.51	227.35	0.00
	Residual	89.95	242	0.37		
	Total	343.48	245			
H2	Regression	210.25	1	210.25	363.10	0.00
	Residual	141.28	244	0.58		
	Total	351.53	245			
H3	Regression	238.93	2	119.47	266.13	0.00
	Residual	109.09	243	0.45		
	Total	348.02	245			
H4	Regression	188.15	2	94.08	87.30	0.00
	Residual	261.87	243	1.08		
	Total	450.02	245			
H5	Regression	163.16	1	163.16	225.36	0.00
	Residual	176.66	244	0.72		
	Total	339.83	245			

In model H1, 74% of the observed variability in accessing online knowledge and information is explained by the 3 independent variables. The adjusted R^2 is 74% and the observed value of 0.86 indicates that the linear regression model predicts well.

In model H2, 60% of the observed variability in work using the online system/network is explained by the 1 independent variable. The adjusted R^2 is 60% and the observed value of 0.77 indicates that the linear regression model predicts well.

In model H3, 69% of the observed variability in sharing and exchanging information is explained by the 2 independent variables. The adjusted R^2 is 68% and the observed value of 0.83 indicates that the linear regression model predicts well.

In model H4, 42% of the observed variability in participating in e-learning is explained by the 2 independent variables. The adjusted R^2 is 41% and the observed value of 0.65 indicates that the linear regression model predicts moderately.

In model H5, 48% of the observed variability in participating in workgroup activities is explained by the 1 independent variable. The adjusted R^2 is 48% and the observed value of 0.69 indicates that the linear regression model predicts moderately.

6.11.6 Multiple Regression – Perceived Usefulness

Table 6-47 demonstrate the fit of the model and provides the value of R, R^2 and the adjusted R^2. Table 6-48 shows the ANOVA in construct perceived usefulness. There was no problem with multicollinearity as the tolerance level was > 0.1, the VIF result (see Appendix I) was between 1.75 and 6.39 (< 10) and there was no substantial correlations (R>0.9) between predictors.

Table 6-47 Model fit for perceived usefulness

Model	R	R Square	Adjusted R Square	S.E. of the Estimate	Durbin-Watson
H1 Online knowledge and information	0.83	0.68	0.68	0.67	1.82
H2 Work using online system/network	0.77	0.59	0.59	0.77	1.94
H3 Share and exchange information	0.80	0.64	0.64	0.72	1.97
H4 Participate in online learning	0.64	0.40	0.40	1.05	1.42
H5 Participate in workgroup activities	0.71	0.51	0.50	0.83	1.71

Table 6-48 ANOVA for perceived usefulness

Model		Sum of Squares	df	Mean Square	F	Sig.
H1	Regression	234.62	4	58.66	129.85	0.00
	Residual	108.87	241	0.45		
	Total	343.48	245			
H2	Regression	207.05	2	103.53	174.12	0.00
	Residual	144.48	243	0.60		
	Total	351.53	245			
H3	Regression	222.60	2	111.30	215.64	0.00
	Residual	125.42	243	0.52		
	Total	348.02	245			
H4	Regression	181.94	2	90.97	82.46	0.00
	Residual	268.08	243	1.10		
	Total	450.02	245			
H5	Regression	173.28	3	57.76	83.93	0.00
	Residual	166.54	242	0.69		
	Total	339.83	245			

In model H1, 68% of the observed variability in accessing online knowledge and information is explained by the 4 independent variables. The adjusted R^2 is 68% and the observed value of 0.83 indicates that the linear regression model predicts well.

In model H2, 59% of the observed variability in work using the online system/network is explained by the 2 independent variables. The adjusted R^2 is 59% and the observed value of 0.77 indicates that the linear regression model predicts moderately.

In model H3, 64% of the observed variability in sharing and exchanging information is explained by the 2 independent variables. The adjusted R^2 is 64% and the observed value of 0.80 indicates that the linear regression model predicts well.

In model H4, 40% of the observed variability in participating in e-learning is explained by the 2 independent variables. The adjusted R^2 is 40% and the observed value of 0.64 indicates that the linear regression model predicts moderately.

In model H5, 51% of the observed variability in participating in workgroup activities is explained by the 3 independent variables. The adjusted R^2 is 50% and the observed value of 0.71 indicates that the linear regression model predicts well.

6.11.7 Regression Models

All the predictors were entered into the regression to determine which predictors contributed significantly to the CNL model (results shown in Appendix I). All predictors that had low significance ($p>0.05$) were identified for removal. This study adopts Field's (2005) recommendation to rerun the analysis to include only the important predictors and use the resulting parameter estimates to define the regression model. The result is shown in Appendix J and was used to build the models H1-H5 in Figures 6-16, 6-17, 6-18, 6-19 and 6-20. The results of the estimates were also discussed in the previous sections from 6.11.1 to 6.11.6.

Path analysis technique entails the use of a causal model and examines the pattern of relationships between variables as an extension of multiple regression procedures

(Bryman et al., 2005). The purpose is to provide quantitative estimates of the causal relationships between a set of variables. In this study the pivotal role of the regression model illustrates the significance of the constructs that constitute the antecedents of CNL (as shown in Figures 6-16, 6-17, 6-18, 6-19 and 6-20). The beta (β) value measures how strongly each predictor (independent) variable influences the criterion (dependent) variable. The β value is measured in units of standard deviation. If the absolute value of β is high, the more important the variable is in predicting the outcome. The higher the β value the greater the impact of the predictor variable on the criterion variable. Only predictors with high significance were maintained in the models after stage two of the analysis (see Appendix K) and were completed as recommended by Field (2005). Interestingly, all the independent variables were positively correlated with the dependent variable CNL.

Figure 6-16 shows the regression model for H1 "Access information online".

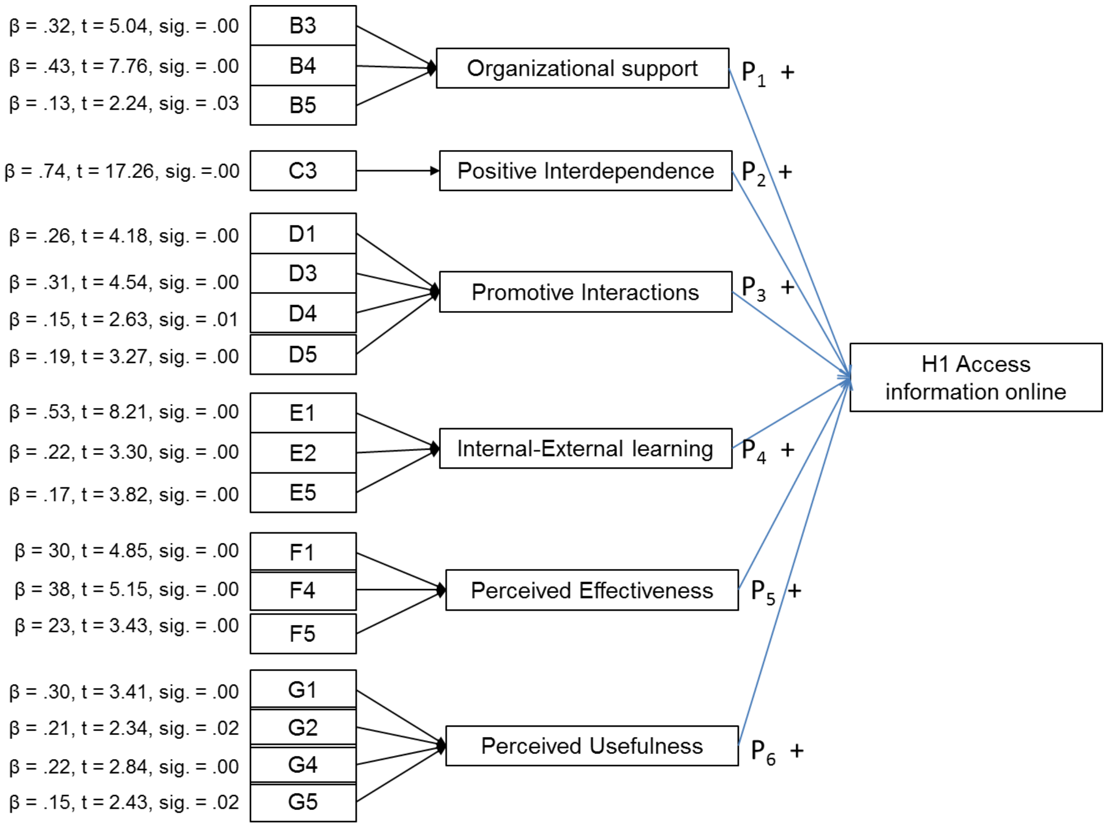


Figure 6-15 Regression model H1 – Access information online

The independents variables and constructs were identified and they strongly supported dependent variable CNL for model H1. Predictors B2 (sig. =7.95), C1 (sig.=1.65, C4 (sig. =0.18), C5 (sig. =0.82), D2 (sig. =0.11), E3 (sig. =0.16), F2 (sig. =0.05), F3 (sig. =0.17), and G3 (sig. =0.74) were removed because of low significance (p> 0.05). Independent variable C3 "Job requires to share ideas, work and information" (β = 74%, t= 17.26, sig = 0.01) was the strongest predictor for H1 "Access information online".

Figure 6-17 shows the regression model for H2 "Work using the online system or network".

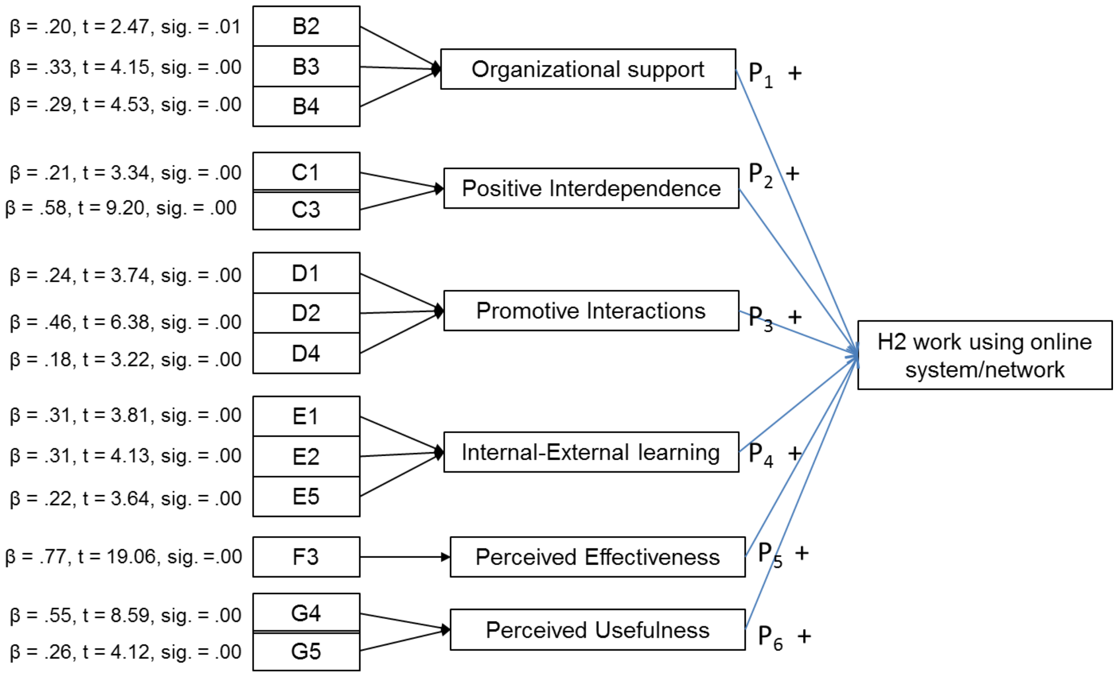


Figure 6-16 Regression model H2 – Work using online system/network

The independents variables and constructs were identified and they moderately supported CNL for model H2. Predictors B5 (sig. =0.05), C4 (sig.=0.13), C5 (sig. =0.38), D3 (sig. =0.24), D5 (sig. =0.05), E3 (sig. =0.17), F1 (sig. =0.33), F2 (sig. =0.22), F4 (sig. =0.25), F5 (sig. =0.06), G1 (sig. = 0.17), G2 (sig =0.05), and G3 (sig. =0.09) were removed because of low significance (p > 0.05). Independent variable F3 "Use of computer to share information" (β = 77%, t= 19.06, sig = 0.01) was the strongest predictor for H2 "Work using online system or network".

Figure 6-18 shows the regression model for H3 “Sharing and exchanging online information”.

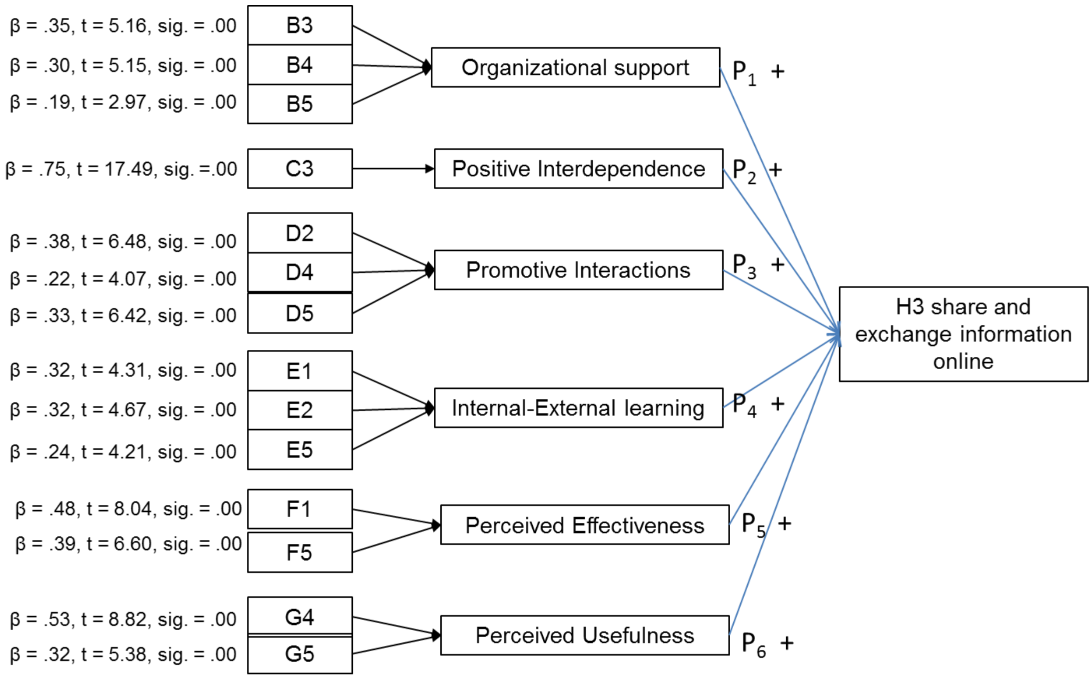


Figure 6-17 Regression model H3 – Share and exchange online information

The independent variables and constructs were identified and they strongly supported CNL model H3. Predictors B2 (sig. =0.79), C1 (sig.=0.19), C4 (sig. =0.37), C5 (sig. = 0.12), D1 (sig. =0.21), D3 (sig. =0.51), E3 (sig. =0.09), F2 (sig. =0.42), F3 (sig. =0.28), F4 (sig. =0.26), G1 (sig. = 0.16), G2 (sig =0.09), and G3 (sig. =0.66) were removed because of low significance ($p > 0.05$). Again, the independent variable C3 “Job requires to share ideas, work and information” (β = 75%, t= 17.49, sig = 0.01) was the strongest predictor for H3 “Share and exchange information online”.

Figure 6-19 shows the regression model for H4 “Participate in online learning”.

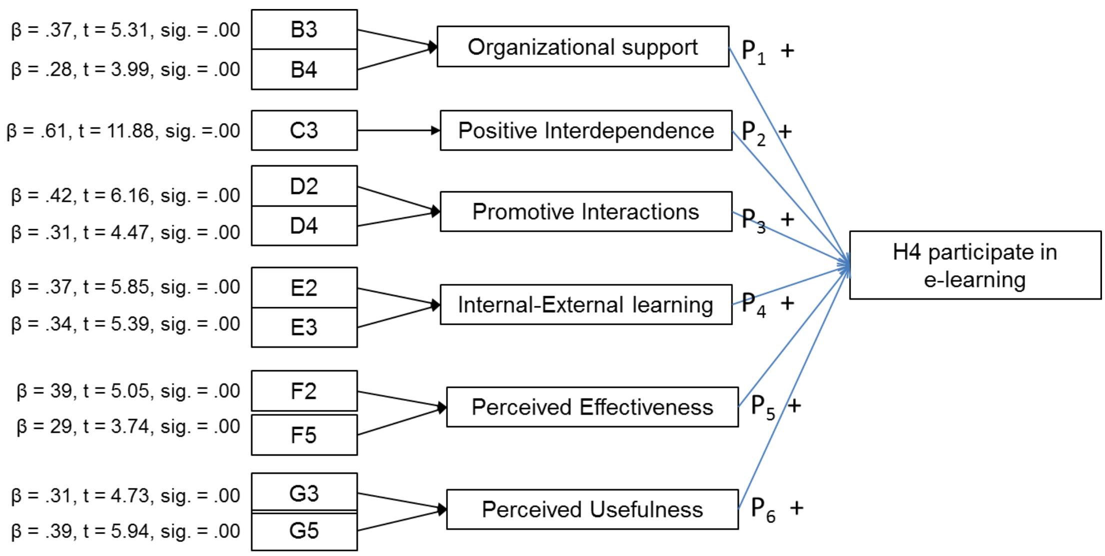


Figure 6-18 Regression model H4 – Participate in online learning

The independent variables and constructs were identified and they moderately supported CNL model H4. Predictors B2 (sig. =0.97), C1 (sig.=0.78), C4 (sig. =0.21), C5 (sig. = 0.16), D1 (sig. =0.35), D3 (sig. =0.64), D5 (sig. = 0.51), E1 (sig. =0.06), E5 (sig. =0.53), F1 (sig. =0.19), F3 (sig. =0.77), F4 (sig. =0.46), G1 (sig. = 0.93), G2 (sig =0.38), and G4 (sig. =0.24) were removed because of low significance ($p > 0.05$). Again, independent variable C3 “Job requires to share ideas, work and information” (β = 61%, t= 11.88, sig = 0.01) was the strongest predictor for H4 “Participate in online learning”. However, the construct ‘organization support’ with adjusted R^2=35% and the observed value of 0.60, and ‘promotive interactions’ with adjusted R^2=36% and the observed value of 0.61 indicated that both constructs would predict poorly for online learning participation.

Figure 6-20 shows the regression model for H5 “Participate in workgroup activities”.

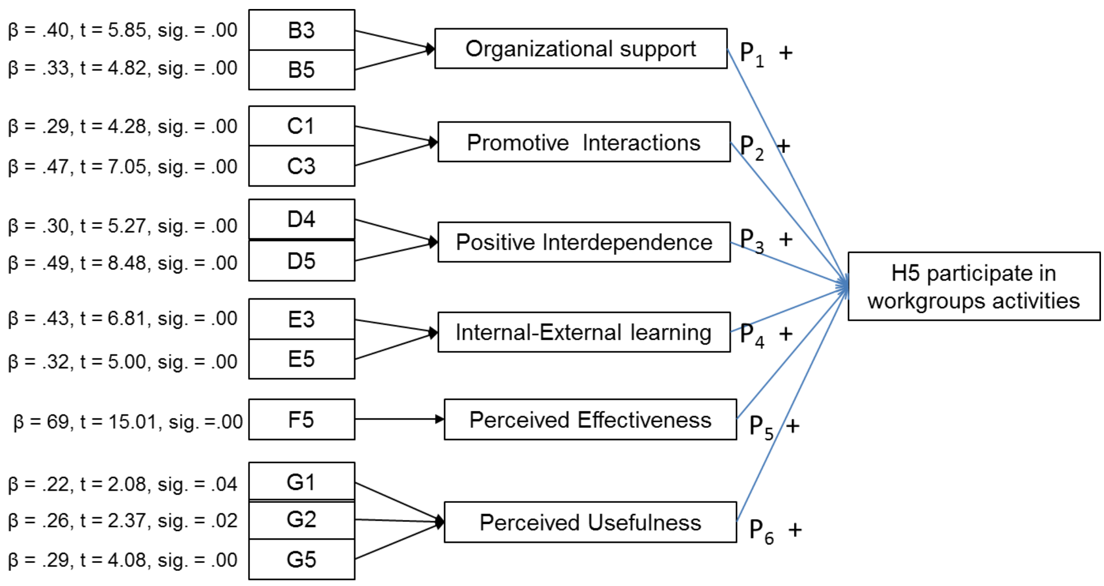


Figure 6-19 Regression model H5 - Participate in workgroup activities

The independent variables and constructs were identified and they moderately supported CNL model H5. Predictors B2 (sig. =0.11), B4 (sig.=0.06), C4 (sig. =0.14), C5 (sig. = 0.32), D1 (sig. =0.45), D2 (sig. =0.30), D3 (sig. = 0.76), E1 (sig. =0.12), E2 (sig. =0.05), F1 (sig. =0.72), F2 (sig. =0.69), F3 (sig. =0.14), F4 (sig. =0.36), G3 (sig. = 0.51), and G4 (sig =0.48) were removed because of low significance ($p > 0.05$). Independent variable F5 “Team produces quality collaborative work” (β = 69%, t= 15.01, sig = 0.01) was the strongest predictor for H5 “Participate in workgroup activities”.

6.12 Summary

Descriptive statistics have clearly outlined the means between all variables and differentiated those that were highly significant. The cross-tabulated results indicated differences in engagement of CNL between MNCs and SMEs. Multiple regression examined the relationships between all the independent variables with CNL. The regression models shown in H1, H2, H3, H4 and H5 were used to construct a profile of predictors (or antecedents) with high significance in relation to CNL. Results of the statistical analysis are discussed in Chapter 8.

CHAPTER 7: QUALITATIVE DATA ANALYSIS AND RESULTS

7.1 Introduction

This chapter presents findings from the semi-structured interviews and from the analytical process of codification and interpretation of the qualitative data. The qualitative data provided a rich source of information and insights into the participants' experiences, thoughts, perceptions and opinions (Cameron et al., 2009). The analysis of interview transcripts used in the content analysis sought to "quantify content in terms of predetermined categories and in a systematic and replicable manner" (Bryman, 2008, p.275). (Also see Cameron et al., 2009; Nardi, 2006). Similarly, de Laat et al. (2006b) found that content analysis is the most commonly used method for studying networked learning. Content analysis forms part of the quantitative-dominant mixed analyses [QUAN → qual], which believes the inclusion of qualitative data and approaches are likely to enhance the findings (Onwuegbuzie et al., 2009).

Textual qualitative data was used to corroborate findings from the quantitative data. Following Lally and De Laat's (2002) recommendation that NVivo should be used for coding and interpretation of CNL events and situations, NVivo was used for this study. NVivo software provided the workspace for handling qualitative data, such as organizing, sorting, classifying, searching and reporting. It provided a holistic view of the study and a systematic approach to qualitative data organization and structuration. The data was coded into themes that captured the overarching concept in textual data and also the underlying factors that supported the research questions and propositions.

7.2 Restatement of the Research Questions

This study assumed that semi-structured interviews would provide reasonably sound explanations and clarity to the phenomena and would answer the research questions. Additionally, to achieve the purpose of the study, the following research questions were addressed in the quantitative data analysis:

RQ1. What are the significant antecedents for a CNL model in manufacturing?
RQ2. How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning?
RQ3. What are employees' perceptions of CNL's usefulness and effectiveness in manufacturing?
RQ4. What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?

7.3 Data Collection for Semi-Structured Interviews

Following the questionnaire surveys, semi-structured interviews were conducted with 11 participants randomly selected from various manufacturing organizations. The participants were general managers (2), department managers (2), domain experts (5), project leaders (1), and an assembly worker (1). Individual interviews were conducted at various locations. According to Blaikie (2010) a semi-structured interview allows for "interaction and provide greater insights into why certain opinions are held" (p.297). The semi-structured interviews were designed to gather information that built on the results from the analysis of the quantitative data and to strengthen the propositions with descriptions of the phenomena.

The interview process was intentionally semi-structured, so that the researcher would remain focused as to the objectives of the research and at the same time exercise flexibility to explore further, drawing on answers to the questions. Hence, the actual questions posed in the interviews did not necessarily match the proposed questions word for word. In most cases, open-ended questions were asked. Asking open-ended questions is a good way of finding out what participants think (Nardi, 2006). A conversational style of interviewing was chosen rather than a descriptive question-answer session to enable participants' free-flow of information with clear examples from past experiences.

With each participant's agreement, interviews were digitally audio recorded. The study sought to investigate any issues of interest that emerged from the quantitative analysis. This approach was designed to improve the validity of the analysis. The questions had been pilot-tested in an informal interview with three participants in order to ensure clarity and understanding. Thereafter, the questions were simplified to remove ambiguities.

