

**COGNITIVE AND METACOGNITIVE STRATEGIES  
IN READING SCIENTIFIC TEXTS AMONG  
ESL SCIENCE UNDERGRADUATES**

**SAMSIAH ABDUL HAMID**

**A thesis submitted for the fulfillment of  
the Degree of Doctor of Philosophy**

**June 2011**

## Synopsis

The present study employed both quantitative and qualitative data collection techniques to investigate the pattern of strategy use of high and low English proficiency science learners and the impact of metacognition, English proficiency and scientific prior knowledge on strategy use and reading comprehension of two scientific texts. Research instruments used include Metacognitive Awareness inventory (Schraw and Dennison, 1994), an 80-item Scientific Text Academic Reading Strategy (STARS) inventory, Scientific Prior Knowledge inventory, two scientific texts of different syntactic difficulty and topic familiarity, and three different measures of reading comprehension of scientific texts. Think-aloud methods and retrospective interviews were utilized to collect the qualitative data of five case studies.

The major findings from the quantitative study indicate that L2 proficiency contributes in the range of 5.2% to 24.3% to the variance in second language reading comprehension of scientific texts, higher cognitive strategies, in particular summarizing and analyzing visual diagrams, contribute another 11%, and the knowledge of scientific terminology contributes some 1.5% to 2.2%. In sum, the findings reveal that the contribution of L2 proficiency to the reading comprehension of scientific texts increases with the increase of readers' proficiency and texts difficulty. The evidence gathered from the quantitative and qualitative data shows that L2 proficiency remains the pre-requisite for reading and understanding L2 scientific texts but it is not the ultimate predictor of good L2 readers of the text.

One surprising finding is the role of metacognitive awareness as a predictor to the reading comprehension of a scientific text. It was found that high metacognitive awareness possessed by ESL readers could be stymied by their low L2 proficiency and lack of independent reading practice, thus render it ineffective. The data of this study also indicated that in reading scientific texts, scientific prior knowledge, as opposed to general prior knowledge, is crucial to reading comprehension and scientific prior knowledge is not vigorously accessed when it exists in abundance but when it does not. Finally the thesis discusses the theoretical and pedagogical significance of the study and provides suggestions for future research.

## Sinopsis

### **Strategi Kognitif dan Metakognitif dalam Pembacaan Teks Saintifik di Kalangan Mahasiswa Jurusan Sains Yang Menggunakan Bahasa Inggeris Sebagai Bahasa Kedua**

Kajian ini menggunakan kaedah penyelidikan kuantitatif dan kualitatif untuk meniasat corak penggunaan strategi pembacaan di kalangan penuntut sains yang fasih dan kurang fasih berbahasa Inggeris dan juga kesan metakognisi, kemahiran berbahasa Inggeris sebagai bahasa kedua, dan pengetahuan saintifik sedia ada terhadap penggunaan strategi pembacaan dan kefahaman. Instrumen kajian yang digunakan termasuk inventori Kesedaran Metakognisi (Schraw and Dennison, 1994), inventori Kesedaran Strategi Pembacaan Teks Akademik Saintifik (STARS), inventori Pengetahuan Saintifik Sedia ada, dua teks saintifik yang berlainan tajuk serta tahap kesukaran dari segi struktur bahasa, dan tiga kaedah pengukuran tahap kefahaman bacaan teks saintifik. Kaedah *think-aloud* dan interview digunakan untuk mengumpul data kualitatif dari lima kajian kes.

Dapat kajian yang utama daripada data kuantitatif mendapati bahawa kemahiran bahasa kedua menyumbang di antara 5.2% dan 24.3% kepada kefahaman bacaan teks saintifik, strategi aras kognitif tinggi seperti strategi meringkas dan memahami gambarajah menyumbang sehingga 11%, dan pengetahuan tentang terma saintifik menyumbang sebanyak 1.5% hingga 2.2%. Secara ringkasnya, dapatan kajian menunjukkan bahawa sumbangan kemahiran bahasa kedua kepada kefahaman bacaan teks saintifik meningkat secara berkadar terus dengan peningkatan kemahiran bahasa kedua pembaca dan juga peningkatan tahap kesukaran teks bacaan. Dapatan daripada kedua-dua data kuantitatif dan kualitatif menunjukkan bahawa kemahiran bahasa kedua

kekal sebagai pra syarat kepada pembacaan dan kefahaman teks saintifik tetapi ianya bukanlah peramal utama dalam menentukan seseorang sebagai pembaca teks saintifik yang baik.

Satu dapatan yang di luar jangkaan adalah peranan kesedaran metakognisi sebagai penentu kepada kefahaman bacaan teks saintifik. Kajian mendapati bahawa tahap kesedaran metakognisi yang tinggi dalam diri pembaca bahasa Inggeris sebagai bahasa kedua mungkin menjadi kurang berkesan jika pembaca tersebut mempunyai kemahiran bahasa Inggeris yang rendah dan juga kurang latihan membaca secara bersendirian/berdikari. Data juga menunjukkan bahawa pengetahuan saintifik adalah amat penting dalam kefahaman bacaan teks saintifik berbanding dengan pengetahuan umum. Pengetahuan saintifik sedia ada yang banyak tidak akan diakses secara sedar dan bersungguh-sungguh oleh pembaca tetapi sebaliknya apabila pengetahuan itu kurang, kadar ianya akan cuba diakses akan bertambah untuk meningkatkan kefahaman. Akhir sekali, tesis ini membincangkan tentang signifikan kajian dari sudut teori dan pedagogi dan seterusnya menyarankan beberapa cadangan untuk kajian akan datang.