7.4 Data Entry and Coding

According to Onwuegbuzie (2009), having a post-positivist orientation does not prevent a pragmatist researcher from conducting qualitative analyses using content analysis that involves the counting of words, codes, categories, or other aspects of the qualitative data. Before codification, the transcriptions were checked against the voice recording for accuracy and consistency. In order to gauge the general sense of the data, including conversations with the participants in which they related their experience, impressions and perceptions of CNL, marginal notations were made. The field notes contained accounts of the interviews and were entered into NVivo.

Data coding was used to find themes and recurring patterns in the data for interpretation and theoretical analysis. The central purpose of coding is to extract, generalise and abstract from the complexity of the original data in order to find significant themes and develop theories about the situation that illuminate it (Lally et al., 2002). The technique follows the procedure set by Coffey and Atkinson (1996), who recommend the generation of codes, frequent revisions of the coding, grouping of the codes, development of categories and finally the development of themes from the data. Relationships between specific contexts of CNL's antecedents were identified and expressed in codes. The transcripts in NVivo were coded into nodes and then trees, and verified by an independent academician. Nodes were assigned to the transcripts based upon semantic features, such as key concepts, expression of ideas, chain of argument, and topics of discussions using the smallest unit, known as the unit of meaning (Chi, 1997). The categories were organized under a hierarchical structure as shown in Appendix K.

Using a hierarchical structure was a useful way to illustrate relationships between the nodes and the antecedents of CNL. Nodes organized the concepts in reference to both the context of CNL and to the literature as a basis for the theoretical understanding of the phenomena under study. The nodes were analysed and coded into categories and sub-categories, included predetermined themes. The study employed ethnographic content analysis in reference to the approach that emphasizes the role of the researcher in the construction of meaning. This allowed categories to emerge out of the data and enabled understanding of the meaning in the context (Bryman, 2008). As suggested by Bogdan and Biklen (2003), the study recoded and refined the data into themes and re-contextualised the data into key ideas. Analysis was directed by the constant comparative method. The activity continued until "theoretical sufficiency" was achieved, which led to theoretical generalizations (Diaz Andrade, 2009). As pointed out by Diaz Andrade (2009) "theoretical sufficiency" (termed by Dey, 1999, p. 117) allows the researcher "to build up and work upon constructs which emerge from the problem under investigation" (p. 48).

7.5 Profile of Participants

This study followed the recommendation of Miles and Huberman (1994) in that it achieved maximum variation in purposeful sampling by selecting 15 participants from various manufacturing organizations across different functions (see Table 7-49). WS_20001 was used for recording general information (memo) about the research.

Table 7-49 Demographic profile semi-structured interview (n=11)

Participants	Age	Gender	Education	Organization	Department
WS_20002	20-29	Female	Degree	SME	Quality
WS_20003	30-39	Male	Masters	MNC	Production
WS_20004	40-49	Male	Degree	MNC	Quality
WS_20005	40-49	Male	Degree	SME	Engineering
WS_20006	30-39	Male	Degree	MNC	Operations
WS_20007	30-39	Male	Degree	MNC	Operations
WS_20008	40-49	Male	STPM	SME	Management
WS_20009	30-39	Male	Masters	MNC	Engineering
WS_20010	40-49	Male	Degree	SME	Management
WS_20011	20-29	Female	Diploma	MNC	Technical
WS_20012	30-39	Female	SPM	MNC	Production

Eleven participants responded (response rate of 73%). All the participants were from diverse manufacturing industries: 7 were from MNCs and 4 were from SMEs. Together, they represented 8 different manufacturing organizations. All the participants were given information about the research (see Appendix B).

7.6 Data Validity

Concurrent validity was assessed following semi-structured interviews with participants in connection with their experiences in working and using CNL in their respective manufacturing organizations. After transcribing the interviews, participants reviewed the report and did not dispute the factual account presented by the researcher (Diaz Andrade, 2009; Yin, 2003). Guba and Lincoln (1988) further propose four criteria for judging the soundness of qualitative research. The results of qualitative research must be **credible** from the perspective of the participant in the research. Interviews were digitally audio recorded, transcribed using NVivo and checked for accuracy against the original recording through repeated playbacks. The transcripts were also checked against the context in which the participants made references in their conversations. The completed transcriptions were sent to the interviewees for validation as a component of reliability (Creswell, 2009; Kvale & Brinkman, 2009), and credibility data trustworthiness (Keefer, 2010). **Transferability** is the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings. According to Hoepfl (1997) transferability refers to the degree to which the findings of an inquiry can be transferred or applicable to a new situation. Transferability is promoted through the use of detailed findings, sufficient to “provide the data base that makes transferability judgments possible on the part of potential appliers” (Lincoln et al., 1985, p. 316). This study thoroughly describes the research context, process of data collection and analysis that are central to the research**. Dependability** emphasizes the need to account for dynamic context within the nature of the research. Studies which are dependable exhibit the ability to adapt to changes in the research environment and the ability to add new inputs over time during research (Hamberg et al., 1994). **Confirmability** refers to the degree to which the results can be confirmed or corroborated by others. Confirmability focuses on the neutrality of the findings which are clearly extracted from the data, without influence of the researcher’s imagination (Brown et al., 2002). The interview data was coded to provide criteria for gauging the validity of the scales (Bryman, 2008).

7.7 Result of Content Analysis

The central purpose of content analysis was to generalize and extract from the complexity of interview messages evidenced in CNL activities. Content analysis reveals information and interaction patterns to be found below the surface of the transcripts (Schrire, 2006a). The study used content analysis to identify the relationship between specific contexts that are prevalent in CNL's antecedents.

7.7.1 Question Categories

Table 7-50 illustrates the question categories that guided the interview questions and led to obtaining the codes. Question categories were also designed to ensure the researcher stayed focused on the research questions (RQ) in section 7.2.

Table 7-50 Question categories

Interview Questions	Categories
Q1.Do you use any CNL system?	Collaborative networked learning; collaborative technologies
Q2. What is your purpose in using a CNL system and tool?	Promotive interaction; positive interdependence; internal-external learning
Q3. How extensive is the use of CNL in the organization?	Organizational support; promotive interaction; positive interdependence; internal-external learning; perceived effectiveness; perceived usefulness
Q4. What motivates or demotivates the company to implement CNL?	Organizational support
Q5.Could you share your experience in using any of the CNL systems and tools?	Organizational support; promotive interaction; positive interdependence; internal-external learning; perceived effectiveness; perceived usefulness
Q6. Why do you perceive that the present CNL system is effective or ineffective?	Organizational support; perceived effectiveness
Q7. Why do you perceive that the present CNL system is useful or otherwise?	Organizational support; perceived usefulness
Q8. How can the present CNL system be improved to make it more useful?	Organizational support; perceived usefulness
Q9. Why do you think CNL has or has not contributed towards helping you complete your daily tasks or project?	Promotive interaction; positive interdependence; internal-external; perceived effectiveness; perceived usefulness

The questions were designed to extract a wide array of information from the participants, without being limited to a single category of construct. For instance, question Q3 "how extensive is the use of CNL in your organization?" was designed as an open question which would enable participants to relate their experience in using any of the collaborative systems or tools for learning. The researcher then coded the contexts in relation to organizational support, promotive interaction, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness.

7.7.2 Hierarchical Coding Scheme

Veldhuis-Diermanse (2002) developed a coding schema for investigating group learning activities, while De Laat and Lally (2004) adapted the schema for their research on asynchronous networked learning. However, the schema is irrelevant in this study because it focuses on the outcome of learning and not the antecedents of CNL. Therefore, the study had to develop a new coding schema for CNL. Table 7-51 shows the hierarchical coding scheme that was developed, with consideration to the research questions in section 7.2.

Table 7-51 Hierarchical coding scheme

T: Organizational support (1646)					
C:Infrastructure and Systems (719)				**C:Functions and Capabilities (749)**	**C:People (160)**
C:Application system and collaborative technology (161)	**C:Enterprise system (283)**	**C:Global system (101)**	**C/nd.: Hardware (38)**		
nd.:Amorplus(7)	nd.:Work instruction(43)	nd.: Accardin(8)		nd.:Accessible(64)	nd.: IT and technical (57)
nd.:AutoCad(15)	nd.:Schematics(35)	nd.:eCATS(17)		nd.:Analysis(50)	
nd.:Chat room(8)	nd.:Doc con system(27)	nd.:MES(16)		nd.:Automatic(50)	
nd.:Email(25)	nd.:ECM(43)	nd.: MyTech(9)		nd.:Communication (23)	
nd.:E-Bulletin(8)	nd.:ERP or MRP(79)	nd.:PDM(33)		nd.:Feedback(33)	
nd.:Lotus(7)				nd.:Linkage(58)	
nd.:Netmeeting(8)				nd.:Monitoring(32)	nd.: Management (40)
nd.:Sharepoint(8)				nd.:Notification(42)	
nd.:Video-conf(8)				nd.:Online(50)	
nd.:Spreadsheet(30)				nd.:Real-time(25)	
nd.:Shared drive(19)				nd.:Recording(34)	
nd.:Shared folder(34)				nd.:Reporting(42)	
nd.:Others(14)				nd.:Revising(33)	nd.:Peers (23)
				nd.:Archiving(43)	
				nd.:Synthesis(35)	
				nd.:Triggering(35)	
				nd.:Updating(52)	

T:Promotive Interaction (980)	
C:With system (612)	**C:With people (309)**
nd.:Checking (59)	nd.:Engaging (59)
nd.:Developing (40)	
nd.:Dispositioning (52)	
nd.:Evaluating (43)	nd.:Learning (52)
nd.:Extracting (52)	
nd.:Generating (59)	
nd.:Implementing (25)	nd.:Meeting (59)
nd.:Programming (17)	
nd.:Revising (27)	
nd.:Transacting (49)	nd.:Sharing (66)
nd.:Updating (66)	
nd.:Uploading (50)	

T:Positive Interdependence (480)			
C/nd.:Collaborating (50)	**C/nd.:Cooperating (43)**	**C:Exchanging (96)**	**C:Sharing (241)**
		nd.:Exporting (35)	nd.:Between department (66)
		nd.:Importing (0)	nd.:Between peer (59)
		nd.:Both (18)	nd.:Between sites (50)

T:Internal-External Learning (123)	
C/nd.: External learning (35)	**C/nd.: Internal learning (44)**

T:Perceived Effectiveness & Usefulness (373)			
C/nd.: Useful (77)	**C/nd.: Effective (65)**	**C/nd.: Relevant (65)**	**C/nd.: Ease of use (82)**

T: Themes; C: Categories; C/nd.: Categories & nodes; nd.: nodes

Queries were used to question the data and find patterns through the contexts and nodes. Text queries searched for words and phrases about CNL and other concepts that related to it. To ensure accuracy of the coding, the researcher avoided using auto-coding in NVivo. Instead, the researcher used his knowledge and experience to code the data. The result of content analysis is shown in Appendix K. The themes supported the research objectives, and the codes supported the themes.

Relevant themes from the data were extracted and arranged in a hierarchy and their precise meaning was documented (Glaser & Strauss, 1967). The main categories for the theme of organizational support were infrastructure and system (nd. =719), application system and collaborative technologies (nd. =161), enterprise systems (nd. =283), global systems (nd. =101), hardware (nd.=38), functions and capabilities (nd.=749) and people (nd.=160). The main categories for promotive interactions were system (nd.=612), and people (nd.=309). The main categories for positive interdependence were collaborating (nd.=50), cooperating (nd.=43), exchanging (nd.=96), and sharing (nd.=241). The main categories for internal-external learning were internal learning (nd.=44) and external learning (nd.=35). The main categories for perceived usefulness and effectiveness were useful (nd.=77), effective (nd.=65), relevant (nd.=65) and ease of use (nd.=82).

Organizational support (nd.=1646) emerged as a predominant theme, followed by promotive interactions (nd.=980), and positive interdependence (nd.=480). Perceived effectiveness and usefulness (nd.=373) were grouped as one because participants frequently related both into a single inference or context in their conversations. Internal-external learning (nd.=123) was the least frequent. Participants felt more comfortable in relating their experience and perception of CNL than expressing whether learning was internally or externally oriented. Out of 75 codes identified from the transcripts, the most frequently mentioned concepts were: ease of use (nd.=82), ERP/MRP (nd.=79), useful (nd.=77), updating (nd.=66), sharing (nd.=66), between departments (nd.=66), effective (nd.=65), relevant (nd.=65), and accessible (nd.=64).

7.7.3 Contributions from Individual Participants

Table 7-52 shows the number of nodes and references coded from the transcripts. The number of nodes and references were dependent upon participants' ability to provide breadth and depth of information in the context of CNL.

Table 7-52 Nodes and references to participants (n=11)

Participants	Organization	Department	Nodes (nd.)	References (ref.)
WS_20002	SME	Quality	3	27
WS_20003	MNC	Production	61	1225
WS_20004	MNC	Quality	76	1780
WS_20005	SME	Engineering	46	735
WS_20006	MNC	Operations	61	1136
WS_20007	MNC	Operations	53	981
WS_20008	SME	Management	32	457
WS_20009	MNC	Engineering	86	1704
WS_20010	SME	Management	31	420
WS_20011	MNC	Technical	75	1360
WS_20012	MNC	Production	5	20

Participant WS_20009, a MNC product engineer, was able to provide many insights (nd.=86, ref.=1704) into the use of collaborative technology and how the systems and tools are used in product development. Participant WS_20004, a MNC's quality manager, also was able to relate his experience (nd.=76, ref.=1780). However, participant WS_20012, also from a MNC organization, could not relate much about CNL (nd.=5, ref.=20) as she was not given access to a computer network for learning and sharing information, or even a computer network for other needs, due to her role as a production assembler. Similarly, participant WS_20002 (nd.=3, ref.=27), a quality officer from a SME organization, faced the same challenge of not being provided with support for CNL in her role. She could not relate knowledge or experience of CNL. Ironically, participant WS_20008 (nd.=32, ref.=457), a senior manager in a local SME, was able to share his understanding and knowledge of CNL, even though the implementation of CNL was not extensive in his organization and far from being mature.

7.8 Results of Textual Contexts

Semi-structured interviews allowed the researcher to plan retrospectively, recalling issues and gaps in the survey questionnaire that could further improve the reliability and validity of the study. The study followed the suggestion of Atkinson and Delamont (2008) that "the analysis of the spoken language remains firmly embedded in studies of organizational context, process of socialisation, routine of work, personal transformation, people processing, and so forth" (p.291). The interview questions in Table 7-50 were specifically designed to relate the responses to the operationalized objectives. Needless to say, participants were encourage to discuss issues openly and share their experience and understanding to include all other relevant details that may or may not have been part of the questions asked. The role of the ethnographic researcher is to lead the participants to provide rich information to the context of their experience (Atkinson & Delamont, 2008).

7.8.1 Organizational Support

Different organizations, regardless of size and type, offer different support for CNL. The question posed to the participants about their experiences in using communications and collaborative technology was necessary in order to differentiate between those who were using CNL systems and those who were not. In order to facilitate an environment for CNL, ideally each and every employee has to be provided with ease of access to a computer network and a wide variety of application-based services that include the Intranet and/or Internet. The study found that most manufacturing organizations used emails for communication and information sharing, Netmeeting (as described by participant WS_20009), bulletin boards or chat rooms and other forms of asynchronous and synchronous collaborative tools.

> *"Email is our number one tool, then the Internet communicator. For formal and informal communication is the email. For informal communication is the Internet communicator (for chatting). Those are the two most important communication tools." (WS_20009).*

It was also found that most participants from MNCs had some experience using some form of online learning, sharing information through chat rooms (e.g. Netmeeting), and downloading documents from shared folders or posting forum messages in bulletin boards seeking for problem resolution. Most production operators or assemblers from MNCs were given access to emails and/or shared folders.

Furthermore, this study found that MNCs support enterprise information systems (EIS), such as enterprise resource planning (ERP) which integrates manufacturing information plus critical-to-operations supply chain modules including finance/accounting; manufacturing and inventory management; customer relationship management (CRM); human resources management (HRM); and purchasing/procurement across the entire organization. This facilitates the flow of information between all business functions within the organization as well as establishing information connections with key external stakeholders such as customers, suppliers, subsidiaries and partners (Basu & Wright, 2005). IT applications of ERP/MRP and data communications allow agile manufacturing to achieve time reductions and quality improvement in product design and development (Cao & Dowlatshahi, 2005). The ERP/MRP proliferates information involving manufacturing resources in the organization's efforts to collaborate across organizations. Nonetheless, the ERP/MRP systems are widely used among large manufacturing organizations, and more so by MNCs than SMEs. Due to the complexity of the business environment, MNCs tend to complement the use of ERP/MRP with other application software such as a manufacturing electronics system (MES), product database management (PDM), as experienced by participant WS_20009, or eCATS (electronic Corrective Action Tracking System), as experienced by participant WS_20007. Unlike the ERP/MRP, dedicated application software such as MES, PDM and MyTech are often used within specific department(s) rather than enterprise-wide. In the case of participant WS_20009, PDM was being used extensively to perform daily tasks or projects.

> *"The ERP system is currently in place. Then we have the MES (Manufacturing Electronics System) to run production. In the future we will have the SAP[6] system. For Engineering we have a separate system called the PDM (Product Database Management) for managing engineering drawing. We used email everyday, everyhour and constantly." (WS_20009).*

Likewise, no single system caters for all uses. Most organizations run multiple systems simultaneously and a large amount of data is transmitted between systems from

[6] Founded in 1972, SAP is a highly integrated business system designed to support organizations and provide collaborative business solutions for all types of industries.

different platforms or operating systems. This requires strong organizational support, the provision of IT infrastructures, and software and hardware to facilitate and sustain the system's complexity and diversity. Thakkar, Kanda and Deshmukh (2011) in their case studies involving SMEs also found that high investment required for purchase and maintenance hinders SMEs from adopting ERP/MRP systems. They also found that the inventory management in SMEs is ad-hoc and is not supported by some well-proven strategies like the demand-pull system. Instead, most of these organizations use simple and cost effective application tools readily available in the market, such as Microsoft Excel for planning and scheduling (as described by participant WS_20010).

> *"At present, production is only using (Microsoft's) Excel printout for communication, work orders, etc. MRP is Excel and Excel is MRP." (WS_20010)*

Likewise, participant WS_20004 said that expensive software was not necessary for CNL. He felt that simple applications such as email and shared folders could serve the purpose of communicating, collaborating and sharing information, vital for operations with proper management and control.

> *"I think the best is email, then the shared folders and the data repository so that anybody can access to the folders and information. But only to those authorized and that is how we share".(WS_20004)*

The notion of expensive systems to promote CNL is problematical. It was found that most SMEs have neither the financial means nor the resources to implement elaborate systems. Suffice to say, most SMEs adapt and adopt CNL at a much smaller scale.

> *"Besides, we don't use Microsoft. Instead, we used Open Office applications, or open source software. Save a lot of money, but not too sure about the security." (WS_20005)*

> *"(About the R&D centre) We haven't decided. We don't know what to do. But they introduced some modelling software and it is very costly." (WS_20005).*

Like any system, information sharing and learning needs controls to handle different levels of authorization (WS_20005). Management will determine employees' accessibility to available ICT and CNL resources. Employees are authorized to access resources and information required for them to perform their work.

"We share information through the system. But not every information is accessible, depending on the types of information and the level of authorization. We got SAP as a primary means of information management. We have shared folders. We have Lotus Notes and its sub-programs." (WS_20005)

"We use share drive to share all our information. Secondly, we have the Mytech system, which we can use to obtain updated information, example, output, yield, etc.,...the WIP." (WS_20003)

A similar question of interest is to understand whether CNL is widely proliferated and useful to all employees regardless of their roles and positions in an organization. Ashton (2004) found that organizational support influences learning and access to learning with a differential impact on employees' position and status within an organization. The hierarchical structuring of relationships produces uneven learning opportunities and access to knowledge within the organization (Ashton, 2004; Billett, 2001). In this study, organizational knowledge and its resources were easily available to senior staff and engineers but limited for support and clerical staff. Participant WS_200012 explained that not all production operators in MNCs needed access to information in the network.

"Operator is different from... just does whatever we are told to do. Computer is more (relevant) for supervisors or line leaders. They need it more than us (production operators)" (WS_20012).

What is interesting is that participant WS_20012's statement above demonstrates that not all employees in MNCs have the privilege to use ICT or are provided with network access. Evidently, not all MNC organizations provide organizational support for all employees to access information in the network. Those who have access to the network use it for updating data into the system or obtaining online work instructions critical to perform their jobs.

This study found that SMEs recognize the importance of using better systems or tools for planning and scheduling. All the SME organizations that provided participant interviews had plans to deploy some form of ERP/MRP system in the long term. Participants WS_20010 optimistically declared:

"We are going to use an ERP system. Currently, we have started with work scheduling, work orders and sales orders modules. We have been using Company C's accounting system and it's in the pipeline to implement their ERP software. At present, we are not using any ERP system. Only software

available is for accounting and Sales. We are using EBS (Enterprise Business System)."(WS_20010)

Most SMEs face barriers and limitations in implementing a complete system. It is also interesting to note that the Accounts Department would normally be the first to implement new application software, specifically for accounting purposes. In the case of WS_20010, the Accounts Department had been using UBS for quite some time before deciding to expand the use across the company. Upon closer examination, cost was usually the main factor which hindered the implementation (WS_20008).

"We do use Microsoft Excel and some AutoCAD. Accounts uses a specific accounting software (UBS Accounting)[7]. Production Planning still using Excel sheets but we do have plan to use dedicated software but it is expensive. Actually, we have bought the software (UBS Inventory Management) but we have yet to use it." (WS_20008).

"It is competitive and price factor is the main driver because renowned software like Oracle is extremely expensive." (WS_20010)

On the other hand, it has to be asked if SMEs have the resources and support to implement CNL. It was found that most SMEs have limited IT resources or staff need to effectively plan, deploy and sustain a new system.

"We are already delayed this project (ERP implementation) for a year. We started a year ago and hired an IT manager, taking care of IT system. I cannot handle the project by myself and lose focus on production. ."(WS_20010)

It was found that training and support services play a vital role in ensuring CNL resources are being used effectively. Collaborative technology needs to be upgraded from time to time or evolved to meet business objectives as well as to ensure knowledge and information is effectively managed and widely disseminated across the organization.

What motivates or demotivates a company to implement CNL? This question is relevant to senior managers in the organization, who hold leadership positions and

[7] UBS is locally developed software with more than 135,000 SME users for accounting; inventory and billing; payroll and human resources; point of sales (POS), etc.

responsibilities for decision making in regard to investment in IT infrastructure. One senior manager in a SME organization (WS_20010) described how his company continued to evolve and upgrade its enterprise system.

> *"Actually this (software) company is still new, not really stable; currently they are upgrading the thing (software). Previously we used for accounting and their support and service has been good. When they came up with an ERP system, the company's Managing Director who is also close with the software company said we should engage their service." (WS_20010).*

The decision to deploy or upgrade any enterprise system solely relies upon the owner(s) or key shareholder(s) of the SMEs organization. The relationship with the software developer or vendor is based on trust and long-term partnership. Clearly price plays a pivotal role in the decision making process. MNCs on the other hand, rely on professional opinions and decisions made by managers, in particular from an IT background.

The senior manager in a SME (WS_20010) was optimistic about the prospect of engaging more knowledge workers to further improve business vitality. The participant expressed hope that the new technical staff would bring change to the company for future expansion.

> *"I wanted to hire Process Engineers. Currently we have the QC (quality control) team. I think it is time we should hire Process Engineers. Actually, I got about 7 to 8 production executives. We have regular production meeting to share information, and we are using email quite a lot."(WS_20010)*

The process engineers would seek opportunities for process improvements in the manufacturing operations, reducing wastages and improving efficiency. He expected the process engineers to engage actively in learning, collecting and analysing data, and collaborating within the organization as well as with the customers for further improvements.

Even post implementation presents itself as a challenge to most organizations. Many organizations use different systems for different purposes, the integration and exchange of data between these systems requiring extensive customization and programming. MNCs are constantly looking for opportunities to improve and to integrate. In the case of WS_20009, the organization had decided to implement SAP in order to integrate different types of data and information into an enterprise system.

"However, there is problem with contradictions of data. We have JD (Edwards) and also MES (Manufacturing Electronics System). These two systems function as manufacturing tool to drive materials but they do not inform finance the cost of materials. MES, which is manufacturing electronics system plays a bigger role from inventory right up to finances. Without either system the plant is at a standstill. That is why we are implementing SAP, which is one tool, one stop center, integrate all the dicrepancies or the gaps between the two systems. Right up from inventory, inputs, to the output of sales and finance. That is the long term plan for the company." (WS_20009).

It has been claimed that constant upgrading is not only costly; it affects the motivation and quality of work. Employees need to be trained and retrained whenever new systems are introduced into organizations. New systems deployment often requires meticulous planning, including large data migration and integration. More resource hours are needed for the initial stage of the deployment, which may take months to complete.

"We spend RM30million for that. A lot of improvements are expected, and suddenly we need to change. We need to do a lot of improvements. We need people to key-in the data. At the beginning, we need more people and after that they will get used to it. We try to reduce quite a number (of staffs) especially from the IT. There is an increased of workloads for the operators" (WS_20005)

"I thought the analysis part helps. Like pricing and costing; we can shorten a lot of time for costing, but the amount of transactions is killing us." (WS_20005)

System integration is ideal yet costly, particularly for SMEs. In the case of WS_20005, linking all the factories would help to support CNL through information sharing. Again, a massive project requires substantial financial investment and strong organizational support from the management.

"We want to make full use of the information like what we used in the Lotus, we can get it from the SAP system, but linking up could be costly… in the end it will benefit the company." (WS_20005).

"(About the cost of investment of RM30 million). The board of directors have approved. We will link-up all the other factories, about 11 or 12 factories around Malaysia." (WS_20005).

Organizational support is also evident in the case of participant WS_20004, whereby management ensured that all employees complied with the new standard and the changes were effectively communicated across the organization.

> *"One thing good about the company is that when they want to implement anything they will officialize it by documenting the procedures or instructions into the SOP (standard operating procedures). That's how they could sustain it (our improvements)."(WS_20004)*

Therefore, strong organizational support is critical for CNL implementation, not just to use ICT as a business tool but more importantly to use ICT as an enabler for employees to learn and share information.

7.8.2 Positive Interdependence

Most of the organizations use a CNL system to collaborate and exchange manufacturing information. In the case of WS_20011, the SAP system was being used for labour tracking which allowed the organization to track employees' time spent on assembling, testing and retesting products on the line.

> *"SAP like the usual, to labor on and labor off units, at retest, final test, and HASS. That's about all. Yes, it is part of the recording system because we need to have system of record in SAP (for all units). In future, if we got problem then we could check back our record to verify (the background of the test operations and history of the unit)." (WS_20011)*

It was noted that most shop floor employees resented the use of the labour tracking system because it was time consuming and often subject to human error – failing to "labour on" or "labour off" the resource hours. Obviously, it is highly task dependent. However, from a finance standpoint it provides essential data for product costing and impetus to improve shop floor labour efficiency. When a cost centre is created, a specific labour charge code for employees can be assigned. In addition, manufacturing organizations use this to report the profit margin of any product category, track information about inventory levels, or even export the information to payroll or billing systems. The complexity of information sharing and exchanging requires process and task interdependencies that are crucial for the success of the business and manufacturing operations.

Other organizations support the use of ICT for supervisory staff for line monitoring and quality/yield triggering. Managers use the same system to generate reports to help make decisions. That is exactly why CNL is different from conventional learning, in the sense that information and learning is achieved through the network, and collaboration between individuals and workgroups form an essential part of learning.

> *"My leaders find it useful but the operators don't have access. Their work is just to run the production line but my leaders will monitor the results: the aging, WIP (Work in Progress) and output. They don't go for the yeild. Yeild is only trigger by technicians. Everyday, managers will use the system to generate reports and check the information. They do not have to ask the supervisors to send them emails or text every 4 hours or calling them or sending report because the information is available online." (WS_20003).*

Besides the ERP/MRP system, it was found that some manufacturing organizations use product database management (PDM) software to manage, track and control product data involving technical specifications, schematics and engineering drawings, requirements for manufacturing, test parameters, quality tests and inspections, and materials specifications required in making the product. The PDM serves as a central repository of product data and knowledge, and promotes integration and data exchanges among key stakeholders (Yam et al., 2007). Those who are involved with PDM are project managers; research and development; procurement; manufacturing; quality; and sales and marketing. Participants WS_20011 related his experience in using PDM, as follows:

> *"PDM is used for checking schematic, checking part list, components, etc. For troubleshooting still need PDM (product database management) because the schematics reside in PDM (product database management)." (WS_20011).*

Unlike ERP/MRP, product database management (PDM) has detailed functions that support product development and product lifecycle (PLC), particularly useful for those involved in developing and designing new products. New product development (NPD) involves collaboration among different functions, in order to avoid replication, and to ensure the right information is available to the right person at the right time (Kleinsmann & Valkenburg, 2005; Yam et al., 2007). A collaboration process also happens in concurrent engineering, when a team of experts jointly develop a new product (Camarinha-Matos & Afsarmanesh, 2006). Employees interact in a dynamically established virtual team and enterprise setting, during the concept, design, build, or servicing of a product to create a more innovative, profitable, higher quality product brought to market sooner than the parties would have accomplished on their own (Sayah et al., 2005). Product engineers or design engineers like participant WS_20009 are highly dependent on product database management (PDM) for performing their daily tasks or work.

> *"For R&D (research and development), ERP is only used for setup and tracking basis. Not for daily use. However, PDM (product database management) is being used daily in the R&D activities because we keep creating new part numbers, new drawings and so forth... so we are creating information. The information is then shared across the team. When we have created new designs or new drawings, we have to cascade the information through communications or meetings, and to present findings, creations and they have to be approved by dedicated management team. It happens electronically as well as physically within the company." (WS_20009)*

CNL bridges the gap between the existing product design and new ones, so that product engineers can optimally integrate the new design into the supply chain, sourcing and factory capacity planning. The unique features of electronic or digital product database management (PDM) are that it allows large data to be stored or archived into the system. This information is then shared and transformed by other key stakeholders, within the organization or across sites.

Apart from product and design engineers, there is a coherent relation with other departments along the value chain. Participant WS_20011, who worked as a technician, related her experience in using product database management (PDM) in managing engineering drawings and schematics.

> *"PDM (product database management) is about schematics. After troubleshooting, we have to access a link like in SAP. If the unit require troubleshooting, we will create another routing for troubleshooting (in SAP system). So that we will know, and that is how we check if we need to change any parts or components. Then, we have to key-in those information into SAP, like part number, ECN (engineering change notification) number, CCA (component circuit card) part number, and their revision together with the required components. If we do not key-in the information pertaining to the components, how could we review back? We need the components information to retrieve materials for replacement parts. This needs to happen…"(WS_20011).*

Product database management (PDM) provides the assemblers, technicians or repairers with vital information such as technical specifications, test records, revision status of the circuit cards or components, etc. CNL links large sets of databases into electronic or digital format, which is then made accessible through the networks. Such information is generated by product and design engineers, verified and combined with tests and inspection parameters by quality engineers, to enable production personnel to comprehend exact requirements.

In general, it was found that collaborative software such as email and chat or instant messaging is useful in support of interdependent processes such as product design and development. Examples include computer aided design (CAD), product visualization applications, data sharing via Intranet/Extranet to carry out engineering change management and release control on components revisions/issues in product, and product configurations and structures such as bill of materials (BOM) for assemblies. Similarly, in a case study by Hasbro by Yam et al. (2007), product design information, engineering specification, product design files, product feasibility detail, costing of product, safety requirement, product test plans, tooling authorization were captured in the systems. Such intricate activities can be supported with the use of CNL, where information sharing and transformation can be carried out concurrently across different geographic locations.

7.8.3 Promotive Interactions

For MNCs a great emphasis is given to ensure all information is being consistently and effectively managed. Indirectly, the system promotes interactions between employees from different functions within the organizations as well as across the organizations. According to WS_20007, eCATS (electronics Corrective Action Tracking System) was widely used by employees to login quality issues, to track containment actions and corrective actions, for timely closure of the case and to prevent recurrence or excursion.

> *"For quality there is a tool called eCATS (electronics Corrective Action Tracking System) .... So, for every single tab we need to provide some answers before submitting the (electronic corrective action request) and then it will prompt for closure on the issues, and request for approve or disapproved. We need to include preventive actions and timely closure." (WS_20007).*

The electronics Corrective Action Tracking System (eCATS) is an Internet-based software using secure socket layer (SSL) for data encryption, and is accessible from any computer with Internet access and an Internet browser. The key feature of eCATS is the ability to maintain and update information on a corrective action from the problem description until approval and verification, as indicated by participant WS_20007. All verifications and approvals are done electronically. The advance search and query allow employees to find detailed information across multiple sites. A production or quality engineer typically generates an eCATS. The supplier quality engineer (SQE) can assign cases to the external suppliers. External suppliers can access the system to update their part of the information exchange and value chain. After the supplier has responded, the SQE may schedule follow up and effectiveness audits before closure. When an action is required or overdue, the system automatically sends out an e-mail reminder. The process is meticulous and necessary for sharing and learning in a CNL environment. It is also a close-loop system that promotes interactions and communications among the employees to share information and knowledge about the product and process. Key stakeholders such as managers, engineers, technicians, supervisors, and suppliers have to collaborate in order to fulfil the requirements of the quality management process (Basu & Wright, 2005).

For SMEs, information management for quality information is not as vital as it is for MNCs. Participant WS_20002, described her daily tasks as Senior Quality Control Officer in a SME organization, and said:

> *"My job is on quality control. I check production area... and then... control critical control points, approve or reject finished product, and check incoming raw materials. We don't analyze the result (laughing). We just keep the results." (WS_20002)*

Clearly, the simplicity of the quality management processes in a SME organization (take the case of WS_20002) makes it evident that promotive interactions are less than for those working in MNCs. It could be explained that the complexity of the quality management system in MNCs (WS_20007) highlights the need to promote interactions. Collaboration can enrich learning through promotive interactions (Lindblom-Ylänne et al., 2003; Van den Bossche et al., 2006a). According to Dillenbourg (1999) certain forms and types of interactions are expected to occur among participants; nevertheless, there is no guarantee that these interactions will actually happen. However in CNL, interactions are between individuals and individuals, individuals and workgroups, and workgroups and workgroups, not just between users and network computers. It is also imperative to clarify at this point, that those were the outcomes of the process of collaborations and not cooperation. Key stakeholders are expected to contribute their part individually. The project or task is considered as incomplete should any member fail to contribute their part in the process.

7.8.4 Internal-External Learning

Most organizations use ICT to measure and track the performance of the operations. Others track production units using a manufacturing electronics system (MES).

> *"When I was in Company B, we used MES (manufacturing electronics system). Let say the unit build is 10, we could easily locate their whereabouts, either test or troubleshoot or staging areas." (WS_20011).*

It was found that employees learn internally either individually or through their peers. External learning involves training consultants and training providers as well as trainers sent from other sites to provide training and support.

> *"In my previous factory, production using MES (manufacturing electronics system), Shipping and Store use SAP. So, they has separated the functions well beforehand. So people who need access SAP would be well verse on its functionality and likewise people who uses MES (manufacturing electronics system). There is no problem because they serve their functions well." (WS_20011).*

Experienced employees were able to relate the use of MES and learn of other application systems from other organizations. Sharing and learning is becoming borderless as employees can easily share and learn what is good and what is bad from other organizations, as in the case of participant WS_20007.

> *"...I have seen in some other company did it... We scan it auto fail or auto pass. We don't make it human dependent." (WS_20007)*

Likewise, manufacturing and process engineering leverage on CNL to improve their production line efficiency. Process recipes and equipment settings are shared and learned by virtual teams. Any quality defects and process anomalies can be quickly communicated to other virtual teams for validation, and they then collaborate to resolve issues. Participant WS_20004 described this scenario as follows:

> *"Machinery and processes that are commonly used by sites… the technical function in the corporate will look into part or component commonality, and machine efficiency, so that new technology can be developed and we could share the new knowledge with the rest of the sites."(WS_20004)*

The benefit of CNL in support of internal-external learning is again described by the next participant WS_20004 in the following context:

> *"They developed a system that could enable all technical knowledge to be shared and deployed down across the sites. And basically this is how we leverage our technical competencies, and technical knowledge with the less competent sites."(WS_20004)*

Overall, the participants in this study agreed that collaborative systems and tools if utilized effectively as a collective system could promote learning through CNL. The frequency of interactions and collaborations is not as important as the result of learning itself. Learning to work collaboratively with internal and external teams helps employees to perform their job or complete their project on time and effectively. In the case of participant WS_20009, employees working in technical departments demonstrated higher ability and frequency of using these technologies.

> *"We hold conference call is on regular basis. Sometimes, twice a week or thrice weekly. We also have video conferencing. Video conference is only used for milestone reviews. We have Netmeetings and a system called Accardin. Accardin is basically a video conferencing or netmeeting system. We only used it when we need to show or share information, other than that we don't use it that often. We have cross functional teams in San Jose in USA, Miser in Netherlands, Penang and Singapore. We use Accardin when we want to view live-meeting, where we could actually share information on real-time. People in Miser or San Jose can actually view my presentations on their screens, or laptops, so it is cost effective, and we do not need to send large files over the Internet." (WS_20009).*

Virtual teams are potentially much more viable facilitators of knowledge sharing than individuals or traditional teams (Kauppila et al., 2011). Cross-site collaborations and external learning are common and necessary for the success of the projects. Sharing and learning among design engineers are crucial. Decisions are negotiated and members in the workgroup each contribute their ideas, designs and recommendations. CNL not only provides access to iterative designs among participants but enables concurrent engineering and facilitates both the process of learning and the transformation of explicit knowledge into product design by virtual teams.

With careful planning, CNL can be proliferated across organizations, sharing vital information and promoting learning both internally and externally. Most of the employees engaged in sharing and learning using CNL expressed their confidence in the systems. CNL also involves learning by sharing ideas on improving the present systems to create work that is more productive, efficient and better quality. It does not need to be a costly upgrade but some incremental improvisations are sometimes well suited for the purpose and the use of the employees from diverse backgrounds and educations.

> *"Perhaps they might add some columns... because now we only have the approval column, so sometimes the approval could be different with different owner(s). So, they might be able to add some columns for the owners."(WS_20006)*

> *"We have Excel file in share drive, like troubleshooting tracking. Other than that, we have the WIP (work in progress) aging report, which we update constantly in the shared drive. For troubleshooting, it depends as when we have units to troubleshoot. For WIP (work in progress) aging, we update it twice a week." (WS_20006)*

> *"It needs to be more users friendly. I mean for those working in the shopfloor…need to take into account their education level. It's challenging and they need to have lots of training. The staffs are okay but they are…you know when we changed from the old system to new system."(WS_20005)*

It was determined that what is important in CNL is the employees' engagement in the learning process. Manufacturing employees need to feel confident in using collaborative technology to share ideas, transform information and make sense of the information for their work. By using simple Microsoft Excel applications and shared folders, information can be easily stored and managed. For instance, participant WS_20006 used Microsoft Excel and shared folders to manage factory improvement projects. Information pertaining to type of projects, project charter, description of improvement, timeline and implementation, significance, etc. can be clearly documented for project tracking, cost saving reporting and archive.

> *"We are using share drive to update active records like Excel files and to be used for information sharing. We are also using the shared drive to update*

kaizen (improvement projects). We get online and enter all the relevant information into the system"(WS_20006).

Although, WS_20006 related his experience working in MNCs, this simple and cost effective tool is of use for SMEs. It does not require extensive knowledge and cost. It just requires some basic knowledge to manipulate the tools for effective management of information. However, internal-external learning requires a conscientious effort from manufacturing employees. While organization support could be strong, it does not necessary translate into employee engagement in learning and sharing. Take the case of participant WS_20011. The technician claimed that the system was unable to provide troubleshooting records of the defective units.

"It is odd. If all the data is sufficient, then everytime we troubleshoot we should be able to check the historical records in the system, but often this is not the case" (WS_20011).

Upon close examination and clarification from her supervisor, she found that the system apparently provided avenues to document troubleshooting techniques or methods; however, those avenues had not been effectively utilized by the former team of technicians, thus leaving a gap in the database.

Some employees create their own systems to cater for their own needs. Participant WS_20011, for example, created a simple yet effective database for her own reference and to improve the quality of her work. More importantly, her own key learning was also well proliferated among her peers.

"For my own use, I have created an excel form in the shared folder. Whatever I do...let say retest, I will make use of the folder for my own reference, not even my supervisor know about it. Before I do any transaction in the SAP, I have these for my records. In future if anything happens, I could used these as my references. Nazri (another technician) did the same." (WS_20011).

However, the purpose of the study is not to examine the usefulness or effectiveness of ICT in manufacturing, but rather the effective use of ICT in promoting CNL. Participant WS_20011 demonstrated her ability to analyse and use technology to fill in the gaps left by the existing system.

"The first time, when I created the folder, it was really complete, with details of any technical issues. Example, if a unit had failed HASS (Highly accelerated stress screening) 1.2.3, and when I keyed-in 1.2.3., I will have all the required information that I needed in details. But in the SAP, that level of detais are not required and therefore not indicated. Only test tag was created when I keyed-in in the UCN number, CCA (circuit card assembly) part number which are only important, but the essential information like why the units had failed and in which station hot or cold, I could not obtain the complete information, which is important for me." (WS_20011).

7.8.5 Perceived Effectiveness

If CNL is doable in any context, large or small, then would it be effective? This study corroborates the results of the survey questionnaire and supports the construct's perceived effectiveness. Participants explained the reasons for CNL and their perceptions of its effectiveness or ineffectiveness. Participant WS_20011 claimed that it was effective, as the engineering change notification (ECN) would update all the necessary information in the system accordingly.

"It updates accordingly like if they implement ECN (engineering change notification) or new ECO (engineering change order) and then they will update the part number, so we need to check" (WS_20011).

How do employees perceive the system as being effective or ineffective? Participant WS_20007 said that their system was ineffective because it only acted as a facility to archive information. Other employees used eCATS (electronics Corrective Action Tracking System) to record or document quality issues as compliance to AS9000[8] requirement. As a result, overloading of information created more confusion and increased the workload for employees.

"Seems like there is no linkage. That's right. We spend so much time and effort documenting the containment actions, corrective actions, and then forgotten about them. We reissued again for new CAR (corrective action request) and repeat the process. People don't realize the recurring problem. That's one of the weakness. Some other sections may have encountered the same problem, but we wouldn't know. Incidentally, everybody just issue new CAR (corrective action request). Q&R (Quality and Reliability) also wouldn't know what to update. Too many in the system." (WS_20007).

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[8] Aerospace Basic Quality System Standard was developed by a group of US aerospace prime contractors based on the ISO 9000 standard, with 27 additional requirements unique to the aerospace industry.

Others, such as participant WS_20004 favored the present system as it enabled members in his organization to share information globally. Engineering change for common parts and products could be effectively managed through the use of synchronous and asynchronous networked learning (SNL/ANL). As a result any sites could access the same information on a real-time basis to complete their part of CNL.

> *"The present system is meeting my expectation. For example, the engineering change is a global system and we have this MRP system (which is also a global system) which enables us to share information globally. That means that any sites can accessed to our global database for data sharing." (WS_20004)*

While it was found that CNL supports information sharing, promotes interactions between employees and possibly generates interdependencies, it was also found to be equally important that the system is effective. Participants said that the CNL system should demonstrate the functions and capabilities outlined in Table 7-3 in the content analysis. Perhaps the significance of the effectiveness of using technology is the ability to accurately obtain large amounts of data on a real-time basis. The online system is accessible and information can easily be obtained through any network, be at the factory, home or elsewhere. The perception about the effectiveness of the system appears to be evolving over time as technological boundaries advance. This was well noted by participant WS_2003, as follows:

> *"They are effective because we could obtain information on real-time basis at our fingers tip. Just a click away and then we can get online. We don't need to reboot or refresh it or anything like that. It's online at all times"(WS_20003).*

Accessibility and speed of transmission of information are as important as the functionality of the systems themselves. In the digital age, employees expect information to be easily accessible, obtainable and retrievable without having to waste precious time. Participants WS_20007 and WS_20003 echoed that need.

> *"PDM (product database management) is only the connection, very slow. Very difficult to retrieve file in a short time. We need some data but we need to download the entire file. So, these are the two weakness." (WS_20007).*

> *"The quality of the information is relevant, and updated. Suppose I am talking about Mytech system. It is online, and the information is immediately*

> *updated. Whatever there is a lot movement the information will be captured automatically, there is no delay in 5 minutes, 10 minutes or end of the shift. All is automated"(WS_20003).*

It was evident that collaborating parties were involved in direct access and transfer of data across sites and geographical boundaries. The product database management (PDM) server resided in single data storage or multiple sites, apparently depending on the needs of the organization.

All the participants had little knowledge about improving the effectiveness of a CNL system. This is because CNL is more complex than just an ICT tool for communications and data processing. Participant WS_20010, who is a senior manager in a SME organization, thought that by recruiting the right personnel for the job, the task of designing and developing an effective CNL system could be well managed.

> *"The IT plan has just begun. So if I want to improve the system, I need another IT executive to work with the IT Manager. We have one manager working closely with PBS (software developer). We are working with them, and we need to put forward our (working) requirements. Currently it is just their (software and operating) requirements. We are trying to fit in. So, we purchase the software and then we will try to modify the package according to our needs." (WS_20010).*

It can also be said that the CNL system is at a premature stage. Lack of knowledge and competency are critical issues yet to be addressed. Participants in SMEs generally struggled to define their needs and balance those needs with affordance. Most managers agreed that the system should be able to generate reports or metrics for evaluation, but that the system should not make decisions. However, some level of automation was expected rather than a purely static bulletin board for the storing and posting of information.

> *"They are effective because we could obtain information on real-time basis at our fingers tip. It is user friendly with few clicks. There is no report that need to run or export to excel. We don't have to do that." (WS_20003).*

Aside from being effective, the study also found an interesting statement that is out of the scope of the research but worth noting. A product engineer from a MNC suggested complementing the current system with a human presence.

> *"I would say the next step is actually having more periodical plant visits in my sector. I speak for my sector because I work with other project leaders across sites. So, I feel that it is necessary for us to communicate physically rather that too much of network type of conversations. I feel face-to-face relationship, bonding and understanding among team members is crucial. I would say maybe half-yearly or quarterly trips between project leaders." (WS_20009)*

The participant's opinion is well supported by Thomas and MacGregor's (2005) study on online project-based learning. Some studies accentuate the role of face-to-face interaction in creating trust and a collective identity among the team members (Kauppila et al., 2011; Malhotra et al., 2007). Participants in this study preferred face-to-face meetings after using the asynchronous and synchronous systems in support of their offline activities. Whenever employees interact or engage, they create a social space, whether they come together face-to-face, or do so virtually online (Addleson, 2013). Earlier, the same participant (WS_20009) expressed his satisfaction with the CNL system in his organization and explained that the system had provided a wide array of collaborative technologies both synchronous and asynchronous.

Overall, it was found that in both MNCs and SMEs CNL is still far from being perfect. Static information is not well perceived by manufacturing employees who constantly demand advanced analytic tools that can help reduce workloads and improve work efficiencies. In other words, almost all participants that were interviewed perceived that an effective CNL system could translate and transform large information into meaningful and concise metrics or performance indicators. They believed that it should assist their work and bring about positive changes for quality and productivity improvements.

7.8.6 Perceived Usefulness

Participants said that to be effective and useful, organizational knowledge and information had to be seamlessly integrated across the organization. The dedicated modules or sub-systems supported employees in their respective roles and functions (see WS_20006 below). The ERP/MRP is often projected as a complex system, analysing large pool of data for decision making in an environment that requires great flexibility and quick response. As participant WS_20006 put it:

> *"SAP is mainly used across all functions and departments. But there are different set of codes for different functions, like production use GMWB[9], MMBE[10], MEA4[11] and for planning maybe different set of codes. For operators they have their own codes, for example GMWB[12] is most commonly used for every operations. They have to login to SAP to labor on and labor off to capture the labour time."(WS_20006)*

It was found that most organizations use vital manufacturing information to collaborate between members in different departments or workgroups. This information is translated into meaningful reports and metrics (as described by WS_20003) for further analysis and often requires follow-up actions and decisions from higher management.

> *"We keep information about our yield, WIP (work in progress), and aging."(WS_20003)*

Employees participating in CNL collaborate with peers and teams using technology as an enabler. However, most information in its raw form does not add value to employees or their organizations. In order for the information to be useful, CNL technologies could support learning by transforming information into reports, metrics and performance indicators.

> *"Information in the shared folder is also accessible, but can be further improved if the system can auto-generate report (automatic reporting). Today it is used for depositing the raw data, then we need to extract out the raw data to create reports. So, that is where the setback is. But I think that can easily be done if system development can be defined the format, then the system can be programmed. That's how I see it" (WS_20004).*

By probing responses it was apparent that every function in the manufacturing organization plays an important part in creating and transforming data at various points of the operations. Production operators entering resource hours "labour on" and "labour off" data may seem insignificant, but when information is transformed into performance metrics, the usefulness of the system becomes more apparent.

[9] Transaction code (T-code) for production module in SAP.
[10] Transaction code (T-code) for material management module in SAP.
[11] Transaction code (T-code) for purchasing module in SAP.
[12] Transaction code (T-code) for manufacturing work bench in SAP.

Complex manufacturing operations like those in consumer electronics, semi-conductors and printed circuit board assembly (PCBA) require elaborate assembling sequences or steps. Without documented standard work instructions, it would be difficult to manufacture components and products with precision, accuracy and high quality. The extent of usefulness in the manufacturing environment can be best described by WS_20006 as follows:

> *"For standard work instructions, they (production operators and technicians) will have to refer back to SAP. Engineers create rework orders, check CN (configuration numbers) and configurations. Engineering Ref (reference) will relate to PDM (product database management). For managers level, I think mainly they will check for inventory, how many units are available for this part. Let say, if you are gated by parts, or CCA (circuit card assembly), then they will need to check how many pieces are left in the PRB (parts review board) for disposition. Then they will generate report for analysis, like QN (quality notification) report, PRB (parts review board) report, and also some WIP (work in progress) aging reports - all in which are generated from the SAP. The yeild report is used for cycle time analysis." (WS_20006)*

The complexity of a heterogeneous manufacturing environment demands a fast pace of data processing, with inter-connected functional application software that works across the organizational boundaries (WS_20006).

> *"The same information is also used for NPI (new product introduction), for example during phase 1,2,3 and 4 of Dixie[13] project. But in EM (electro-mechanical), we don't have NPI (new product introduction) because it was already completed (before the product transfer). We consider them as FAI (first article inspection)." (WS_20006).*

Product transfer and new product introduction may require transfer of information through the network. Collaborative tools could enhance the design content of the product and reduce the time for the approval of products (Yam et al., 2007). The same piece of information is crucial in order to sustain the level of quality, that otherwise would be compromised with the loss of essential product knowledge and information. Perkowitz and Etzioni (1999) link information quality with usefulness by arguing that the information is useful only if the user considers the information on the web site to be accurate, informative and up-to-date. In another study, Cornelius and MacDonald

[13] Dixie is a codename for a technology and product transfer project across two countries.

(2008) posit that rapid responses to practical questions, up-to-date information, and discussion of current issues is considered as valuable.

Many SMEs in the study have since evolved and implemented standardized work instructions, in compliance with the requirements of the ISO9000 standard. Most MNCs have upgraded their network with online standard work instructions (WS_20004). Participant WS_20004 mentioned the availability of network computers (NC) in assembly workstations, which meant that all production operators, technicians and engineers were able to access online information, including technical specifications and standardized work instructions. Bouhnik et al. (2009) in their empirical research on high-technology organizations remark that asynchronous sources "allow high accessibility to varied and updated information" (p. 426). This key infrastructure is seen as evidence of strong organizational support from the management or leadership of CNL.

> *"We used online work instructions. We called it online assembly build instructions. Basically, all the assembly stations will have these NCs (network computers), so everytime they (production operators) build a part they have to access the work instructions for that part number. It details out instructions for the work step by step."(WS_20004)*

The response to the question whether all employees need to transform and become involved in information transformation was generally no, not all employees are responsible for changing or transforming the information. Obviously, production operators are not required to change critical information such as product specifications, test parameters, or quality requirements. However, contrary to general belief, production operators could still initiate or influence the change by engaging primary stakeholder(s) such as product engineers, sustaining engineers or manufacturing engineers to change the standard work instructions.

> *"They (production operators) don't change the information. They have to feedback to the engineers who maintain the work instructions. They will raise a change request, update it and upload it back into the system with the new revision." (WS_20004)*

Many participants expressed their hope that the CNL system could help to make their work much easier. For instance, participant WS_20011 related her experience in using the engineering bulletin (EB) and participant WS_20004 in using assembly visual instruction (AVI).

> *"Like EB (engineering bulletin), before we start testing the unit we need to use EB (engineering bulletin). From the EB (engineering bulletin), we will check if the information has been updated or revised. From there we will know. But they will provide a grace period because it requires feedback from the United States and India. They need to update some information like type of revision, reason(s) for revision, etc. It takes time. Before that they need to complete the feedback form to validate and review when to cut-in, etc." (WS_20011).*

> *"For the AVI (assembly visual instruction), it is very effective. We can check the product information and made accessible to the people working on the lines." (WS_20004)*

The usefulness and relevancy of the information depends on how employees use it to perform their work. Several participants complained that their systems were overloaded with information. Bouhnik et al. (2009) in their research found information that was not always focused and on other occasions only provided partial information. Participant WS_20011 was one such discontented user.

> *"I think the SAP system is not useful. Let say...it is too elaborate and yet often it is insufficient." (WS_20011).*

Responses showed that unlike eCATS or SAP, which are often perceived as an encumbrance, information in the engineering bulletin (EB) is constantly being updated and pertinent information is being cascaded down to employees across the world. On top of that, the system is unique in the sense that it requires feedback from key stakeholders as part of the engineering change management process. It fulfils the role of the CNL system for employees not only to share knowledge and information, but also contribute their ideas, make sense of the information and complete their part by transforming the information given.

Some systems, however, are simple but useful in providing essential information for work (WS_20003). Members in a team can share information to monitor operational performance. Therefore, the aspect of time could actually impact on the perceived usefulness of CNL. When data is needed immediately, the response time may be too slow (Bouhnik et al., 2009). One particular participant WS_20007 highlighted concern about the speed of accessibility.

> *"Nevertheless, the PDM (product database management) is very good but it is also very slow because the server is residing elsewhere". (WS_20007)*

PDM system was used by participant performed analytical data processing and generated structured reports. Part of CNL's role is to enable manufacturing employees to gather information, analyse it, and then learn by applying this new knowledge and information to improve their work performance. CNL provides the means to generate reports from large databases and create virtual workspace for members to collaborate. As described by participant WS_20003, the information is being effectively used to identify the processes that require attention or improvements.

> *"For now, there is no lacking in the system. It is very useful. For me, for the engineering folks, technicians, we constantly monitor the yeild. I am running production, and it is important that I understand my WIP, bottleneck process, the yeild, and the aging because we have aging units that we need to clear. Then we could also identify the process that needs help through use of the system." (WS_20003)*

Other findings for the use of CNL are the highlighting of production requirements to assist repair works (WS_20011). For parts replacement, the system provides information about the history of the product, including quality records on test results, component part numbers, revision numbers and other technical specifications. This part of CNL promotes learning through a combination of experimentations based on past experience and learning. Without this component, repair or rework technicians would have no reference, and would continue to experiment based on a series of trails and errors.

> *"For example if the CCA (circuit card assembly) is faulty, then we need to change the components, and if it happens again, we should not direct to the UCN (unique control number) because we have the end-item part number. So, we need to know the end-item part number and from there we will check the build. From the build we will gather the UCN (unique control number) and then we could trace back. Usually that how we do it." (WS_20011).*

Employees in SME organizations recognized the relevancy and usefulness of a larger CNL. Senior manager WS_20008, from a SME organization, was optimistic that a better system would enable shop floor employees to check inventory management online. The SME organization although seemingly small, disorganized and certainly not high tech, recognized the importance of sharing information and management.

> *"Definately (UBS and Microsoft Excel) useful. It can be seen. People working on the shop floor can check stock directly." (WS_20008).*

Although some employees, for example WS_20006, expressed their reservations, overall they contended that even simple application software like Microsoft Excel could be effectively used for CNL. What is important is not the complexity of the system but the functionality and its design to disseminate knowledge among employees in manufacturing organizations.

> *"For some applications (the present systems) are useful, but not all. For instance, the kaizen (improvement projects) system that we implement is particularly useful. Every employee will go into sharepoint and share drive to submit and update their kaizen projects. It has a 7 days cycle, to verify inventory movement. The coordinator or owner(s) will assign people for the projects, enter in the cost saving for the kaizen and update all the gains or benefits." (WS_20006)*

Nevertheless, some enterprise systems are perceived to be burdensome. Resources are needed to perform data entry. Time and effort are heavily invested in ensuring accuracy and integrity of the data, as experienced by participants WS_20007 and WS_20011 in using an ERP/MRP system.

> *"SAP is very human/manual dependent because we have to do every since meticuluos transaction, one step at a time. It is prone to human error during data entry." (WS_20007).*

> *"I think the SAP system is not useful. Let say...it is too elaborate and yet often it is insufficient. Insufficient resources to enter all the information unto the SAP." (WS_20011).*

> *"Right now in the SAP, we need to key-in passed or failed. Sometimes, an operator could mistakenly keyed-in a unit which has failed as passed. Moreover, there are a lot of transactions involved." (WS_20007)*

> *"Although in SAP it does show their (production units) location, still we need to find them physically (because of insufficient information).The system has its limitations. Like at 8.30am the unit is in pre-test. After 9.00am it is still in pre-test according to SAP. But not sure why?" (WS_20011).*

There was a general consensus that an enterprise system brought more good than harm to manufacturing organizations. ERP usually contributes to the development of core competencies (Gao & Dowlatshahi, 2005). The present manufacturing business generates a large amount of data and information that require computational analysis for reporting and decision making. Most participants agreed that the system helped to increase productivity and promote operational efficiency in the long run.

> *"Yes, in the sense that SAP really helps us to shorten production cycle times. For operators, I don't think they find it as useful because the information and data is irrelevant to them or their work. Moreover, they (production operators) got to do a lot of data entry and so every operator is linked through the computer network." (WS_20005)*
>
> *"System wise, it is sufficient although there is limitation….but I believe we can handle those limitations. With the current tools we are able to sustain our operations and channel the messages across quite effectively. The current system provides real-time information and helps us in making good decision." (WS_20009).*

Almost all of the participants interviewed expressed their optimism that the systems could and would be further improved. Today's manufacturing employees (such as WS_200011) are more dependent on ICT for their jobs, and that inspires greater expectations and determination for more innovative ways of learning using CNL.

> *"At one time, they said they wanted to provide auto prompt. Whenever there is a change of revision…actually, they have...like normally the documents are handled by ME (manufacturing engineer). Let say if there is any NPI (new product introduction), so they (the manufacturing engineers) will check the current status (for pilot or preliminary production" (WS_20011).*

7.9 Summary

The qualitative data analysis provided data for the coding of CNL patterns using content analysis. The themes corroborated the quantitative findings in Chapter 6, and provided clarity in explaining participants' motivations and experiences, which supported and strengthened the propositions in sections 3.4.1 to 3.4.7. The qualitative findings are crucial in lending a voice to the numerical data and statistical inferences and providing a more holistic and interpretivistic view for the research. The researcher applied an ethnographic approach in the interpretations of the transcripts, in order to make sense of the contexts; terminologies involving information systems and operations management;

manufacturing processes; and employees' experiences in the manufacturing environment. The ethnographic approach enabled the researcher to relate to participants' experiences, and understand the contexts of their speeches in relation to the answers provided.

CHAPTER 8: DISCUSSION OF RESULTS

8.1 Introduction

This chapter presents the integrated findings from the quantitative and qualitative data as presented in Chapters 6 and 7 and summarizes key findings in accordance with the research questions, research objectives and research propositions.

8.2 Evaluation of Research Questions (RQ)

The study summarises key findings of this research in accordance with the research questions:

RQ1. What are the significant antecedents for a CNL model in manufacturing?
RQ2. How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning?
RQ3. What are employees' perceptions of CNL's usefulness and effectiveness in manufacturing?
RQ4. What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?

8.2.1 Research Question 1 - What are the significant antecedents for a CNL model in manufacturing?

This study has extended the empirical research of CNL in the manufacturing environment. All the proposed antecedents: organizational support, promotive interactions, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness were found to be significant. This is evident in section 6.11.7 where the regression models H1, H2, H3, H4 and H5 show predictors for each of the constructs tested and were found to be significant. The qualitative findings in section 7.7.2 corroborated these results and all the antecedents emerged as key themes: organizational support (nd.=1646); promotive interaction (nd.=980); positive interdependence (nd.=480); perceived effectiveness and usefulness (nd.=373); and internal-external learning (nd.=123). The result of the content analysis is shown in Appendix K.

8.2.2 Research Question 2 - How significant are the relationships between CNL and organizational support, positive interdependence, promotive interactions, and internal-external learning?

All the antecedents: organizational support, promotive interaction, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness demonstrated a highly significant relationship with CNL. Only significant predictor variables were retained in the regression models H1, H2, H3, H4 and H5 in section 6.11.7. Results of the multiple regression are shown in Appendix J. As evident in the multiple regression in sections 6.11.1 to 6.11.6, some antecedents were found to be well supported by multiple predictor variables, while others were only supported by a single predictor variable. For example predictor C3 “Job requires to share ideas, work and information” (for Model H1, H3 and Model H4), predictor F3 “Use computers to share information effectively” (for Model H2) and predictor F5 “Team produces good quality collaborative work” (for Model H5) only had a single predictor. Predictors C4 “Job can only be completed if other members complete theirs” and C5 “Performance depends on the results of the team” were eliminated as they were low in significance for any of the models tested. From the interviews, the participants further opinioned that all the proposed antecedents were significant (sections 7.8.1 to 7.8.6), although results from the content analysis show organizational support and promotive interaction as the predominant themes.

8.2.3 Research Question 3 - What are employees’ perception of CNL’s usefulness and effectiveness in manufacturing?

Employees perceived CNL to be both effective and useful, provided the information was relevant for their work, updated and of good quality. Employees from MNCs had a higher perception of CNL effectiveness and usefulness than those from SMEs. Employees from MNCs were confident in using computers to share information (M = 4.31; s.d. =0.83). Employees from SMEs felt they could work efficiently using information from the network (M = 2.94; s.d. =1.39). However, both groups agreed that using information from the network could not achieve their goals working as a team. Employees from MNCs perceived the network system/tool as being useful (M = 4.35; s.d. =0.81) for sharing information (M = 4.34; s.d. =0.85). However, they disagreed about the online meetings with external parties (M = 3.88; s.d. =1.20). Employees from SMEs perceived both the network system/tool (M = 3.01; s.d. =1.30) and shared database (M = 3.00; s.d. =1.32) as being useful, but they disagreed on the usefulness of the online learning system (M = 2.61; s.d. =1.23).

The participants from both groups generally agreed that CNL had helped to increase productivity and promote operational efficiency (as shown from the qualitative results in sections 7.8.5 and 7.8.6). CNL effectively stored, transferred and analysed the data into a meaningful report to support decision making. Nevertheless, there were mixed perceptions about CNL. Those who had disagreed claimed that the system was too complex and time consuming, a waste of resources and costly. The following are some of the highlights:

> *"For now, there is no lacking in the system. It is very useful." (WS_20003)*
>
> *"They are effective because we could obtain information on real-time basis at our fingers tip." (WS_20003)*
>
> *"For operators, I don't think they find it as useful because the information and data is irrelevant to them or their work."(WS_20005)*
>
> *"Definately useful" (WS_20008).*
>
> *"The current system provides real-time information and help us in making good decision."(WS_20009)*
>
> *"For some applications (the present systems) are useful, but not all." (WS_20011)*

8.2.4 Research Question 4 - What are the differences between CNL for multinationals companies (MNCs) and CNL for small medium enterprises (SMEs)?

In general, the proposed antecedents of CNL in manufacturing were strongly supported. However, there were significant differences between the intensity and frequency of usage in CNL between MNCs and SMEs. The following differences are noted from the quantitative and qualitative findings in this study:

i. MNCs are most likely to have the means to provide sufficient resources or organizational support for CNL strategies and programs. The study shows that the management of SMEs has the awareness to create incremental low cost and small scale programs.

ii. Most MNCs have implemented enterprise information management (EIM) and enterprise resource planning (ERP) systems that support manufacturing information integration across the entire organization and across the world. SMEs are mostly localized and use of enterprise information management (EIM) is either unheard of or at initial stages.

iii. The usage of CNL for MNCs is greater than SMEs in terms of online learning, online meetings, and emails for work. The differences were found to be highly significant.

iv. Both MNCs and SMEs do not differ significantly in the use of shared database. Management from both MNCs and SMEs recognize the importance of using shared databases or networks for information management and sharing.

v. There were participants from both MNCs and SMEs who engaged in more than 40 hours per year in e-learning. However, 85% of the participants from SMEs had never engaged in any form of online learning.

vi. Eighty seven percent of the participants from MNCs spent more than 15 hours a week using a shared database or networked information. This compares with 84% of participants from SMEs who said that they did not have access to a shared database or networked information.

vii. Ninety one percent of the participants from MNCs as compared to only 9% from SMEs spent between 6 to 10 hours a week using online meetings.

viii. Eighty six percent of the participants from MNCs spent between 1 to 5 hours a day using email for work, in contrast to 94% from SMEs who had never used emails for work. Those who spent more than 15 hours per day using emails for work were from MNCs (80%) as compared to SMEs (20%).

8.3 Evaluation of Research Objectives (RO)

The study summarises key findings of this research in accordance with the research objectives:

RO1. Develop an integrative CNL framework and bridge the gap between theory and praxis.
RO2. Establish a comparative study by comparing and contrasting diverse industries and between MNCs and SMEs.
RO3. Examine networks of manufacturing collaborations and seek to understand the antecedents that set the stage for information sharing and knowledge transformation among members in manufacturing organizations.
RO4. Conduct a multi-disciplinary research that will include experiential learning, workplace learning and consider other research into CNL and knowledge sharing. Revisit and validate the definition of CNL.

8.3.1 Research Objective 1: Develop an integrative CNL framework to bridge the gap between theory and praxis.

This study has developed a framework for CNL to bridge the gap between theory and praxis (as shown in Figure 8-21). The use of exploratory factor analysis resulted in 33 items being accepted with a high factor loading between 0.80 and 0.95, exceeding a minimum value of 0.60 (Nunnally et al., 1994) and factors extracted highly between 76.20% and 86.93% exceeding 50% of the total variance explained (Hair et al., 1998), as shown in sections 6.6.1 to 6.6.7. The Cronbach's α reliability test range from 0.90 to 0.96 was considered to be highly reliable, exceeding > 0.7 (Hair et al., 2006; Nunnally, 1978; Nunnally et al., 1994). The proposed constructs: organizational support, promotive interactions, positive interdependence, internal-external learning, perceived effectiveness and perceived usefulness were proven to be excellent antecedents that positively influence CNL in the manufacturing context. The type of organization acts as the moderating variable for CNL with differences between MNCs and SMEs. The study further strengthens the argument that a theoretical framework is different from the context of the information system in practice. The distinction is clearly made from the goal of learning. Employees' goal of collaborating in learning networks is to resolve work related issues where practicality and applications of knowledge is crucial for the success of the collaborative endeavour. Moreover, the choice and decision are positively influenced by perceptions on both the use and the effectiveness of technologies in CNL.

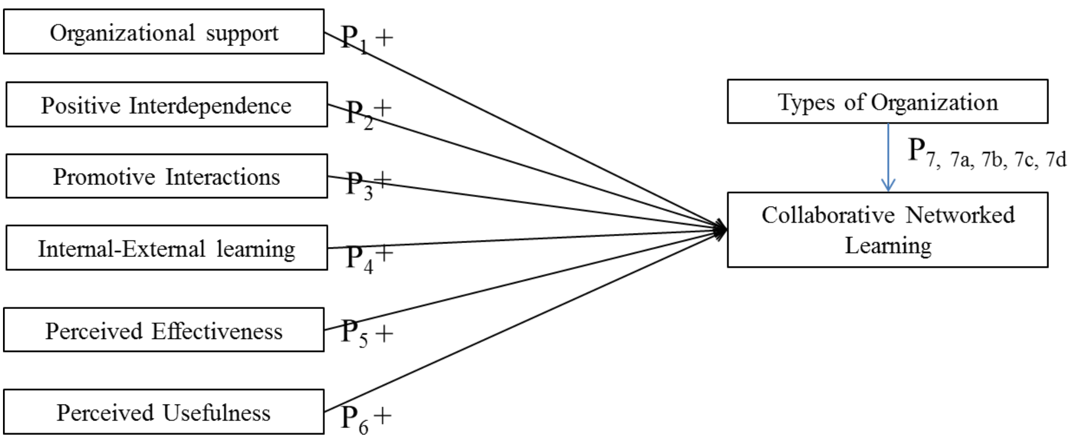

Figure 8-20 Framework for antecedents of CNL in manufacturing

8.3.2 Research Objective 2: Establish a comparative study by comparing and contrasting diverse industries and between MNCs and SMEs.

A comparative study was carried out within the research to compare and contrast the use of CNL between MNC and SME organizations. The findings reinforced the notion that employees from MNCs spend a considerable amount of time communicating and using CNL as compared to employees from SMEs (see Appendix G and H).

i. **For online learning** – Overall, the majority (32.9%, n =81) of participants spent less than 10 hours per year on online learning, while a proportion (22.8%, n =56) spent between 11 to 20 hours per year, and others (15.4%, n =38) never used e-learning or any online learning tools. However, employees from MNCs (M = 3.35, s.d. 1.45) spent more hours engaging in e-learning than employees from SMEs (M =1.99, s.d. 1.41). The difference was significant ($t(127.71) = 6.76$, $p< 0.05$).

ii. **For shared database** – Overall, participants spent between 6 to 10 hours (23%, n =56) and more than 15 hours (22.8%, n =56) accessing shared databases as compared to those who had neither use nor accessed any shared database (7.7%, n =19). Although employees from MNCs (M =4.17, s.d.=1.41) spent more hours using shared databases or network systems as compared to those from SMEs (M =2.78, s.d. =1.50), the difference was not significant ($t(244) = 6.68$, $p> 0.05$).

iii. **For online meetings** – The majority of the participant (38.6%, n =95) said that they never used online meetings. A proportion used online meetings between 1 to 5 hours (21.5%, n =53) per week, while others spent more than 15 hours per week (4.1%, n =10) using online meetings. Employees from MNCs (M =2.80, s.d. 1.48) spent more hours engaging in online meetings than employees from SMEs (M = 1.68, s.d. =1.21). The difference was significant ($t(111.42) = 6.32$, $p< 0.05$). Both MNCs and SMEs indicated a lower frequency of use of online meetings as compared to the other collaborative tools.

iv. **For email for work** – The majority of participants said that they spent 1 to 5 hours (33.7%, n= 83) per day using email for work. A proportion spent between 6 to 10 hours (25.2%, n =32) per day using email for work as compared to those who had never use email in their workplace (7.3%, n =18). However, employees from MNCs (M = 3.60, s.d.= 1.07) spent more hours using email for work than employees from SMEs (M = 2.54, s.d. =1.38). The difference was significant ($t(101.34) = 5.80$, $p < 0.05$).

8.3.3 Research Objective 3: Examine networks of manufacturing collaborations and seek to understand the antecedents that set the stage for information sharing and knowledge transformation among members in manufacturing organizations.

While seeking to understand how information is shared, learned and transformed, this study found some interesting results:

i. Surprisingly, overall 13% (n =31) of employees actually spent more than 40 hours per year using e-learning or an online learning program and a large percentage 85% (n =208) had some experience. Nevertheless, there is still a percentage of employees who had never used an online learning program, simply because they were not given online access, or the organizations had not implemented an e-learning program.

ii. A large percentage, at 93% (n =228), had experienced using email in their workplace or were using email for their work on a daily basis. Email is the ubiquitous collaborative technology for manufacturing organizations today. The majority of those who did not have access to email were either low position employees such as production assemblers, operators or general workers as explained by the participants in an interview, or the organization did not provide an email facility to their employees.

iii. Again, a large percentage, at 92% (n =227), had accessed and used a shared database to perform their daily work. This is because manufacturing organizations recognize the importance of sharing information through the network to improve their business and operational performance. Their motivations are echoed in section 7.7.1's interviews with senior managers from various organizations.

iv. However, the same cannot be said about online meetings. Thirty nine percent (n =95) of the employees said that they had never used online meetings or tele-conferencing in their workplace. Only 4% (n =10) spent more than 15 hours per week using online meetings for sharing information, collaborating and reviewing projects. Interestingly, those who did not use online meetings were most likely to have been deprived of opportunity to learn from customers, partners or suppliers.

8.3.4 Research Objective 4: Conduct a multi-disciplinary research that will include experiential learning, workplace learning and consider other research into CNL and knowledge sharing. Revisit and validate the definition of CNL.

From the literature review, the study identified some overlapping contributions that may support and corroborate this study on CNL. These include experiential learning, workplace learning and collaborative learning. In fact, the multi-disciplinary approach helped to develop the measurement, ensure consistency and improve the validity in the research. Further, the key concepts and principles of CNL that were first proposed by Findley (1988) were revisited and reviewed for relevancy and accuracy in relating to the present context of manufacturing:

i. *Learning is work, and work is learning*. According to Kolb (1984) "learning is the process whereby knowledge is created through transformation of experience" (p.41). The study confirmed the statement, and suggests that just a thin line separates work and learning. Thompson (2010) enunciates that much of the work of learning happens informally. Postulating from Kolb's (1984) and Thompson's (2010) contentions, work experience is transformed into knowledge and as such organizational knowledge has to be learned and shared. Systems and tools that are used for work are equally important instruments for communicating, sharing information and learning. The changes that are happening in the manufacturing workplace mean that every employee is required to contribute, share and learn at the same time. It is an enormous challenge and yet made easy with the use of collaborative technology embedded into the working and learning systems.

ii. *The process of learning is augmented in the computer networked environment*. The use of Internet-based information and communication technologies to promote CNL is supported by de Laat et al. (2006a); Camarinha-Matos and Afsarmanesh (2006a); Brophy (2001) and Lipponen (2002a). This study also found that collaborative technology and computer networks are used to amplified learning effectiveness, by making information easily available, accessible and sometimes updated to the point of use. Thus, the contention that the process of learning is augmented in the computer networked environment is still prevalent in CNL.

iii. *Group rather than individual focus*. In this study, participants actively communicated and negotiated meaning with one another and their workgroups. CNL is proven as an interactive process of engagement in learning with others in virtual teams, with the collaborative technology acting as enablers for sharing and transforming information. The process of interdependence investigated by the study inherently enforces the requirement of two or more members completing any single task or project. One cannot do without the others, and vice versa. Other researches on computer supported collaborative learning also imply that learners communicate with each other to engage in an argumentative discourse with the goal of acquiring knowledge (Weinberger et al., 2006), learning and thinking as a collective group (Stahl, 2005) and collaborating as a process of participation in collective activities (Lipponen, 2002b).

i. *Induction, synthesis and dialogue rather than deduction analysis and one-way transmission*. The study only partially supports the statement because of its limited scope and the fact that it did not proceed to study the learning process, knowledge acquisition or knowledge construction. Although it found some evidence of interactivity between members and their workgroups, it did not go further to investigate the types of analytical processes as a function of knowledge construction. Nevertheless, de Laat et al. (2006) postulate that CNL has essentially developed new knowledge by connecting ideas and sharing problems and insights in a constructive way through online dialogues and social interactions. By converting raw data into knowledge with the use of a variety of communication and collaborative tools simultaneously (Haythornthwaite et al., 2000), participants' understanding also increased (Johnson, 2001). Learning is always a mix of individual and group processes and knowledge is constructed by a synergistic effect that merges ideas from different individual perspectives (Stahl, 2005).

ii. *Not co-located with peers, management and/or factory*. Both synchronous and asynchronous network learning (SNL/ANL) can link geographically dispersed members and teams into a virtual workspace for collaborating in complex tasks or projects. In this research, participants from MNCs suggested they had more opportunities to collaborate with their peers across multiple geographical sites, mainly due to the requirement of their roles in support of product development projects or quality management resolutions. The same contention is well supported by other studies (e.g. Chudoba et al., 2005; Gressgard, 2011; Warkentin & Beranek, 1999).

iii. *Learning between self-directed co-learners and learners and experts; sharing common purpose, interdependent and accountable to each other for their success*. Goodyear et al. (2003) also suggests the above concept be enacted between one learner and other learners; between learners and experts; and between learning networks and their resources. This requires learners to explicitly schedule their activities and assign roles within the groups (Strijbos, 2004) and quite often interchange their roles as learners and experts (de Laat & Lally, 2003) in different situations, scenarios, tasks or projects. The study is closely related to the context and found that participants who actively interacted and engaged in workgroup activities or projects were more likely to be positively interdependent. Employees who are accountable for the outcome of their results and performances are often influenced by a group's learning environment where employees co-create knowledge together.

8.4 Evaluation of Research Propositions (RP)

The study summarised key findings of this research in accordance with the research propositions:

P_1 Organizational support is an antecedent of CNL.

P_2 Positive interdependence is an antecedent of CNL.

P_3 Promotive interaction is an antecedent of CNL.

P_4 Internal-external learning is an antecedent of CNL.

P_5 Employees' perceived effectiveness is an antecedent of CNL.

P_6 Employees' perceived usefulness is an antecedent of CNL.

P_7 For MNCs and SMEs, the influence of CNL is different.

P_{7a} The influence of online learning is different between MNCs and SMEs.

P_{7b} The influence of a shared database is different between MNCs and SMEs.

P_{7c} The influence of online meetings is different between MNCs and SMEs.

P_{7d} The influence of email for work is different between MNCs and SMEs.

The results of proposition testing at the construct level are summarized in Table 8-53 All *t*-values were significant at $p < 0.05$ level. This indicated that all propositions were verified at the construct level.

Table 8-53 Summary of the test of propositions

Propositions	Findings
P1 - Organizational support is an antecedent of CNL	**Supported****
P2 - Positive interdependence is an antecedent of CNL	**Supported*****
P3 - Promotive interaction is an antecedent of CNL	**Supported****
P4 - Internal-external learning is an antecedent of CNL	**Supported****
P5 - Employees' perceived effectiveness is an antecedent of CNL	**Supported*****
P6 – Employees' perceived usefulness is an antecedent of CNL	**Supported****
P7 – For MNCs and SMEs, the influence of CNL is different	**Partially Supported**
P7a – The influence of online learning is different between MNCs and SMEs	**Supported****
P7b – The influence of a shared database is different between MNCs and SMEs	**Not Supported**
P7c – The influence of online meetings is different between MNCs and SMEs	**Supported****
P7d – The influence of email for work is different between MNCs and SMEs	**Supported****

*= p< 0.1; ** = p<0.05; ***=p<0.01; ****=p<0.001

8.4.1 Proposition P1 - Organizational support is an antecedent of CNL.

This study has found that organizational support is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – B3 “Access to learning through computer network” (β = 0.32, t = 5.04, sig. =0.00), B4 “Access to online shared database to facilitate work” (β = 0.43, t = 7.76, sig. = 0.00) and B5 “Support from management to collaborate” (β = 0.13, t = 2.24, sig. = 0.03).

ii. Model H2 – B2 “Access to email for work” (β = 0.20, t = 2.47, sig. = 0.01), B3 “Access to learning through computer network” (β = 0.33, t = 4.15, sig. = 0.00) and B4 “Access to online shared database to facilitate work” (β = 0.29, t = 4.53, sig. = 0.00).

iii. Model H3 – B3 “Access to learning through computer network” (β = 0.35, t = 5.16, sig. = 0.00), B4 “Access to online shared database to facilitate work” (β = 0.30, t = 5.14, sig. = 0.00) and B5 “Support from management to collaborate” (β = 0.19, t = 2.97, sig. = 0.00).

iv. Model H4 – B3 “Access to learning through computer network” (β = 0.37, t = 5.31, sig. = 0.00) and B4 “Access to online shared database to facilitate work” (β = 0.28, t = 3.99, sig. = 0.00).

v. Model H5 – B3 “Access to learning through computer network” (β = 0.40, t = 5.85, sig. = 0.00) and B5 “Support from management to collaborate” (β = 0.33, t = 4.82, sig. = 0.00).

Employees are provided with access to a computer network to communicate and collaborate with others. The network plays an important role in enabling employees to access, learn and share information. Management support is pivotal in providing the facility and infrastructure as well as learning support to collaborate. Likewise, other researches also recommend a supportive organizational context and supportive interpersonal climate, as well as the positive effects of facilitative leadership (Edmondson et al., 2001; Sarin & McDermott, 2003). Most organizations provide both asynchronous and synchronous tools for communication and collaboration as well as workspace for sharing information. Management is supportive of employees in ways that facilitate the accomplishment of their tasks, for example, removing barriers, developing standards and coordinating activities (Doos et al, 2005). Similarly, Chiaburu et al. (2010) and Fedor et al. (2003) also found that perceived organizational support is positively related to self-efficacy and the motivation to learn. It is also related to team members' ratings of their project success and expectation of a project's impact on the organization.

8.4.2 Proposition P2 - Positive interdependence is an antecedent of CNL.

This study has proven that positive interdependence is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – C3 "Job requires to share ideas, work and information" ($\beta = 0.74$, $t = 17.26$, sig. =0.00).

ii. Model H2 – C1 "Job requires to work in teams" ($\beta = 0.21$, $t = 3.34$, sig. = 0.00) and C3 "Job requires to share ideas, work and information" ($\beta = 0.58$, $t = 9.20$, sig. =0.00).

iii. Model H3 – C3 "Job requires to share ideas, work and information" ($\beta = 0.75$, $t = 17.49$, sig. = 0.00).

iv. Model H4 – C3 "Job requires to share ideas, work and information" ($\beta = 0.61$, $t = 11.88$, sig. = 0.00).

v. Model H5 – C1 "Job requires to work in teams" ($\beta = 0.29$, $t = 4.28$, sig. = 0.00) and C3 "Job requires to share ideas, work and information" ($\beta = 0.47$, $t = 7.05$, sig. =0.00).

Employee's mutual dependency is focused on shared tasks and working collaboratively to accomplish the deliverables set forth by the management or organization. Jobs that require employees to work in teams or to share ideas, work and information are more likely to develop into CNL. Moreover, task interdependence requires assistance and support from multiple teams to work collectively (Van der Vegt et al., 2001; Wageman, 2001). However, it is not possible to ascertain the extent of collaborative effort in this study as MNC employees are widely distributed across different countries. A positive interdependence is produced among employees, since they are aware that other members are working together with them towards a common outcome (Kravcik et al., 2004). Therefore, co-creating of new knowledge is defined by its genesis process that knowledge has to be shared and is often dependent on joint task performance or a merging process between individual thought networks (Doos et al., 2005). The study further supports Grant and Baden-Fuller's (2004) argument that self-managing teams, virtual global teams and other cross-functional teams that support joint improvement activities and new product development (NPD) require positive interdependence for the groups to succeed.

8.4.3 Proposition P3 - Promotive interaction is an antecedent of CNL.

This study has proven that promotive interaction is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – D1 “Frequently share ideas, work and information” (β = 0.26, t = 4.18, sig. =0.00), D3 “Easily obtain help and support from peers/team” (β = 0.31, t = 4.54, sig. = 0.00) , D4 “Frequently share information online” (β = 0.15, t = 2.63, sig. = 0.01) and D5 “Team helps each other to learn” (β = 0.19, t = 3.27, sig. = 0.00).

ii. Model H2 – D1 “Frequently share ideas, work and information” (β = 0.24, t = 3.74, sig. =0.00), D2 “Frequently interact with peers/members online” (β = 0.46, t = 6.38, sig. = 0.00) and D4 “Frequently share information online” (β = 0.18, t = 3.22, sig. = 0.00).

iii. Model H3 – D2 “Frequently interact with peers/members online” (β = 0.38, t = 6.48, sig. = 0.00), D4 “Frequently share information online” (β = 0.22, t = 4.07, sig. = 0.00) and D5 “Team helps each other to learn” (β = 0.33, t = 6.42, sig. = 0.00).

iv. Model H4 – D2 “Frequently interact with peers/members online” (β = 0.42, t = 6.16, sig. = 0.00) and D4 “Frequently share information online” (β = 0.31, t = 4.47, sig. = 0.00).

v. Model H5 – D4 “Frequently share information online” (β = 0.30, t = 5.27, sig. = 0.00) and D5 “Team helps each other to learn” (β = 0.49, t = 8.48, sig. = 0.00).

Employees who frequently interact with peers or teams are more comfortable in working in teams and engaging in CNL. CNL requires employees to frequently share ideas, work and information with others through the use of a computer network. Extensive interaction is required for employees to communicate and solve problems with other internal knowledge peers and network with external experts (Gebauer et al., 2012). This is clearly evident in the study which has shown that participation in a workgroup (in Model H5) requires frequent information sharing and the ability to help each other out. Interaction between people in networked learning environments can be synchronous, asynchronous or both, and this forms an essential part of networked learning (Goodyear et al., 2005). It requires both technical and interactive skills from parties in collaboration (Doos et al., 2005). The intensity of interactions may also help to support other constructs, for example, positive interdependence and internal-external learning. Similar research by Fedor et al. (2003) also found that knowledge generation in both internal and external forms positively relates to team members' rating of their project's level of success and positive expectation of the project's impact on the organization.

8.4.4 Proposition P4 - Internal-external learning is an antecedent of CNL.

This study has found internal-external learning is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – E1 "Learn from shared information from the network" (β = 0.53, t = 8.21, sig. =0.00), E2 "Receive training to collaborate effectively" (β = 0.22, t = 3.30, sig. =0.00), and E5 "Learn from peers/team" (β = 0.17, t = 3.82, sig. =0.00)

ii. Model H2 – E1 "Learn from shared information from the network" (β = 0.31, t = 3.81, sig. =0.00), E2 "Receive training to collaborate effectively" (β = 0.31, t = 4.13, sig. =0.00), and E5 "Learn from peers/team" (β = 0.22, t = 3.64, sig. =0.00)

iii. Model H3 – E1 "Learn from shared information from the network" (β = 0.32, t = 6.48, sig. =0.00), E2 "Receive training to collaborate effectively" (β = 0.32, t = 4.67, sig. =0.00), and E5 "Learn from peers/team" (β = 0.24, t = 4.21, sig. =0.00).

iv. Model H4 – E2 "Receive training to collaborate effectively" (β = 0.37, t = 5.85, sig. =0.00), and E3 "Participate in improvement projects" (β = 0.34, t = 5.39, sig. =0.00).

v. Model H5 – E3 "Participate in improvement projects" (β = 0.43, t = 6.81, sig. =0.00) and E5 "Learn from peers/team" (β = 0.32, t = 5.00, sig. =0.00).

Employees learn to obtain shared information from the network and train to collaborate effectively with their teams (in Model H1). Equally important is the ability to learn from peers and teams in all aspects of CNL whether to access information online, work online, share and exchange information, participate in online learning or even work in groups. To participate in workgroup activities, employees have to learn from their peers and participate in improvement projects. Teams perform best when engaged iteratively in reflecting on their action of learning (Edmondson, 2002; Schippers et al., 2003); reconstruction and involvement in learning transfer processes (Argote et al., 2001); and internal and external learning processes. The study further confirmed the findings from other researches on external learning. For instance, Bierly and Daly (2007) found that learning from customers is a predictor of innovation speed, learning from suppliers is a predictor of operational efficiency, and learning from other industries is a predictor of superior process technologies. The learning experience forms a positive reputation, which in turn motivates more employees and external experts to participate in the knowledge network (Gebauer et al., 2012).

8.4.5 Proposition P5 – Employees' perceived effectiveness is an antecedent of CNL.

This study has found employees' perceived effectiveness is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – F1 "Work efficiently through use of information from the network" (β = 0.30, t = 4.85, sig. =0.00), F4 "Team achieves goals for projects by using information from the network" (β = 0.38, t = 5.15, sig. =0.00), and F5 "Team produces good quality collaborative work" (β = 0.23, t = 3.43, sig. =0.00).

ii. Model H2 – F3 "Use computer to share information effectively" (β = 0.77, t = 19.06, sig. =0.00).

iii. Model H3 – F1 "Work efficiently through use of information from the network" (β = 0.48, t = 8.04, sig. =0.00), and F5 "Team produces good quality collaborative work" (β = 0.39, t = 6.60, sig. =0.00).

iv. Model H4 – F2 "Work interdependently using the computer network" (β = 0.39, t = 5.05, sig. =0.00), and F5 "Team produces good quality collaborative work" (β = 0.29, t = 3.74, sig. =0.00).

v. Model H5 –F5 "Team produces good quality of collaborative work" (β = 0.69, t = 15.01, sig. =0.00).

Similarly to Murgolo-Poore et al. (2003) this study found a significant relationship between perceived effectiveness and the amount of information disseminated through the network. The frequency at which employees access information online is influenced by employees' perception about the system's ability to generate information for them to work efficiently and as a result, the team's ability to attain goals and produce high quality collaborative work. Likewise, for employees to work online using CNL, the system has to be effective in sharing information. To share and exchange information online, employee must perceive that the information that they obtain from the network will help them to work efficiently and produce high quality collaborative work. In fact, in all aspects of CNL, the ability to generate high quality collaborative work outperforms all other factors. Employees have high expectations that CNL should be highly effective.

8.4.6 Proposition P6 - Employees perceived usefulness is an antecedent of CNL.

This study has found employees' perceived usefulness is an antecedent of CNL. It is evident that the independent construct strongly supports the dependent variable CNL:

i. Model H1 – G1 "Network system/tool useful for work" (β = 0.30, t = 3.41, sig. =0.00), G2 "Shared database useful for work" (β = 0.21, t = 2.34, sig. =0.02), G4 "Network system useful for sharing information" (β = 0.22, t = 2.84, sig. =0.00), and G5 "Online learning is useful" (β = 0.15, t = 2.43, sig. =0.02)

ii. Model H2 – G4 "Network system useful for sharing information" (β = 0.55, t = 8.59, sig. =0.00), and G5 "Online learning is useful" (β = 0.26, t = 4.12, sig. =0.00)

iii. Model H3 – G4 "Network system useful for sharing information" (β = 0.48, t = 8.04, sig. =0.00), and G5 "Online learning is useful" (β = 0.39, t = 6.60, sig. =0.00)

iv. Model H4 – G3 "Online meetings with external parties are useful" (β = 0.31, t = 4.73, sig. =0.00), and G5 "Online learning is useful" (β = 0.39, t = 5.94, sig. =0.00)

v. Model H5 – G1 "Network system/tool useful for work" (β = 0.22, t = 2.08, sig. =0.04), G2 "Shared database useful for work" (β = 0.26, t = 2.37, sig. =0.02), and G5 "Online learning is useful" (β = 0.29, t = 4.08, sig. =0.00)

Like perceived effectiveness, the study also borrows the construct of perceived usefulness from TAM to measure the antecedents of CNL. In general, employees expect the online learning system or programme to be useful in order for CNL to be successful in all aspects. To participate in workgroup activities (model H5) and a network system, a shared database and online learning has to be useful for work. Likewise, to work online (Model H2) and share and exchange information online (Model H3), the network system has to be useful for sharing information, as well as online learning. In another empirical study, Ritchie et al. (2011) found that a greater level of usefulness will lead to higher levels of intention to use an application software.

8.4.7 Proposition P7 – For MNCs and SMEs, the influence of CNL is different.

This study has found that CNL is different between MNCs and SMEs. The results can be summarized as follows:

i. Online learning– MNCs (M=3.35, s.d. =1.45); SMEs (M=1.99, s.d. =1.41).
ii. Shared database– MNCs(M=4.17, s.d.=1.41); SMEs (M=2.78, s.d.=1.60).
iii. Online meetings– MNCs (M= 2.80, s.d.=1.48); SMEs (M=1.68, s.d. =1.21).
iv. Email for work– MNCs (M=3.60, s.d.=1.07); SMEs (M=2.54, s.d. =1.38).

The differences can be further explained by the qualitative results. MNCs are better equipped and have better resources at their disposal. Often SMEs struggle to adopt and benefit from such systems, citing lack of financial resources and technical capability as reasons (Morrell & Ezingeard, 2002). Morrell and Ezingeard (2002) also found that "lack of vision and awareness are restricting the adoption and the realization of benefits associated with such systems" (p.46). Past experiences, learnt beliefs and values are the hindrances to the acceptance of new thinking and tend to place more emphasis on management of tacit knowledge (Thakkar et al., 2011). CNL is not new to most MNCs as e-learning and learning management systems (LMS) have been widely used among large organizations. Higher business and operational complexity further explain why most MNCs require the use of multiple platforms and multiple systems, which often have to be seamlessly integrated. Branzei, Nakamura and Vertinsky (2011) and Branzei (2005) in their empirical researches on collaborative R&D also show differences between MNCs and domestic firms. MNCs invest more in collaborative R&D at low levels of experiential learning that requires well-honed routines and micro-processes, whereas collaborative R&D calls for exploration and quick adaptation. MNCs are more likely than domestic firms to show such ambidexterity. This study supports the proposition that CNL is indeed different between MNCs and SMEs in term of the intensity of usage. The following propositions $P7_a$, $P7_b$, $P7_c$ and $P7_d$ further deliberate on these differences.

8.4.8 Proposition P7a – The influence of online learning is different between MNCs and SMEs.

The study found significant difference between groups t(127.71) = 6.76, p< 0.05). Those participants from MNCs (M = 3.35, s.d. = 1.45) spent more hours on online learning compared to those from SMEs (M = 1.99, s.d.= 1.41). Unlike, MNCs which provide e-learning as part of the organizational development (OD) strategy, SMEs are more focused on informal learning. The phenomena is explained by Conlon (2004) who in his review found that more than 80% of employees' learning content comes from informal learning which is linked to both incidental learning and experimental learning. Informal learning refers to the individual gains of skills, knowledge, and attitudes from everyday experience and from one's social environment (Moreland & Lovett, 1997). Ridoutt et al. (2002) also found that it was the nature of training, rather than the volume, that varied by enterprise size. They found that SMEs engage in more informal training than do larger enterprises. Similarly, Schofield (2003) found that three of the companies studied (Ford, ANZ, and Qantas) viewed e-learning as essential in implementing a corporate strategy to deal with the competitive pressures of today's environment.

8.4.9 Proposition P7b – The influence of a shared database is different between MNCs and SMEs.

The study has found that the use of a shared database is not significantly different for CNL between MNCs and SMEs. Although there was a difference between hours participants spent on using a shared database or network information system per week – MNCs (M = 4.17, s.d. =1.41) and SMEs (M = 2.78, s.d. = 1.60), the difference was not significant $t(244) = 6.68$, $p > 0.05$). In other words, both MNCs and SMEs recognize the importance and use of a shared database or network system for their employees in the sharing of information across the organization.

8.4.10 Proposition P7c – The influence of online meetings is different between MNCs and SMEs.

The use of online meetings is more significant for CNL in MNCs than SMEs. Those from participants from MNCs spent more hours using online meetings (M = 2.80, s.d. = 1.48) as compared to those from SMEs (M = 1.68, s.d. = 1.21) and the difference was moderately significant $t(111.42) = 6.32$, $p < 0.05$). Although the proposition is well supported, the use of online meetings is comparatively lower than other means and uses of CNL like shared database, email and online learning.

8.4.11 Proposition P7d – The influence of email for work is different between MNCs and SMEs.

The use of email for work is more significant for CNL in MNCs than SMEs. There was a significant different between groups $t(101.34) = 5.80$, $p < 0.05$): Participants from MNCs spent more hours emailing (M =3.60, s.d. = 1.07) compared to those in SMEs (M

= 2.54, s.d. = 1.38). Although employees in most SMEs are provided with email to perform their work, the amount of hours spent on communication and sharing information among employees from MNCs is still dominant.

8.5 Summary

The propositions P_1, P_2, P_3, P_4, P_5 and P_6 are strongly supported. However, proposition P_7 is partially supported due to the fact that proposition P_{7b} being rejected. Participants from SMEs did not show a significant difference from those from MNCs in regards to the use of a shared database. Participants from SMEs spent as much time using a shared database or network information system as those from MNCs.

CHAPTER 9: CONCLUSION

9.1 Introduction

This chapter highlights key contributions, acknowledges research issues and presents avenues for future research. Martin (2004) posits that the application of theory is a vital process, in which the researcher has a significant role to play, particularly where the situation or the process is complex or new. The discussion in this chapter narrows the gap between theory and praxis, and identifies practical implications for organizations, managers and employees.

9.2 Contribution of the Study

The lack of CNL study in manufacturing in the literature has been observed and discussed Chapter 2. Previous studies focused on knowledge management and organizational learning. This study contributes significantly to the body of knowledge for use of CNL in manufacturing and has explored the importance of CNL from the perspective of the manufacturing environment linking four primary domains:

i. Bridging the theory and praxis of CNL
ii. Development of an integrative CNL framework for manufacturing
iii. Development of CNL instrument and measurement
iv. Adopting mixed method in exploratory research of CNL
v. Integration of CNL into operational management
vi. Other practical implications of CNL

9.2.1 Bridging the Theory and Praxis of CNL in Manufacturing

This study contributes significantly to the theoretical exposition on the roles of theory and praxis of CNL in the manufacturing environment. Truch, Ezingeard and Birchall (2000) posit that there are differences in expectations between the industry and academics. To overcome the differences, this study proposes a set of pragmatic antecedents through validated and critical analysis of knowledge transfer and information sharing to the practice of CNL in manufacturing by examining employees' perceptions and motivations to share and collaborate through complex networks of information systems. Employees' learning is interwoven into intricate networked systems that are less formalized and often unstructured. As attested by Camarinha-Matos and Afsarmanesh (2007), collaborative networked organizations (CNO) have extended beyond the boundaries of face-to-face communication. This thesis amplifies the relevance of socio-technical systems (STS) theory and bridges the gap between social and collaborative technologies, and interactions between complex CNL system infrastructures and manufacturing employees. The findings are that for CNL to be effective, it is imperative to provide information that is relevant for employees to perform their daily work activities. Collaborative tools have to be strategically planned, designed, purposeful and supported by management to facilitate learning and sharing of information.

9.2.2 Development of an Integrative CNL Framework for Manufacturing

CNL is a recent phenomenon for which no coherent theoretical framework previously existed in manufacturing. This study presents a framework for CNL in manufacturing. As suggested in the literature, previous theoretical frameworks are based on an educational context (Martínez et al., 2006). Arbaugh and Benbunan-Fich (2004) also recommend research on the application of theoretical frameworks in the study of networked learning and supports. Redmond and Lock (2006) suggest that "the focus of the framework is to shift from online learning environments into collaborative and interactive space" (p.270). The co-construction of knowledge, which is an interdependent process of interaction with the social environment, should be the emerging force within the framework (Redmond et al., 2006). CNL is used to integrate information sharing and transformation into collaborative business processes. Drawing from the findings, the study recommends organizations and managers to adopt an integrative CNL framework (see Figure 8-1) for design and development of a more complete networked learning system. The focus expands from online learning or e-learning to a much broader scope encompassing collaborative and interactive workspaces. Unlike educational collaborative learning models which are restrictive, the CNL framework provides a holistic perspective for workplace learning that is unbounded, engaging and accounts for users' perceptions about technology.

9.2.3 Development of CNL Instrument and Measurement

Socio-technical system (STS) theory through the development and validation of a survey instrument and measurement scales for studying the antecedents of CNL in the context of manufacturing is an important contribution to this study. Prior studies in collaborative learning merely mirrored the use of computer mediated learning, particularly among participants in learning institutions or with the focus on a population of students. The CNL survey instrument used in this study, however, examines employees from manufacturing organizations. The survey instrument (see Appendix D) complements the use of the technology acceptance model (TAM) which is theoretically grounded, well documented in the literature and widely used and accepted within information systems to explain the acceptance of technology (Davis, 1986, 1989; Venkatesh et al., 2003). This study has expanded the TAM model to include organizational support, interdependence, interactions and internal-external learning as clear factors which have a direct influence on employee’s adoptions and engagements in CNL. Through content analysis, the importances of these factors were again emphasized and the validity of the survey instrument was thus strongly supported.

9.2.4 Adopting Mixed Methods in Exploratory Research of CNL

Previous empirical studies used ethnographic approach, case studies, surveys (Goggins et al., 2011), content analysis, critical event recall and social network analysis (De Laat, 2006). In this study, the findings from quantitative and qualtitative approach blends well into the scope of the research and further strengthened social-technical systems (STS) theory. The qualitative findings corroborated with the results from quantitative survey and add rich explanatory dimensions and insights into the phenomena. The explanatory findings from qualitative approach further strengthen the validity of the quantitative study. Conversely, by using qualitative approach without quantitative findings, weaken the transferability and confirmability of the research as described in section 7.6. In addition, the hierarchical coding scheme (in Table 7-50) can be transfered and used for other similar areas of networked learning research.

9.2.5 Integration of CNL to Operational Management

It is postulated that the integration of CNL into organizational design and manufacturing work systems will accelerate organizational learning. Network thinking that recognizes the individual elements (actors) of the system enterprise and their reciprocal relationships is becoming increasingly important (Picot et al., 2008). Through the use of the CNL framework, it is shown that managers are required to provide the impetus to enhance learning and knowledge sharing. Manufacturing organizations should expand the use of virtual teams for promotion of knowledge transformation aside from project management, new product introduction, technology transfer and engineering change management. The growth of collaborative networks is expected to increase the propensity of interactions among manufacturing employees. This study has demonstrated that employees from diverse roles and responsibilities can work collectively and effectively in any networked organization. Inevitably, employees and their workgroups will become more interdependent in their new roles, given that individuals' roles have been intertwined into a complex information network within an organization. As a result, organizational design may be tasked to nurture organizational development and other essential networking skills in the context of operational management.

9.2.6 Other Practical Implications of CNL

This study finds practical implications of CNL for manufacturing organizations, managers and employees to be as follows:

For Manufacturing Organizations, the use of CNL to:

i. Integrate between learning management system (LMS) and work systems, where employees are enable to make sense of online learning modules as useful tools and methods to perform their work.

ii. Create work systems that promote learning using collaborative technologies, and which become the game changer for networked organizations. Learning evolves beyond learning management system (LMS).

iii. Evolve mobile enterprise system from static information to transformative applications where information can be exchanged and transformed from anywhere and everywhere. Employees can access enterprise networks using mobile CNL applications.

iv. Leverage on enterprise information systems (EIS) through use of CNL to incorporate product database management (PDM), manufacturing electronic system (MES) and other product development systems into seamless information integrations.

v. Enforce the idea of shared network systems among employees. No longer is there a need for one workstation for every employee. CNL can be used locally and globally, where shared networked workstations are shared and information is highly connected and accessible.

vi. Expand beyond intra-enterprise and provide critical learning and sharing of information with external stakeholders like third party logistics, suppliers, partners and customers.

For Managers, the use of CNL to:

i. Manage daily improvements (MDI) and assigned accountability to individuals and work groups. Every transactions, interactions and information exchanges can be tracked and updated to reflect current state of operational performance.

ii. Accelerate learning curve among new employees and old employees in cross training. Information is easily and effectively made accessible through CNL.

iii. Appraise employees' performance by measuring their contributions in ideas and information shared through work groups, work tasks and projects. The frequency, intensity and value of individual contributions can be objectively measured and displayed in online dashboards.

iv. Use as a set of management levers that reduce barriers to collaboration leading to value creation processes by leveraging internal-external expertise.

For Employees, the use of CNL to:

i. Access network systems and database for work and learning. This is crucial for networked organizations. Already we see a trend whereby some manufacturing organizations are dependent on information systems to perform their work.

ii. Share share ideas, knowledge and information designed to promote interactions and interdependencies among employees. These interactions may not necessary require face-to-face communication. Communication is widely established though use of collaborative technologies.

9.3 Research Issues

This study acknowledges some of the limitations:

i. The study examined factors elicited from the literature, but also identified other variables such as “quality of information” and “employees’ roles and responsibilities” as antecedents. Several studies postulate that the quality of online information may affect the sustainability of a system and quality to be identified and understood (Ahn et al., 2004; Cao et al., 2005a; DeLone et al., 2003; Lin, 2007b; Rodgers et al., 2005).

ii. As this study was limited to the Malaysia manufacturing environment, the findings can only be generalized to other contexts. Outside Malaysia the outputs of the study are referential and indicative.

iii. Participants for this study were voluntary and random. There were 246 participants. The sample size for the quantitative analysis limits generalization of the results beyond the specific sample used in this study (Nardi, 2006). A study with a larger sample size would allow more focus on the use of different collaborative technologies in other industries. A larger sample would facilitate the testing of more complex models, with the focus on group dynamisms and could relate CNL with performance and operational outcomes.

iv. In designing the questionnaire, the researcher was aware that the quantitative data collection method using the survey instrument has a tendency to limit the scope of a study. Care was taken by use of the pilot study to review questions to ensure that they were not ambiguous (Creswell, 2009).

v. The instrument was tested and survey data were collected over a seven-month period, raising the possibility of some bias. Steps were taken to mitigate this concern, including careful design of the questionnaire and pilot study and the separation of qualitative data.

9.4 Recommendations for Future Research

Development of an effective CNL system requires meticulous planning and alignment with operational and business strategies. As discussed, the level of organizational support and employees' perceptions influence the use of CNL. Although the adoption of CNL is mainly determined by organizational and leadership strategies, its effectiveness is highly dependent on the members' acceptance (managers and workers), nuances and in-depth application of collaborative technology in all organizational work systems as well as in project or workgroup oriented tasks. For CNL to be effective, organization and management of the information and knowledge produced by interaction through collaborative or individual actions is necessary (Daradoumis et al., 2000).

9.4.1 Development of New Collaborative Technology

Although suitable infrastructures as well as information and communication technologies (ICT) exist, especially web-based tools to facilitate and enable the process of knowledge transfer (Muller-Prothmann et al., 2009), technology itself does not resolve all the challenges of learning and collaboration. As such, the research on the selective use of collaborative technology in organizational learning, information transmission and knowledge transformation needs to be further explored. Similarly, Rittgen (2009) cautions that those engaged in collaboration not only bring their different organizational cultures but also different, often incompatible, information systems. This is particularly crucial for large manufacturing organizations that require information exchange between multiple sites, suppliers, customers and developers. Future research could examine how organizations address this gap and develop an integration process for the diverse operating systems and collaborative technologies, in support of learning environment using appropriate pedagogic theory (Huang et al., 2009).

9.4.2 Embedding Social Contexts in Collaborative Networked Learning

Human activity is highly nuanced and contextualized. Collaboration takes effort and the intention of employees to work collaboratively with others (Addleson, 2013). Lipponen (2002) and Addleson (2013) argue against the notion that technology alone guarantees that employees will collaborate or that technology will produce collaboration. Similarly, Ackerman (2000) found a fundamental mismatch between what is required socially and what technology has to offer. Most application frameworks are designed to support business requirements and lack the technical mechanisms to support the social dimension. The balance between human-computer interactions (HCI), and human-human interactions are becoming vague. HCI cannot postulate all aspects of human social requirements. Building a CNL system requires employees to think in terms of organized networks of mutual interdependence against the strong tendencies for employees to follow bureaucratic norms in order to secure their autonomy and resentment towards intrusions by peers and management (Heckscher, 2007). Although the creation of interdependencies through cross-functional teams, network ties and training in consensual problem solving techniques enable effective collaboration, they have failed to overcome entrenched individual differences (Heckscher, 2007). Future research could address organizational strategies in promoting social interactions and collaboration in manufacturing and determine how employees overcome their social and cultural differences in order to collaborate effectively. Also, is there any moderating effect of demographics (i.e. age, gender, education, position) on CNL?

9.4.3 Organizational Design for Collaborative Networked Learning

In order to obtain maximum value from CNL, it is found that management has to design and provide strategies, policies, procedures, training and value to its employees surrounding the use of technology (Lee et al., 2009). In retrospect, there must be a consistency between policy, structure and management to propagate CNL. Lee and Holmquist (2009) also caution against significant increase in the volume of messages, user-to-user time to respond, length and detail of the messages, role determination of the recipients and accountability for the information received. Therefore, organizational design needs to envisage change in the work systems, and provide systems that will allow manufacturing employees to openly document and share their knowledge about the process, product and design. Others like Muller-Prothmann and Frost (2009) highlight the importance of overcoming knowledge-related barriers such as knowledge codification, translation, evaluation, and integration into related business processes. Further research is needed to explore a new organizational design for CNL. How could the Enterprise Information System (EIS) be logically, consistently and effectively organized, so that information could easily be accessible and made use of as and when required? Future research may also examine the dynamics of workgroups or virtual teams in relation to the use of CNL. How could workgroups in collaboration be effectively organized and/or structured?

9.4.4 New Paradigm for Workplace Learning

The opportunity to learn in a workplace is not just a product of training programs but open opportunities to participate in work-related activities from which all employees learn (Billet, 2001, 2004; Fuller et al., 2004; Keating, 2006). Manufacturing organizations need to transform and embrace knowledge culture, create trust-building activities, and promote team building, communication training, localization and transparency of expertise (Muller-Prothmann et al., 2009; Rich et al., 2009). Previous studies have also shown that employees will not share information in the absence of a suitable organizational reward structure (Orlikowski, 1992b). Managers and employees may not share similar incentive or reward structures, resulting in systems being less used than desired (Grudin, 1989). In addition, managers and employees may have different perspectives or opinions of their work because their roles are different (Hopkins & Maglen, 2000). Whereas in the past, where boundaries between jobs were the basis for job classifications, CNL disengages these boundaries and undermines the system of training entitlements for employees. A workplace would ideally support employees to identify individual learning goals and engage with others in learning networks (Smith, 2003). Further research could focus on building trust and relationship among employees engaging in CNL. Besides trust, how would frequency, intensity, and centricity of interaction influence CNL and transform workplace learning?

The researcher would welcome any future replication study and the opportunity to collaborate in using different sources of data or with longitudinal studies in different environments.

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APPENDICES

Appendix A – Ethics approval by AUTEC

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To:	Nevan Wright
From:	**Dr Rosemary Godbold** Executive Secretary, AUTEC
Date:	24 November 2011
Subject:	Ethics Application Number 11/299 **Antecedents of collaborative networked learning in manufacturing: A comparative study between multinational companies and small-medium enterprises.**

Dear Nevan

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 14 November 2011 and I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 12 December 2011.

Your ethics application is approved for a period of three years until 24 November 2014.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through **http://www.aut.ac.nz/research/research-ethics/ethics**. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 24 November 2014;
- A brief report on the status of the project using form EA3, which is available online through **http://www.aut.ac.nz/research/research-ethics/ethics**. This report is to be submitted either when the approval expires on 24 November 2014 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this. Also, if your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply within that jurisdiction.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact me by email at **ethics@aut.ac.nz** or by telephone on 921 9999 at extension 6902.

On behalf of AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Dr Rosemary Godbold
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Quik Wee Hock weehock.quik@aut.ac.nz

Appendix B – Survey consent form

Survey Questionnaire
Collaborative Networked Learning

Dear Sir/Madam,

My name is Quik Wee Hock. As part of my research project at AUT University, Auckland, I am conducting a survey on the use of collaborative networked learning in manufacturing.

The aim of this study is to examine the antecedents of collaborative networked learning in the manufacturing industry, and compare between multinationals companies and small-medium enterprises.

Completion of this questionnaire is limited to those of 20 years of age or above and who are employed within a manufacturing organization.

This questionnaire is intended solely for research purposes and will take about 5 to 10 minutes. There are no costs associated with it.

The Participant Information Sheet can be viewed on the next page.

By completing this survey you indicate your consent to participate

Instruction: Select the most appropriate answer for each question by checking the box given.

Appendix B – Survey consent form (translated)

Soalan Kajiselidik

Rangkaian Pembelajaran Kolaboratif

Tuan/puan,

Saya, Quik Wee Hock sebagai penyelidik projek untuk AUT University, Auckland, sedang menjalankan kaji-selidik tentang rangkaian pembelajaran kolaboratif di dalam sektor pembuatan.

Tujuan kajian ini ialah bagi mengkaji sumber-sumber rangkaian pembelajaran kolaboratif di dalam industri pembuatan, serta membuat perbandingan antara syarikat multinasional dengan syarikat kecil dan sederhana.

Hanya peserta-peserta yang sedang bekerja di sektor perkilangan serta berumur lebih daripada 20 tahun ke atas dijemput menyertai kaji-selidik ini.

Kaji-selidik ini bertujuan untuk penyelidikan dan mengambil masa antara 5 hingga 10 minit. Tiada kos terlibat dalam menyertai kaji-selidik ini.

Helaian Maklumat Penyertaan boleh diperolehi daripada halaman yang seterusnya.

Dengan menjawab kaji-selidik ini, anda secara langsung telah memberi persetujuan anda untuk turut-serta.

Arahan: Pilih jawapan yang paling tepat bagi setiap soalan dengan menandakan pada kotak-kotak yang berkenaan.

Appendix C – Participant information sheet

Participant Information Sheet

Date Information Sheet Produced:
2/12/2011

Project Title
Antecedents of collaborative networked learning in manufacturing: A comparative study between multinational companies and small-medium enterprises.

An Invitation
My name is Quik Wee Hock and I am a doctoral student at AUT University, undertaking primary research as a fulfilment for my doctoral thesis. I am inviting you to participate in an independent study into the use of Collaborative Networked Learning (CNL) in manufacturing. Your participation is voluntary and you may withdraw at any time. Choosing to participate or not will neither advantage nor disadvantage you.

What is the purpose of this study?
The general aim of this study is to explore the antecedents of collaborative networked learning (CNL) in manufacturing and then compare the differences between multinational companies and small-medium enterprises.

How was I identified and why am I being invited to participate in this study?
You have been randomly selected to participate in this study because you are an employee in a manufacturing business in Malaysia. Those who are working in the respective manufacturing organizations may have been identified by your manager/supervisor or human resources manager.

What will happen in this study?
The data collected and its analysis will provide an insight into the antecedents of collaborative networked learning in manufacturing. The findings will be published in my doctoral thesis, academic journals and presented at conferences.

What are the discomforts and risks?
Participation in the survey is voluntary and will be anonymous. You will NOT be asked questions pertaining to your values, beliefs, cultures or work performance. We acknowledge that the information you will be providing is private. Your identity and the name of your organization will not be disclosed in writings, journal publications, conferences or in the thesis. Instead, alphanumeric codification will be used for quantitative data analysis. All information provided shall be treated with strict confidentiality.

How will these discomforts and risks be alleviated?
If you feel uncomfortable, you may choose to discontinue or withdraw your participation at any time.

What are the benefits?
The study has the potential to explore our understanding of collaborative networked learning in manufacturing. By examining the CNL antecedents, manufacturing organizations will be able to leverage on complex networks of information systems to increase the propensity of interactions and information sharing among manufacturing employees. It may also serve as a source of information for the development of future collaborative technologies. The researcher will publish the key findings in his doctoral thesis as part of the requirement for a doctoral degree.

How will my privacy be protected?
All data will be held in secure locations within AUT University in compliance with Auckland University of Technology Ethics Committee (AUTEC) regulations.

What are the costs of participating in this study?
There are no financial costs in participating in the research. Should you agree to participate in the online questionnaire, we envisage that it will take a maximum of 10 minutes to complete.

What opportunity do I have to consider this invitation?
Please take some time to consider this invitation. If you need further information or clarification, please contact the researcher (email and contact number below).

How do I agree to participate in this study?
Individuals may consent to participate or elect not to participate. By completing this survey, you indicate your consent to participate.

Will I receive feedback on the results of this study?
Results of this study will be available on request from the researcher. You may access the findings of the research through **www.researchgateway.ac.nz**

What do I do if I have concerns about this study?
All concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Associate Professor Dr. Nevan Wright, WF833, Faculty of Business and Law, AUT University, Private Bag 92006, Auckland. Tel +649 9219999 ext 5711 email: nevan.wright@aut.ac.nz

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Dr. Rosemary Godbold, rosemary.godbold@aut.ac.nz , +649 9219999 ext 6902.

Whom do I contact for further information about this study?
Quik Wee Hock, Faculty of Business & Law, Auckland University of Technology, Private Bag 92006, Auckland 1142, New Zealand. Tel: +649 9219999 ext.5338. Email: weehock.quik@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 24/11/2011 AUTEC Reference number 11/299

Appendix C – Participant information sheet (translated)

Helaian Maklumat Penyertaan

Tarikh Helaian Maklumat Penyertaan Disediakan:
2/12/2011

Tajuk Penyelidikan
Latar belakang rangkaian pembelajaran kolaboratif di dalam sektor pembuatan: Satu kajian perbandingan di antara syarikat-syarikat multinasional dan perusahaan kecil dan sederhana

Jemputan
Saya Quik Wee Hock, seorang mahasiswa kedoktoran di universiti AUT sedang membuat kajiselidik demi memenuhi keperluan tesis kedoktoran saya. Saya ingin mengundang anda untuk menyertai di dalam kajian bebas ke atas penggunaan rangkaian pembelajaran kolaboratif (CNL) dalam pembuatan. Penyertaan anda adalah secara sukarela dan anda tidak diwajibkan untuk menyertainya jika anda tidak ingin. Sama ada anda memilih untuk turut serta ataupun tidak, langsung tidak memberi sebarang kesan ke atas diri anda.

Apakah tujuan penyelidikan?
Tujuan utama kajian ini adalah untuk menerokai latar belakang rangkaian pembelajaran kolaboratif (CNL) di dalam sektor pembuatan dan kemudian membandingkan perbezaan di antara syarikat-syarikat multinasional dan perusahaan kecil dan sederhana.

Bagaimana saya terpilih untuk menyertai penyelidikan ini?
Anda telah dipilih secara rambang untuk menyertai kajian ini kerana anda seorang pekerja dalam sektor perkilangan di Malaysia. Pekerja dalam syarikat perkilangan masing-masing telah dikenalpasti oleh pengurus / penyelia anda atau pengurus sumber manusia.

Apa yang akan berlaku di dalam penyelidikan ini?
Soal selidik penyelidikan tanpa nama. Data yang diperolehi dan analisis yang akan memberi gambaran tentang latar belakang rangkaian pembelajaran kolaboratif di dalam sektor pembuatan. Analisis data akan disiarkan dalam tesis kedoktoran, jurnal akademik dan persidangan.

Apakah ketidakselesaan dan risiko?
Penyertaan anda secara sukarela. Anda tidak akan ditanya soalan yang berkaitan dengan nilai-nilai, kepercayaan, budaya atau prestasi kerja di syarikat anda. Kami juga mengakui bahawa maklumat yang bakal anda berikan tentang diri anda adalah sulit. Kami tidak akan mendedahkan identiti anda atau syarikat anda baik secara bertulis, jurnal, persidangan ataupun tesis. Sebaliknya, analisa data kuantitatif akan dilakukan dengan menggunakan rangkaian kod.

Bagaimanakah ketidakselesaan dan risiko ditangani?
Jika anda berasa tidak selesa, anda boleh memilih untuk menamatkan kajian ini atau menarik balik penyertaan anda pada bila-bila masa.

Apakah faedah penyelidikan?
Kajian ini berpotensi untuk menerokai bidang rangkaian pembelajaran kolaboratif di dalam sektor pembuatan. Dengan meneliti latarbelakang CNL, organisasi pembuatan akan dapat

memanfaatkan rangkaian kompleks sistem maklumat untuk meningkatkan kecenderungan interaksi dan perkongsian maklumat di kalangan kakitangannya. Ia juga boleh dijadikan sebagai sumber maklumat untuk pembangunan teknologi kolaboratif masa depan. Penyelidik akan menerbitkan hasil kajian di dalam tesis kedoktoran beliau sebagai syarat ijazah falsafah kedoktoran.

Bagaimanakah privasi saya dilindungi?
Semua data akan disimpan di arkib AUT University sejajar dengan pematuhan peraturan Jawatankuasa Etika Auckland University of Technology (AUTEC).

Apakah kos yang terpaksa ditanggung dalam menyertai penyelidikan ini?
Tiada kos untuk menyertai penyelidikan ini. Sekiranya anda bersetuju untuk mengambil bahagian di dalam soal selidik dalam talian, ia akan mengambil tempoh masa maksimum 10 minit untuk selesai.

Apakah peluang saya untuk mempertimbangkan jemputan ini?
Anda diminta untuk memberikan persetujuan anda untuk menyertai sebelum menjalankan soal selidik ini. Sila ambil masa untuk mempertimbangkan jemputan ini. Jika anda memerlukan maklumat atau penjelasan lanjut, sila hubungi penyelidik (emel dan nombor telefon tertera di bawah).

Bagaimana saya bersetuju untuk menyertai penyelidikan ini?
Individu boleh memilih sama ada untuk menyertai atau tidak. Dengan mengemukakan soal kaji selidik, ia akan dianggap sebagai tanda persetujuan anda.

Bolehkah saya menerima maklumkbalas keputusan penyelidikan?
Keputusan kajian boleh diperolehi daripada penyelidik atas permintaan sahaja. Anda boleh meneliti hasil kajian ini melalui **www.researchgateway.ac.nz**

Apakah yang harus saya lakukan seandainya ada kemusykilan?
Segala pertanyaan berkaitan dengan penyelidikan ini harus diajukan kepada Penyelia Projek, Profesor Madya Dr. Nevan Wright, WF833, Faculty of Business and Law, AUT University, Private Bag 92006, Auckland. Tal +649 9219999 ext 5711 emel: nevan.wright@aut.ac.nz

Kebimbangan tentang tatacara penyelidikan perlu diajukan kepada Setiausaha Eksekutif, AUTEC, Dr. Rosemary Godbold, rosemary.godbold @ aut.ac.nz, 649 9219999 ext 6902.

Siapakah yang harus saya hubungi bagi keterangan lanjut tentang penyelidikan ini?
Quik Wee Hock, Faculty of Business & Law, Auckland University of Technology, Private Bag 92006, Auckland 1142, New Zealand. Tal: +649 9219999 ext.5338. Emel: weehock.quik@aut.ac.nz

Diluluskan oleh Jawatankuasa Etika Auckland University of Technology pada 24/11/2011. Nombor Rujukan AUTEC 11/299

Appendix D – Survey questionnaire

Survey Questionnaire

Collaborative Networked Learning

AUT
UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Definition: Collaborative networked learning (CNL) is a process of participating in knowledge communities to construct and maintain a shared conception of a problem. CNL occurs when employees and their workgroups learn or attempt to learn through organizational networks and work interactions using collaborative technologies.

A1 Type of manufacturing organization

☐ Multinational company

☐ Small-medium enterprise

For question B1- H5, please rate your experience with collaborative networked learning.

No.	Questions	Scales				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
B1	I have access to a computer workstation to perform my job	1	2	3	4	5
B2	I have access to networked computer/email to work with others	1	2	3	4	5
B3	I have access to training and learning through computer network	1	2	3	4	5
B4	I have access to online shared databases to facilitate my work	1	2	3	4	5
B5	I have support from my supervisor/manager to collaborate with others	1	2	3	4	5
C1	My job requires me to work in teams	1	2	3	4	5
C2	My job requires me to hold tele-conferences with members from other sites	1	2	3	4	5
C3	My job requires me to share my ideas, work and information with others	1	2	3	4	5
C4	My job can only be completed if other members complete theirs	1	2	3	4	5
C5	My performance depends on the results of my team	1	2	3	4	5
D1	I frequently share ideas, work and information with others	1	2	3	4	5
D2	I frequently interact with my peers and members in the team online	1	2	3	4	5
D3	I can easily obtained help and support from my team/peers online	1	2	3	4	5
D4	I frequently share information in online meetings or discussions	1	2	3	4	5
D5	Members in the team help each other to learn and engage	1	2	3	4	5
E1	I learn from shared information from the network	1	2	3	4	5
E2	I received training to enable me to collaborate effectively	1	2	3	4	5
E3	I participate in improvement projects	1	2	3	4	5
E4	I learn from suppliers/customers or external parties	1	2	3	4	5
E5	I learn from my peers and members in the team	1	2	3	4	5
F1	I work efficiently through use of information from the network	1	2	3	4	5
F2	I work interdependently using the computer network	1	2	3	4	5
F3	I use computers to share information effectively with others	1	2	3	4	5
F4	My team achieved goals for projects by using information from the network	1	2	3	4	5
F5	My team produces good quality collaborative work	1	2	3	4	5
G1	The network systems and tools are useful for my work	1	2	3	4	5
G2	The shared databases are useful for my work	1	2	3	4	5
G3	The online meetings/discussions with external parties are useful	1	2	3	4	5
G4	The network systems are useful for sharing information	1	2	3	4	5
G5	The online learning system and training are useful	1	2	3	4	5

No.	Questions	Scales				
		Never	Seldom	Sometimes	Very often	Always
H1	I accessed knowledge and information through computer system/network	1	2	3	4	5
H2	I updated my work through the computer system/network	1	2	3	4	5
H3	I learned by sharing and exchanging information with others	1	2	3	4	5
H4	I participated in e-learning or online courses	1	2	3	4	5
H5	I participated in workgroups to complete projects or tasks	1	2	3	4	5

For question I1- J4, please tick [X] only one answer for each question.

I1 Number of hours using online learning or e-learning per year

- [ ] Never
- [ ] Less than 10 hours per year
- [ ] 11- 20 hours per year
- [ ] 21-30 hours per year
- [ ] 31-40 hours per year
- [ ] More than 40 hours per year

I2 Number of hours using a shared database or network information per week

- [ ] Never
- [ ] Less than 1 hour per week
- [ ] 1- 5 hours per week
- [ ] 6- 10 hours per week
- [ ] 11- 15 hours per week
- [ ] More than 15 hours per week

I3 Number of hours spent on online meetings or tele-conferencing per week

- [ ] Never
- [ ] Less than 1 hour per week
- [ ] 1- 5 hours per week
- [ ] 6- 10 hours per week
- [ ] 11- 15 hours per week
- [ ] More than 15 hours per week

I4 Number of hours spent on sending/replying to e-mails for work per day

- [ ] Never
- [ ] Less than 1 hour per day
- [ ] 1- 5 hours per day
- [ ] 6- 10 hours per day
- [ ] 11- 15 hours per day
- [ ] More than 15 hours per day

J1 Gender

- [ ] Male
- [ ] Female

J2 Age

- ☐ 20 - 29 years
- ☐ 30 - 39 years
- ☐ 40 - 49 years
- ☐ Above 50 years

J3 Education

- ☐ Post graduate/masters/doctorate
- ☐ Bachelor degree/diploma
- ☐ STPM/SPM
- ☐ SRP/PMR
- ☐ Others (please specify: ....)

J4 Department

- ☐ Management / Leadership
- ☐ Technical / Engineering
- ☐ Human resources / Administration / Security
- ☐ Purchasing / Procurement / Sourcing / Buying / Materials
- ☐ Planning / Sales / Marketing
- ☐ Production / Operations / Manufacturing / Assembly
- ☐ Quality / Safety
- ☐ Logistic / Warehouse / Store
- ☐ Finance / Accounts / Costing
- ☐ Others (please specify: ....)

We are grateful for the time and effort you have made to complete this survey.

Kind Regards,

Quik Wee Hock
Researcher
AUT University

Associate Professor Dr Nevan Wright
Project Supervisor
AUT University

Associate Professor Dr John Tookey
Project Supervisor
AUT University

Appendix D – Survey questionnaire (translated)

Soalan Kajiselidik

Rangkaian Pembelajaran Kolaboratif

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Definisi: Rangkaian pembelajaran kolaboratif (CNL) merupakan satu proses penyertaan dalam komuniti maklumat, di mana ahli-ahlinya membina dan mengekalkan konsep penyelesaian satu-satu permasalahan secara bersama. CNL berlaku apabila para pekerja atau pasukan kerja belajar melalui rangkaian organisasi dan berinteraksi dengan menggunakan teknologi kolaboratif.

A1	**Jenis syarikat pembuatan**
☐	Syarikat multinasional (pelabur asing)
☐	Syarikat kecil dan sederhana (tempatan)

Untuk soalan B1- H5, sila nilai pengalaman anda tentang rangkaian pembelajaran kolaboratif.

No.	Soalan-soalan	Skala				
		Sangat tak setuju	Tak setuju	Berkecuali	Setuju	Sangat setuju
B1	Saya dibekalkan dengan sistem komputer untuk kerja harian	1	2	3	4	5
B2	Saya diberikan kemudahan rangkaian komputer/e-mail untuk berhubungan	1	2	3	4	5
B3	Saya diberikan kemudahan latihan dan pembelajaran melalui komputer	1	2	3	4	5
B4	Saya boleh menggunakan pengkalan data berkomputer untuk kemudahan kerja	1	2	3	4	5
B5	Saya digalakkan oleh penyelia/pengurus untuk bekerjasama dengan rakan lain	1	2	3	4	5
C1	Kerja memerlukan saya berkerja secara berpasukan	1	2	3	4	5
C2	Kerja memerlukan tele-sidang dengan rakan kerja luar syarikat	1	2	3	4	5
C3	Kerja memerlukan perkongsian pendapat dan maklumat kerja dengan rakan lain	1	2	3	4	5
C4	Kerja hanya boleh dijayakan dengan bantuan rakan sekerja	1	2	3	4	5
C5	Prestasi kerja saya bergantung kepada pencapaian berpasukan	1	2	3	4	5
D1	Saya sering berkongsi pendapat, dan maklumat dengan rakan lain	1	2	3	4	5
D2	Saya sering berinteraksi dengan rakan kerja secara talian	1	2	3	4	5
D3	Saya mudah mendapat bantuan serta sokongan daripada rakan secara talian	1	2	3	4	5
D4	Saya sering berkongsi maklumat di dalam sidang talian (online)	1	2	3	4	5
D5	Rakan pasukan saling membantu dalam pembelajaran	1	2	3	4	5
E1	Saya belajar untuk berkongsi maklumat daripada rangkaian komputer	1	2	3	4	5
E2	Saya menerima latihan untuk membolehkan saya berkerjasama secara efektif	1	2	3	4	5
E3	Saya menyertai projek penambah-baikan (continuos improvement)	1	2	3	4	5
E4	Saya belajar daripada pembekal/pelanggan atau pihak luar	1	2	3	4	5
E5	Saya belajar daripada rakan pasukan	1	2	3	4	5
F1	Saya bekerja secara efektif melalui sistem rangkaian komputer	1	2	3	4	5
F2	Saya bekerja secara berdikari menggunakan rangkaian berkomputer	1	2	3	4	5
F3	Saya menggunakan komputer untuk berkongsi maklumat dengan rakan lain	1	2	3	4	5
F4	Pasukan saya mencapai matlamat dengan bantuan sistem komputer	1	2	3	4	5
F5	Pasukan saya mencapai kualiti kerja tinggi secara bekerjasama	1	2	3	4	5
G1	Sistem rangkaian dan perkakasan komputer berguna untuk kerja saya	1	2	3	4	5
G2	Perkongsian pengkalan data berguna untuk kerja saya	1	2	3	4	5
G3	Mesyuarat/sidang talian dengan pihak luar amat berguna	1	2	3	4	5
G4	Sistem rangkaian berguna untuk perkongsian maklumat	1	2	3	4	5
G5	Sistem pembelajaran secara talian amat berguna	1	2	3	4	5

No.	Soalan-soalan	Skala				
		Tidak pernah	Jarang	Kadang-kadang	Agak kerap	Selalu
H1	Saya boleh memperolehi maklumat dan pengetahuan melalui rangakai komputer	1	2	3	4	5
H2	Saya mengemaskinikan kerja saya melalui sistem rangkaian komputer	1	2	3	4	5
H3	Saya belajar untuk berkongsi maklumat dengan rakan lain	1	2	3	4	5
H4	Saya menyertai kursus e-pembelajaran (online)	1	2	3	4	5
H5	Saya menyertai projek berpasukan	1	2	3	4	5

Untuk soalan I1- J4, sila tanda [X] satu jawapan yang paling tepat bagi setiap satu soalan.

I1 Jumlah masa digunakan untuk e-pembelajaran (online) di dalam tempoh setahun

- [ ] Tidak pernah
- [ ] Kurang daripada 10 jam setahun
- [ ] 11- 20 jam setahun
- [ ] 21- 30 jam setahun
- [ ] 31- 40 jam setahun
- [ ] Lebih daripada 40 jam setahun

I2 Jumlah masa digunakan untuk pengkongsian maklumat di dalam tempoh seminggu

- [ ] Tidak pernah
- [ ] Kurang daripada 1 hour seminggu
- [ ] 1- 5 jam seminggu
- [ ] 6- 10 jam seminggu
- [ ] 11- 15 jam seminggu
- [ ] Lebih daripada 15 jam seminggu

I3 Jumlah masa digunakan untuk tele-sidang di dalam tempoh seminggu

- [ ] Tidak pernah
- [ ] Kurang daripada 1 jam seminggu
- [ ] 1- 5 jam seminggu
- [ ] 6- 10 jam seminggu
- [ ] 11- 15 jam seminggu
- [ ] Lebih daripada15 jam seminggu

I4 Jumlah masa digunakan untuk membaca/membalas email di dalam tempoh sehari

- [ ] Tidak pernah
- [ ] Kurang daripada 1 jam sehari
- [ ] 1- 5 jam sehari
- [ ] 6- 10 jam sehari
- [ ] 11- 15 jam sehari
- [ ] Lebih daripada 15 jam sehari

J1 Jantina

- [ ] Lelaki
- [ ] Wanita

J2 Umur

- [ ] 20 - 29 tahun
- [ ] 30 - 39 tahun
- [ ] 40 - 49 tahun
- [ ] Lebih 50 tahun

J3 Pendidikan

- [ ] Graduan/siswazah lepasan tinggi/kedoktoran
- [ ] Sarjana muda/diploma
- [ ] STPM/SPM
- [ ] SRP/PMR
- [ ] Lain-lain (sila nyatakan: ....)

J4 Jabatan/Bahagian

- [ ] Pengurusan / Majikan
- [ ] Teknikal / Kejuruteraan
- [ ] Sumber manusia / Pentadbiran / Keselamatan
- [ ] Pembelian / Pembekalan
- [ ] Perancang / Jualan / Pemasaran
- [ ] Pengeluaran / Operasi / Pembuatan / Pemasangan
- [ ] Kualiti / Keselamatan
- [ ] Logistik / Gudang / Stor
- [ ] Kewangan / Perakaunan / Kos
- [ ] Lain-lain (sila nyatakan: ....)

Terima-kasih kerana meluangkan masa dalam menjayakan kaji-selidik ini.

Yang benar,

Quik Wee Hock
Penyelidik
AUT University

Profesor Madya Dr Nevan Wright
Penyelia Projek
AUT University

Profesor Madya Dr John Tookey
Penyelia Projek
AUT University

Appendix E – Survey measurement model

SPSS Code	Item No.	Variables	Type	Measure
Id	none	Identification of each participant in alphanumeric code	alpha-numeric	none
TypeOrg	A1	Type of company	numeric	nominal
ORG	B1…B5	Organizational support (5 rating scale items)	numeric	scale
IDP	C1…C5	Positive interdependence (4 rating scale items)	numeric	scale
INT	D1…D5	Promotive interaction (5 rating scale items)	numeric	scale
LRN	E1…E5	Internal-external learning (4 rating scale items)	numeric	scale
EFF	F1…F5	Perceived effectiveness (5 rating scale items)	numeric	scale
USE	G1…G5	Perceived usefulness (5 rating scale items)	numeric	scale
CNL	H1…H5	Collaborative networked learning (5 rating scale items)	numeric	scale
HrOnline	I1	Number of hours using online learning per year	numeric	ordinal
HrEmail	I2	Number of hours using email per day	numeric	ordinal
HrSharedDB	I3	Number of hours using a shared database per day	numeric	ordinal
HrTeleCon	I4	Number of hours attending online meetings per week	numeric	ordinal
Gender	J2	Gender	numeric	nominal
Age	J1	Age	numeric	ordinal
Edu	J3	Education	numeric	nominal
Dept	J4	Department	numeric	nominal

Appendix F – Correlation matrix

Correlation matrix for organizational support[a]

		B1	B2	B3	B4	B5
Correlation	B1 Access to a computer workstation to perform job	1.000				
	B2 Access to networked computer/email for work	0.944	1.000			
	B3 Access to training and learning through computer network	0.826	0.823	1.000		
	B4 Access to on-line a shared database to facilitate work	0.669	0.703	0.677	1.000	
	B5 Support from supervisor/manager to collaborate	0.685	0.665	0.719	0.598	1.000
Sig. (1-tailed)	B1 Access to a computer workstation to perform job					
	B2 Access to networked computer/email for work	0.000				
	B3 Access to training and learning through computer network	0.000	0.000			
	B4 Access to on-line shared databases to facilitate work	0.000	0.000	0.000		.
	B5 Support from supervisor/manager to collaborate	0.000	0.000	0.000	0.000	

a. Determinant = .007

Correlation matrix for promotive interactions[a]

		C1	C3	C4	C5
Correlation	C1 Job requires to work in teams	1.000			
	C3 Job requires to share ideas, work and information	0.738	1.000		
	C4 Job can only be completed if other members complete theirs	0.633	0.714	1.000	
	C5 Performance depends on the results of the team	0.726	0.766	0.768	1.000
Sig. (1-tailed)	C1 Job requires to work in teams				
	C3 Job requires to share ideas, work and information	0.000			
	C4 Job can only be completed if other members complete theirs	0.000	0.000		
	C5 Performance depends on the results of the team	0.000	0.000	0.000	

a. Determinant = .060

Correlation matrix for positive intedependence[a]

		D1	D2	D3	D4	D5
Correlation	D1 Frequently share ideas, work and information	1.000				
	D2 Frequently interact online with peers and team	0.813	1.000			
	D3 Easily obtain help and support on-line	0.751	0.892	1.000		
	D4 Frequently share on-line meetings or discussions	0.649	0.726	0.759	1.000	.
	D5 Team helps each other to learn and engage	0.725	0.685	0.709	0.634	1.000
Sig. (1-tailed)	D1 Frequently share ideas, work and information					
	D2 Frequently interact online with peers and team	0.000				
	D3 Easily obtain help and support on-line	0.000	0.000			
	D4 Frequently share on-line meetings or discussions	0.000	0.000	0.000		
	D5 Team helps each other to learn and engage	0.000	0.000	0.000	0.000	

a. Determinant = .011

Appendix F – Correlation matrix (cont')

Correlation matrix for internal-external learning[a]

		E1	E2	E3	E5
Correlation	E1 Learn from shared information from the network	1.000			
	E2 Receive training to enable me to collaborate effectively	0.817	1.000		
	E3 Participate in improvement projects	0.631	0.611	1.000	
	E5 Learn from my peers and team	0.711	0.649	0.671	1.000
Sig. (1-tailed)	E1 Learn from shared information from the network				
	E2 Receive training to enable me to collaborate effectively	0.000			
	E3 Participate in improvement projects	0.000	0.000		
	E5 Learn from my peers and team	0.000	0.000	0.000	

a. Determinant = .078

Correlation matrix for perceived effectiveness[a]

		F1	F2	F3	F4	F5
Correlation	F1 Work efficiently through use of information from the network	1.000				
	F2 Work interdependently using the computer network	0.889	1.000			
	F3 Use computers to share information effectively	0.787	0.849	1.000		
	F4 Team achieves goals using information from the network	0.834	0.857	0.873	1.000	
	F5 Team produces good quality collaborative work	0.799	0.778	0.839	0.859	1.000
Sig. (1-tailed)	F1 Work efficiently through use of information from the network					
	F2 Work interdependently using the computer network	0.000				
	F3 Use computers to share information effectively	0.000	0.000			
	F4 Team achieves goals using information from the network	0.000	0.000	0.000		
	F5 Team produces good quality collaborative work	0.000	0.000	0.000	0.000	

a. Determinant = .002

Correlation matrix for perceived usefulness[a]

		G1	G2	G3	G4	G5
Correlation	G1 The network systems/tools are useful	1.000				
	G2 The shared databases are useful	0.898	1.000			
	G3 The on-line meetings/discussions with external parties are useful	0.624	0.664	1.000		
	G4 The network systems are useful for sharing information	0.850	0.854	0.697	1.000	
	G5 The on-line learning system is useful	0.748	0.766	0.654	0.764	1.000
Sig. (1-tailed)	G1 The network systems/tools are useful					
	G2 The shared databases are useful	0.000				
	G3 The on-line meetings/discussions with external parties are useful	0.000	0.000			
	G4 The network systems are useful for sharing information	0.000	0.000	0.000		
	G5 The on-line learning systems are useful	0.000	0.000	0.000	0.000	

a. Determinant = .008

Appendix F – Correlation matrix (cont')

Correlation matrix for collaborative networked learning[a]

		H1	H2	H3	H4	H5
Correlation	H1 Online knowledge and information	1.000				
	H2 Work using online system/network	0.842	1.000			
	H3 Sharing and exchanging information	0.847	0.816	1.000		
	H4 Participating in e-learning	0.674	0.673	0.690	1.000	
	H5 Participating in workgroup activities	0.722	0.689	0.741	0.714	1.000
Sig. (1-tailed)	H1 Online knowledge and information					
	H2 Work using online system/network	0.000				
	H3 Sharing and exchanging information	0.000	0.000			
	H4 Participating in e-learning	0.000	0.000	0.000		
	H5 Participating in workgroup activities	0.000	0.000	0.000	0.000	

a. Determinant = .012

Appendix G – Tables on hours spent on CNL (MNCs and SMEs)

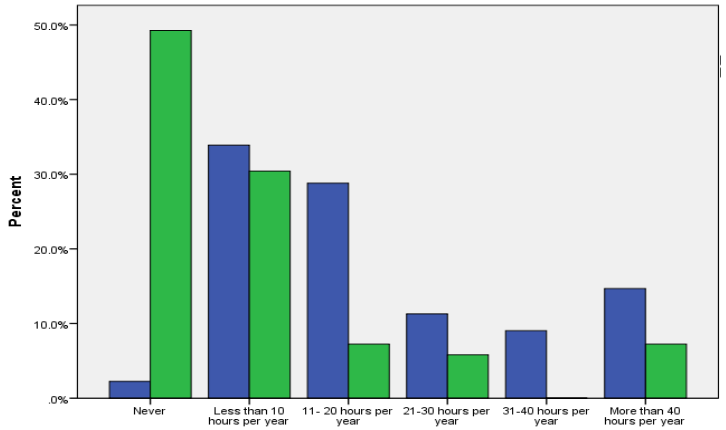
Small-medium enterprises (SMEs)

		E-learning	Shared Database	Online Meeting	Emailing
N	Valid	69	69	69	69
	Missing	0	0	0	0
Mean		1.99	2.78	1.68	2.54
Std. Error of Mean		0.17	0.19	0.15	0.17
Median		2.00	2.00	1.00	2.00
Mode		1.00	2.00	1.00	2.00
Std. Deviation		1.41	1.60	1.21	1.38
Variance		1.99	2.56	1.46	1.90
Skewness		1.78	0.75	1.94	0.86
Std. Error of Skewness		0.29	0.29	0.29	0.29
Kurtosis		2.58	-0.53	3.12	0.06
Std. Error of Kurtosis		0.57	0.57	0.57	0.57
Range		5.00	5.00	5.00	5.00

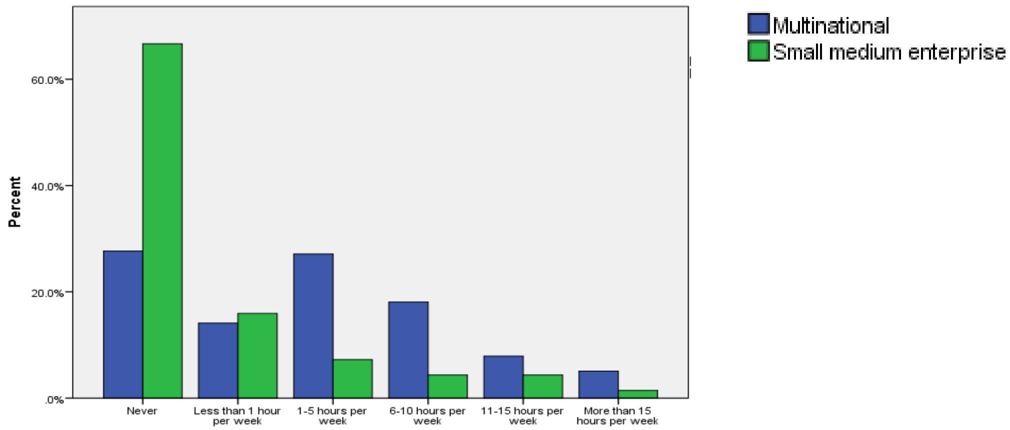
Multinationals companies (MNCs)

		E-learning	Shared Database	Online Meeting	Emailing
N	Valid	177	177	177	177
	Missing	0	0	0	0
Mean		3.35	4.17	2.80	3.60
Std. Error of Mean		0.11	0.11	0.11	0.08
Median		3.00	4.00	3.00	3.00
Mode		2.00	4.00	1.00	3.00
Std. Deviation		1.45	1.41	1.48	1.07
Variance		2.12	1.98	2.17	1.14
Skewness		0.67	-0.10	0.37	0.51
Std. Error of Skewness		0.18	0.18	0.18	0.18
Kurtosis		-0.78	-1.04	-0.73	-0.06
Std. Error of Kurtosis		0.36	0.36	0.36	0.36
Range		5.00	5.00	5.00	5.00

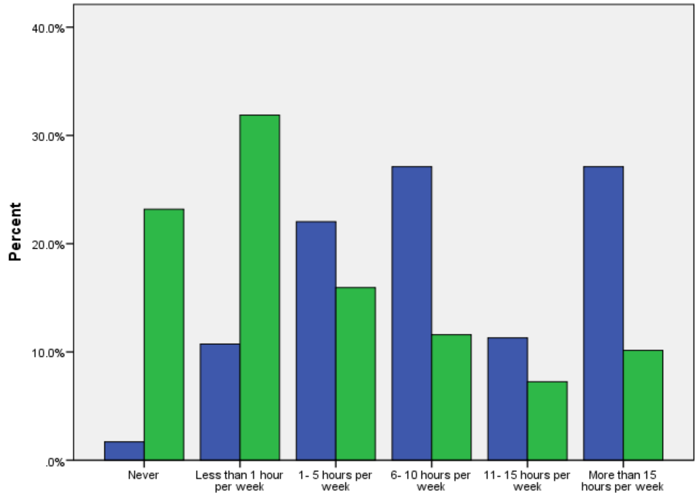
Appendix H – Graphs on hours spent on CNL (MNCs and SMEs)



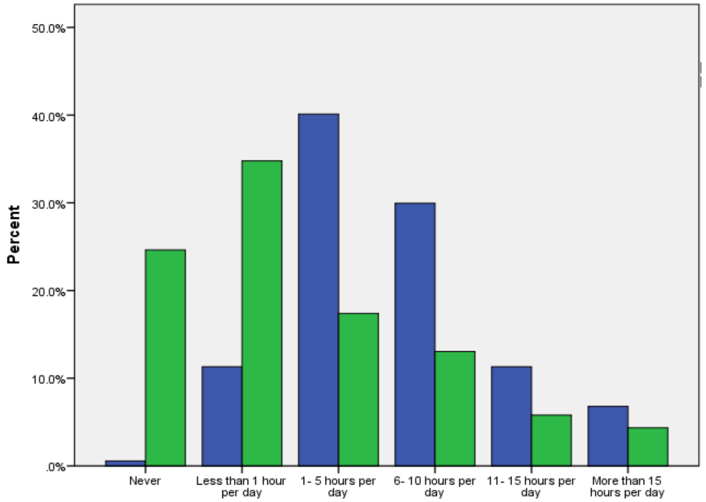
Hours spend on e-learning per year



Hours spend on tele-conferencing per week



Hours spend on shared database per week



Hours spend on email at work per day

Appendix I – Multiple regression stage 1

Model H1	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 Access to networked computer/email for work	.022	.084	.020	.260	.795	.279	3.589
B3 Access to training and learning through computer network	.317	.079	.310	3.992	.000	.263	3.807
B4 Access to on-line shared databases to facilitate work	.397	.055	.424	7.250	.000	.462	2.163
B5 Support from supervisor/manager to collaborate	.158	.072	.129	2.191	.029	.454	2.202
C1 Job requires to work in teams	.107	.077	.095	1.392	.165	.392	2.554
C3 Job requires to share ideas, work and information	.573	.073	.590	7.824	.000	.319	3.130
C4 Job can only be completed if other members complete theirs	.087	.065	.094	1.339	.182	.370	2.699
C5 Performance depends on the results of team	.018	.080	.018	.228	.820	.284	3.519
D1 Frequently share ideas, work and information	.209	.069	.210	3.031	.003	.285	3.503
D2 Frequently interact online with peers and team	.134	.084	.150	1.597	.112	.156	6.418
D3 Easily obtain help and support on-line	.201	.082	.220	2.446	.015	.169	5.908
D4 Frequently share on-line meetings or discussions	.122	.049	.145	2.462	.015	.397	2.520
D5 Team helps each other to learn and engage	.203	.060	.196	3.361	.001	.402	2.490
E1 Learn from shared information from the network	.402	.069	.411	5.806	.000	.272	3.680
E2 Receive training to enable me to collaborate effectively	.230	.064	.236	3.589	.000	.315	3.175
E3 Participate in improvement projects	.081	.057	.075	1.416	.158	.488	2.047
E5 Learn from my peers and team	.205	.063	.188	3.250	.001	.408	2.450
F1 Work efficiently through use of information from the network	.185	.075	.192	2.478	.014	.175	5.714
F2 Work interdependently using the computer network	.168	.085	.170	1.982	.049	.143	7.010
F3 Use computers to share information effectively	.106	.077	.107	1.375	.170	.175	5.707
F4 Team achieves goals using information from the network	.248	.081	.255	3.063	.002	.151	6.619
F5 Team produces good quality collaborative work	.205	.072	.202	2.857	.005	.211	4.733
G1 The network systems/tools are useful	.317	.093	.305	3.410	.001	.165	6.060
G2 The shared databases are useful	.222	.098	.210	2.272	.024	.154	6.495
G3 The on-line meetings/discussions with external parties are useful	.016	.047	.018	.337	.736	.472	2.120
G4 The network systems are useful for sharing information	.212	.080	.214	2.646	.009	.202	4.953
G5 The on-line learning systems are useful	.142	.062	.141	2.291	.023	.346	2.888

Appendix I – Multiple regression stage 1 (cont')

Model H2	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 I have access to networked computer/email for work with others	.206	.093	.182	2.223	.027	.279	3.589
B3 I have access to training and learning through computer network	.276	.087	.267	3.167	.002	.263	3.807
B4 I have access to on-line shared databases to facilitate my work	.250	.060	.264	4.163	.000	.462	2.163
B5 I have support from my supervisor/manager to collaborate with others	.156	.079	.126	1.973	.050	.454	2.202
C1 My job requires me to work in teams	.184	.077	.161	2.393	.017	.392	2.554
C3 My job requires me to share my ideas, work and information with others	.479	.073	.487	6.526	.000	.319	3.130
C4 My job can only be completed if other members complete theirs	.099	.065	.105	1.514	.131	.370	2.699
C5 My performance depends on the results of my team	.071	.080	.070	.888	.376	.284	3.519
D1 I frequently share ideas, work and information with others	.187	.070	.186	2.675	.008	.285	3.503
D2 I frequently interact with my peers and members in the team on-line	.335	.085	.369	3.915	.000	.156	6.418
D3 I can easily obtain help and support from my team/peers on-line	.098	.083	.106	1.176	.241	.169	5.908
D4 I frequently share information on-line meetings or discussions	.107	.050	.126	2.137	.034	.397	2.520
D5 Members in the team help each other to learn and engage	.123	.061	.117	1.997	.047	.402	2.490
E1 I learn from shared information from the network	.288	.080	.292	3.618	.000	.272	3.680
E2 I received training to enable me to collaborate effectively	.284	.074	.289	3.858	.000	.315	3.175
E3 I participate in improvement projects	.090	.066	.082	1.367	.173	.488	2.047
E5 I learn from my peers and members in the team	.206	.073	.186	2.835	.005	.408	2.450
F1 I work efficiently through use of information from the network	.089	.090	.091	.985	.326	.175	5.714
F2 I work interdependently using the computer network	.127	.103	.127	1.240	.216	.143	7.010
F3 I use computers to share information effectively with others	.359	.093	.356	3.848	.000	.175	5.707
F4 My team achieves goals for projects by using information from the network	.114	.098	.116	1.164	.245	.151	6.619
F5 My team produces good quality collaborative work	.167	.087	.162	1.926	.055	.211	4.733
G1 The network systems and tools are useful for my work	.141	.103	.134	1.365	.173	.165	6.060
G2 The shared databases are useful for my work	.212	.109	.199	1.955	.052	.154	6.495
G3 The on-line meetings/discussions with external parties are useful	.090	.053	.100	1.720	.087	.472	2.120
G4 The network systems are useful for sharing information	.284	.089	.282	3.175	.002	.202	4.953
G5 The on-line learning system and training are useful	.150	.069	.147	2.172	.031	.346	2.888

Appendix I – Multiple regression stage 1 (cont')

Model H3	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 Access to networked computer/email for work	.025	.091	.022	.270	.787	.279	3.589
B3 Access to training and learning through computer network	.350	.086	.340	4.079	.000	.263	3.807
B4 Access to on-line shared databases to facilitate work	.283	.059	.300	4.778	.000	.462	2.163
B5 Support from supervisor/manager to collaborate	.227	.078	.185	2.913	.004	.454	2.202
C1 Job requires to work in teams	.099	.076	.087	1.301	.194	.392	2.554
C3 Job requires to share ideas, work and information	.529	.072	.542	7.301	.000	.319	3.130
C4 Job can only be completed if other members complete theirs	.058	.065	.062	.905	.366	.370	2.699
C5 Performance depends on the results of team	.124	.079	.124	1.582	.115	.284	3.519
D1 Frequently share ideas, work and information	.084	.068	.084	1.245	.214	.285	3.503
D2 Frequently interact online with peers and team	.261	.083	.289	3.160	.002	.156	6.418
D3 Easily obtain help and support on-line	.053	.081	.058	.661	.509	.169	5.908
D4 Frequently share on-line meetings or discussions	.176	.049	.208	3.630	.000	.397	2.520
D5 Team helps each other to learn and engage	.309	.059	.297	5.218	.000	.402	2.490
E1 Learn from shared information from the network	.299	.073	.304	4.087	.000	.272	3.680
E2 Receive training to enable me to collaborate effectively	.294	.068	.300	4.343	.000	.315	3.175
E3 Participate in improvement projects	.103	.060	.095	1.708	.089	.488	2.047
E5 Learn from my peers and team	.216	.067	.197	3.240	.001	.408	2.450
F1 Work efficiently through use of information from the network	.342	.083	.352	4.139	.000	.175	5.714
F2 Work interdependently using the computer network	.076	.094	.076	.806	.421	.143	7.010
F3 Use computers to share information effectively	.092	.085	.092	1.078	.282	.175	5.707
F4 Team achieves goals using information from the network	.101	.089	.103	1.129	.260	.151	6.619
F5 Team produces good quality collaborative work	.278	.079	.271	3.507	.001	.211	4.733
G1 The network systems/tools are useful	.138	.097	.132	1.417	.158	.165	6.060
G2 The shared databases are useful	.177	.102	.167	1.730	.085	.154	6.495
G3 The on-line meetings/discussions with external parties are useful	.022	.049	.024	.442	.659	.472	2.120
G4 The network systems are useful for sharing information	.320	.084	.320	3.806	.000	.202	4.953
G5 The on-line learning systems are useful	.240	.065	.237	3.699	.000	.346	2.888

Appendix I – Multiple regression stage 1 (cont')

Model H4	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 Access to networked computer/email for work	.005	.125	.004	.039	.969	.279	3.589
B3 Access to training and learning through computer network	.362	.118	.309	3.076	.002	.263	3.807
B4 Access to on-line shared databases to facilitate work	.276	.081	.257	3.395	.001	.462	2.163
B5 Support from supervisor/manager to collaborate	.144	.107	.103	1.348	.179	.454	2.202
C1 Job requires to work in teams	.029	.104	.022	.277	.782	.392	2.554
C3 Job requires to share ideas, work and information	.459	.099	.413	4.629	.000	.319	3.130
C4 Job can only be completed if other members complete theirs	.111	.088	.104	1.258	.210	.370	2.699
C5 Performance depends on the results of team	.151	.108	.132	1.400	.163	.284	3.519
D1 Frequently share ideas, work and information	.094	.101	.082	.932	.352	.285	3.503
D2 Frequently interact online with peers and team	.308	.123	.300	2.513	.013	.156	6.418
D3 Easily obtain help and support on-line	.056	.120	.054	.471	.638	.169	5.908
D4 Frequently share on-line meetings or discussions	.260	.072	.269	3.599	.000	.397	2.520
D5 Team helps each other to learn and engage	.059	.088	.050	.668	.505	.402	2.490
E1 Learn from shared information from the network	.204	.106	.183	1.930	.055	.272	3.680
E2 Receive training to enable me to collaborate effectively	.248	.098	.223	2.534	.012	.315	3.175
E3 Participate in improvement projects	.344	.087	.278	3.947	.000	.488	2.047
E5 Learn from my peers and team	.061	.096	.049	.632	.528	.408	2.450
F1 Work efficiently through use of information from the network	.169	.129	.153	1.305	.193	.175	5.714
F2 Work interdependently using the computer network	.297	.147	.262	2.020	.044	.143	7.010
F3 Use computers to share information effectively	-.038	.134	-.034	-.287	.774	.175	5.707
F4 Team achieves goals using information from the network	.103	.140	.093	.739	.461	.151	6.619
F5 Team produces good quality collaborative work	.256	.124	.220	2.064	.040	.211	4.733
G1 The network systems/tools are useful	-.012	.144	-.010	-.085	.932	.165	6.060
G2 The shared databases are useful	.133	.151	.111	.882	.379	.154	6.495
G3 The on-line meetings/discussions with external parties are useful	.241	.073	.236	3.296	.001	.472	2.120
G4 The network systems are useful for sharing information	.147	.124	.129	1.182	.239	.202	4.953
G5 The on-line learning systems are useful	.300	.096	.261	3.122	.002	.346	2.888

Appendix I – Multiple regression stage 1 (cont')

Model H5	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 Access to networked computer/email for work	.157	.099	.141	1.588	.113	.279	3.589
B3 Access to training and learning through computer network	.236	.093	.231	2.538	.012	.263	3.807
B4 Access to on-line shared databases to facilitate work	.122	.064	.131	1.910	.057	.462	2.163
B5 Support from supervisor/manager to collaborate	.336	.084	.276	3.987	.000	.454	2.202
C1 Job requires to work in teams	.260	.080	.232	3.236	.001	.392	2.554
C3 Job requires to share ideas, work and information	.358	.077	.371	4.675	.000	.319	3.130
C4 Job can only be completed if other members complete theirs	.101	.068	.109	1.484	.139	.370	2.699
C5 Performance depends on the results of team	.082	.083	.083	.988	.324	.284	3.519
D1 Frequently share ideas, work and information	.162	.081	.164	2.011	.045	.285	3.503
D2 Frequently interact online with peers and team	.102	.098	.115	1.041	.299	.156	6.418
D3 Easily obtain help and support on-line	.029	.096	.032	.305	.761	.169	5.908
D4 Frequently share on-line meetings or discussions	.150	.058	.179	2.597	.010	.397	2.520
D5 Team help each other to learn and engage	.357	.071	.347	5.058	.000	.402	2.490
E1 Learn from shared information from the network	.133	.085	.137	1.569	.118	.272	3.680
E2 Receive training to enable me to collaborate effectively	.157	.078	.162	2.006	.046	.315	3.175
E3 Participate in improvement projects	.365	.070	.340	5.235	.000	.488	2.047
E5 Learn from my peers and team	.187	.077	.173	2.426	.016	.408	2.450
F1 Work efficiently through use of information from the network	.037	.104	.039	.360	.719	.175	5.714
F2 Work interdependently using the computer network	.047	.118	.047	.394	.694	.143	7.010
F3 Use computers to share information effectively	.160	.107	.161	1.490	.138	.175	5.707
F4 Team achieves goals using information from the network	.104	.113	.107	.920	.359	.151	6.619
F5 Team produces good quality collaborative work	.402	.100	.397	4.025	.000	.211	4.733
G1 The network systems/tools are useful	.251	.115	.242	2.182	.030	.165	6.060
G2 The shared databases are useful	.279	.121	.266	2.317	.021	.154	6.495
G3 The on-line meetings/discussions with external parties are useful	.039	.058	.043	.661	.509	.472	2.120
G4 The network systems are useful for sharing information	-.070	.099	-.071	-.703	.483	.202	4.953
G5 The on-line learning systems are useful	.292	.077	.292	3.811	.000	.346	2.888

Appendix J – Multiple regression stage 2

Model H1	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B3 Access to training and learning through computer network	.329	.065	.321	5.043	.000	.388	2.575
B4 Access to on-line shared databases to facilitate work	.402	.052	.429	7.761	.000	.516	1.939
B5 Support from supervisor/manager to collaborate	.160	.071	.131	2.244	.026	.461	2.170
C3 Job requires to share ideas, work and information	.720	.042	.741	17.262	.000	1.000	1.000
D3 Easily obtain help and support on-line	.286	.063	.313	4.542	.000	.291	3.442
D4 Frequently share on-line meetings or discussions	.130	.049	.154	2.627	.009	.401	2.495
D5 Team helps each other to learn and engage	.198	.061	.191	3.268	.001	.403	2.482
D1 Frequently share ideas, work and information	.258	.062	.260	4.178	.000	.357	2.799
E1 Learn from shared information from the network	.518	.063	.530	8.210	.000	.332	3.014
E2 Receive training to enable me to collaborate effectively	.216	.065	.222	3.302	.001	.305	3.275
E4 Learn from suppliers/customers or external parties	.140	.037	.165	3.816	.000	.735	1.360
F1 Work efficiently through use of information from the network	.292	.060	.302	4.851	.000	.279	3.590
F4 Team achieves goals using information from the network	.366	.071	.377	5.145	.000	.201	4.968
F5 Team produces good quality collaborative work	.235	.068	.231	3.433	.001	.240	4.170
G1 The network systems/tools are useful	.315	.093	.303	3.401	.001	.166	6.034
G2 The shared databases are useful	.226	.097	.214	2.336	.020	.156	6.395
G4 The network systems are useful for sharing information	.220	.077	.221	2.844	.005	.217	4.600
G5 The on-line learning systems are useful	.147	.060	.146	2.431	.016	.364	2.746

Appendix J – Multiple regression stage 2 (cont')

Model H2	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B2 Access to networked computer/email for work	.228	.093	.201	2.466	.014	.283	3.536
B3 Access to training and learning through computer network	.339	.082	.327	4.151	.000	.303	3.300
B4 Access to on-line shared databases to facilitate work	.270	.060	.285	4.525	.000	.475	2.104
C1 Job requires to work in teams	.240	.072	.211	3.340	.001	.455	2.199
C3 Job requires to share ideas, work and information	.569	.062	.580	9.202	.000	.455	2.199
D1 Frequently share ideas, work and information	.245	.066	.243	3.737	.000	.332	3.009
D2 Frequently interact online with peers and team	.417	.065	.460	6.378	.000	.271	3.688
D4 Frequently share on-line meetings or discussions	.151	.047	.178	3.219	.001	.462	2.163
E1 Learn from shared information from the network	.302	.079	.305	3.805	.000	.276	3.626
E2 Receive training to collaborate effectively	.301	.073	.306	4.130	.000	.324	3.090
E5 Learn from peers and team	.244	.067	.221	3.643	.000	.480	2.083
F3 Use computers to share information effectively	.780	.041	.773	19.055	.000	1.000	1.000
G4 The network systems are useful for sharing information	.550	.064	.548	8.587	.000	.416	2.405
G5 The on-line learning systems are useful	.267	.065	.263	4.118	.000	.416	2.405

Appendix J – Multiple regression stage 2 (cont')

Model H3	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B3 Access to training and learning through computer network	.364	.071	.352	5.156	.000	.388	2.575
B4 Access to on-line shared databases to facilitate work	.288	.056	.305	5.148	.000	.516	1.939
B5 Support from supervisor/manager to collaborate	.230	.077	.187	2.974	.003	.461	2.170
C3 Job requires to share ideas, work and information	.729	.042	.746	17.492	.000	1.000	1.000
D2 Frequently interact online with peers and team	.339	.052	.376	6.480	.000	.388	2.579
D4 Frequently share on-line meetings or discussions	.188	.046	.222	4.074	.000	.437	2.286
D5 Team helps each other to learn and engage	.345	.054	.331	6.423	.000	.491	2.037
E1 Learn from shared information from the network	.314	.073	.320	4.309	.000	.276	3.626
E2 Receive training to collaborate effectively	.313	.067	.320	4.667	.000	.324	3.090
E5 Learn from peers and team	.260	.062	.237	4.214	.000	.480	2.083
F1 Work efficiently through use of information from the network	.466	.058	.479	8.036	.000	.362	2.760
F5 Team produces good quality collaborative work	.403	.061	.394	6.599	.000	.362	2.760
G4 The network systems are useful for sharing information	.527	.060	.527	8.823	.000	.416	2.405
G5 The on-line learning systems are useful	.325	.060	.321	5.377	.000	.416	2.405

Appendix J – Multiple regression stage 2 (cont')

Model H4	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	S.E.	Beta			Tolerance	VIF
B3 Access to training and learning through computer network	.435	.082	.371	5.305	.000	.541	1.847
B4 Access to on-line shared databases to facilitate work	.299	.075	.279	3.993	.000	.541	1.847
C3 Job requires to share ideas, work and information	.673	.057	.605	11.884	.000	1.000	1.000
D2 Frequently interact online with peers and team	.434	.070	.422	6.161	.000	.472	2.117
D4 Frequently share on-line meetings or discussions	.295	.066	.307	4.473	.000	.472	2.117
E2 Receive training to collaborate effectively	.408	.070	.367	5.847	.000	.626	1.597
E3 Participate in improvement projects	.417	.077	.338	5.387	.000	.626	1.597
F2 Work interdependently using the computer network	.446	.088	.393	5.048	.000	.394	2.536
F5 Team produces good quality collaborative work	.339	.091	.291	3.739	.000	.394	2.536
G3 The on-line meetings/discussions with external parties are useful	.316	.067	.310	4.731	.000	.572	1.747
G5 The on-line learning system are useful	.447	.075	.389	5.938	.000	.572	1.747

Appendix J – Multiple regression stage 2 (cont')

Model H5	Unstandardized Coefficients B	Unstandardized Coefficients S.E.	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
B3 Access to training and learning through computer network	.406	.069	.399	5.853	.000	.484	2.067
B5 Support from supervisor/manager to collaborate	.399	.083	.328	4.816	.000	.484	2.067
C1 Job requires to work in teams	.321	.075	.286	4.277	.000	.455	2.199
C3 Job requires to share ideas, work and information	.456	.065	.472	7.051	.000	.455	2.199
D4 Frequently share on-line meetings or discussions	.254	.048	.304	5.272	.000	.598	1.672
D5 Team helps each other to learn and engage	.502	.059	.488	8.478	.000	.598	1.672
E3 Participate in improvement projects	.462	.068	.431	6.808	.000	.549	1.821
E5 Learn from peers and team	.341	.069	.315	4.977	.000	.549	1.821
F5 Team produces good quality collaborative work	.701	.047	.693	15.012	.000	1.000	1.000
G1 The network systems/tools are useful	.226	.108	.218	2.082	.038	.184	5.436
G2 The shared databases are useful	.269	.113	.257	2.371	.019	.173	5.780
G5 The on-line learning systems are useful	.292	.072	.292	4.078	.000	.395	2.534

Appendix K – Hierarchical coding scheme

Nodes	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded
Internal-External Learning	**5**	**123**	**12,214**	**151**
Internal-External Learning\internal learning	5	44	4,248	54
Internal-External Learning\external learning	4	35	3,718	43
Perceptions of Effectiveness and Usefulness	10	373	36,520	457
Perceptions of Effectiveness and Usefulness\ease of use	10	82	8,192	101
Perceptions of Effectiveness and Usefulness\effective	8	65	6,266	79
Perceptions of Effectiveness and Usefulness\relevant	8	65	6,266	79
Perceptions of Effectiveness and Usefulness\useful	10	77	6,997	94
Organizational Support	**11**	**1646**	**165,514**	**2,042**
Organizational Support\Functions and Capabilities	10	749	73,086	945
Organizational Support\Functions and Capabilities\accessible	8	64	6,224	79
Organizational Support\Functions and Capabilities\analysis	6	50	5,016	62
Organizational Support\Functions and Capabilities\automatic	6	50	4,751	63
Organizational Support\Functions and Capabilities\communication	3	23	3,008	30
Organizational Support\Functions and Capabilities\feedback	4	33	3,455	43
Organizational Support\Functions and Capabilities\linkage	7	58	5,603	71
Organizational Support\Functions and Capabilities\monitoring	4	32	3,420	42
Organizational Support\Functions and Capabilities\notification	5	42	3,729	52
Organizational Support\Functions and Capabilities\online	6	50	4,751	63
Organizational Support\Functions and Capabilities\real-time	3	25	2,875	33
Organizational Support\Functions and Capabilities\recording	4	34	2,707	49
Organizational Support\Functions and Capabilities\reporting	5	42	3,520	51
Organizational Support\Functions and Capabilities\revising	4	33	3,547	42
Organizational Support\Functions and Capabilities\archiving	5	43	4,206	54
Organizational Support\Functions and Capabilities\synthesis	4	35	2,975	42
Organizational Support\Functions and Capabilities\triggering	4	35	2,975	42
Organizational Support\Functions and Capabilities\updating	6	52	4,828	64

Appendix K – Hierarchical coding scheme (cont')

Nodes	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded
Organizational Support\Infrastucture and Systems	10	719	72,499	879
Organizational Support\Infrastucture and Systems\application system and collaborative technologies	7	161	17,838	200
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\Amorplus	1	7	810	8
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\AutoCad	2	15	1,659	19
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\chat room	1	8	1,114	10
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\email	3	25	2,528	29
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\E-Bulletin	1	8	1,231	12
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\Lotus	2	7	810	8
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\Netmeeting	1	8	1,114	10
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\others	2	14	1,355	17
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\Sharepoint	1	8	580	10
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\video-conf	1	8	1,114	10
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\spreadsheet	4	30	3,019	39
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\shared drive	3	19	1,333	22
Organizational Support\Infrastucture and Systems\application system and collaborative technologies\shared folder	4	34	3,322	42
Organizational Support\Infrastucture and Systems\enterprise system	9	283	27,769	344
Organizational Support\Infrastucture and Systems\enterprise system\work instruction	5	43	4,298	53
Organizational Support\Infrastucture and Systems\enterprise system\schematics	4	35	3,718	43
Organizational Support\Infrastucture and Systems\enterprise system\doc con system	3	27	2,487	31
Organizational Support\Infrastucture and Systems\enterprise system\ECM	5	43	4,298	53
Organizational Support\Infrastucture and Systems\enterprise system\ERP or MRP	10	79	7,9375	97
Organizational Support\Infrastucture and Systems\global system	6	101	10,603	126
Organizational Support\Infrastucture and Systems\global system\Accardin	1	8	1,114	10
Organizational Support\Infrastucture and Systems\global system\eCATS	2	17	1,202	20
Organizational Support\Infrastucture and Systems\global system\MES	2	16	2,345	22
Organizational Support\Infrastucture and Systems\global system\MyTech	1	9	530	11
Organizational Support\Infrastucture and Systems\global system\PDM	4	33	3,547	42
Organizational Support\Infrastucture and Systems\hardwares	5	38	3,565	46
Organizational Support\People	7	160	18,064	197
Organizational Support\People\IT and technical	7	57	5,771	69
Organizational Support\People\management	5	40	4,569	49
Organizational Support\People\peers	3	23	3,155	30

Appendix K – Hierarchical coding scheme (cont')

Nodes	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded
Positive Interdependence	8	480	46,455	590
Positive Interdependence\collaborating	6	50	4,869	62
Positive Interdependence\cooperating	5	43	4,206	54
Positive Interdependence\exchanging	5	96	9,163	119
Positive Interdependence\exchanging\both	4	35	2,975	42
Positive Interdependence\exchanging\exporting data	2	18	1,982	23
Positive Interdependence\exchanging\importing data	0	0	0	0
Positive Interdependence\sharing	8	241	23,348	293
Positive Interdependence\sharing\between departments	8	66	6,301	80
Positive Interdependence\sharing\between peers	7	59	5,638	72
Positive Interdependence\sharing\between sites	6	50	5,108	61
Promotive Interactions	9	980	92,877	1,196
Promotive Interactions\with people	9	309	28,839	378
Promotive Interactions\with people\engaging	7	59	5,491	72
Promotive Interactions\with people\learning	6	52	4,828	64
Promotive Interactions\with people\meeting	7	59	5,491	72
Promotive Interactions\with people\sharing	8	66	6,183	81
Promotive Interactions\with systems	9	612	58,547	746
Promotive Interactions\with systems\checking	7	59	5,373	73
Promotive Interactions\with systems\developing	5	40	4,569	49
Promotive Interactions\with systems\dispositioning	6	52	4,828	64
Promotive Interactions\with systems\evaluating	5	43	4,206	54
Promotive Interactions\with systems\extracting	6	52	4,828	64
Promotive Interactions\with systems\generating	7	59	5,638	72
Promotive Interactions\with systems\implementing	3	25	2,528	29
Promotive Interactions\with systems\programming	2	17	1,414	19
Promotive Interactions\with systems\revising	3	27	2,487	31
Promotive Interactions\with systems\transacting	6	49	4,539	60
Promotive Interactions\with systems\updating	8	66	6,183	81
Promotive Interactions\with systems\uploading	6	50	5,108	61