## **Acknowledgements**

I would first like to express my sincere and heartfelt appreciation to my supervisor, Prof. Dr. Moses Samuel, for his guidance, encouragement, patience, and the countless hours of discussions as I completed my four years of doctoral programme. Dr. Moses, your professional advice, friendly remarks and remarkable insights have made significant contributions to the outcome of this study.

I am indebted to Prof. Dato' Dr. Sulaiman Md. Yassin, who then was the Rector of Kolej Universiti Sains dan Teknologi Malaysia, Assoc. Prof. Dr. Fauziah Abu Hassan, the Dean of Faculty of Management and Economics (KUSTEM), and a dear colleague, Assoc. Prof. Mohd Nordin Abdullah for their kind encouragement, strong support and vote of confidence in me to pursue my doctoral study. I am also grateful to Prof. Dr. Fatimah Hashim, Prof. Dr. Hycinth Gaudart, and Prof. Dr. Suradi Salim of University Malaya whose constructive comments, valuable suggestions, and generous recommendations during the proposal vetting helped me to improve on some sections of the proposal which had a positive impact on my data collection procedure. I would also like to express my deepest gratitude to Assoc. Prof. Dr. Koshy Philips (UM), Assoc. Prof. Dr. Jennifer Ann Harikrishna (UM), Dr. Stephen Rossiter (University of London), Dr. Deboleena Roy (San Diego State University), Dr. Noraznawati Ismail (UMT), Dr. Mariam Taib (UMT), Dr. Noor Rohana Mansor (UMT), and Encik Nawis Ismail (SM Teknik Terengganu). Thank you for spending your precious hours looking through and providing invaluable feedbacks on the many research instruments that I sent to you by hand or via email even though I was a total stranger to some of you.

I would also like to thank the following individuals for their generosity and help in establishing the tie between myself and the respondents of this study. Thank you to the Deans of Faculty of Science and Technology in UMT, UKM, USM, and UM as well as Dr. Sudesh Kumar (USM), Dr. Sahidan Senafi (UKM), Dr. Nazlina Ibrahim (UKM), Dr. Endom Ismail (UKM), Dr. Hii (UMT), Cik Nur Fariza (UMT), Encik Abdul Razak Hussein (UKM), Puan Nyonya (UKM), Cik Noor Soffalina Sofian Seng (UKM), Mr Kesaven and Miss Nanthini (USM), science officers in the School of Biological Sciences, USM, and countless other names whose kind souls have made it possible for me to conduct my study in the respective universities with much ease. My sincere thanks also go to the respondents, without their cooperation this study could not have been undertaken.

I am also indebted to my many old and new found friends for being meticulous inter-coders, inter-raters, statistical data analysts, back translator and some for just being there sharing the pains and joys of postgraduate life.

My deepest thanks go to my husband, Md Nasir b Ismail, whose love, understanding, and support has enhanced my determination and persistence in completing this study. I would also like to show my gratitude to my sisters, especially Paizah who kindly shared with me her philosophical insights, caring voice, encouraging advice, comfortable lodging and transportation, and inexhaustible anecdotes throughout my four years of study in Kuala Lumpur. To my children, thank you for your understanding, patience, love and prayer for me even though I was not always there for you these last four years. Your love and affection have given me the strength and motivation to pursue this arduous journey to the end.

# TABLE OF CONTENTS

	Page
<b>Synopsis</b>	ii
<b>Synopsis in Malay</b>	iv
<b>Acknowledgements</b>	vi
<b>Table of Contents</b>	viii
<b>List of Tables and Figures</b>	xvii
<b>List of Appendices</b>	xxii
<b>CHAPTER ONE: INTRODUCTION</b>	
1.1 Overview	1
1.2 Human capital development in science and technology	1
1.3 Reading difficulty of academic texts at tertiary level	4
1.4 Problem statement	12
1.5 Research objectives	16
1.6 Research questions	18
1.7 Significance of the study	19
1.8 Definition of terms	23
1.9 Chapter summary	25
<b>CHAPTER TWO: THEORETICAL FRAMEWORK</b>	
2.1 Overview	27
2.2 Key theories in reading comprehension processes	27
2.3 The Reading Theory	28
2.3.1 Bottom-up Reading Model	29
2.3.2 Top-down Reading Model	30
2.3.3 Interactive Reading Model	32
2.3.4 Stanovich's Interactive Compensatory Reading Model	33

2.4	The Schema Theory	35
2.5	The Metacognition Theory	39
2.5.1	Metacognitive knowledge	39
2.5.2	Metacognitive experience	42
2.6	Theoretical framework	43
2.7	Chapter summary	45

### **CHAPTER THREE: THE REVIEW OF RELATED LITERATURE**

3.1	Overview	46
3.2	Scientific text	46
3.3	Comprehension strategies and reading	54
3.4	Types of comprehension strategies in reading	56
3.5	Cognitive strategies and reading	59
3.5.1	Cognitive strategies in L2 reading research	61
3.5.2	Cognitive strategies in reading scientific texts	66
3.6	Metacognition and reading	70
3.7	Metacognitive strategies and reading	72
3.7.1	Metacognitive awareness & strategies in L2 reading research	74
3.7.2	Metacognitive awareness & strategies in science education	79
3.7.3	Comprehension monitoring in L2 reading and science education research	83
3.8	L2 proficiency and comprehension strategies in L2 reading research	87
3.9	Prior knowledge and comprehension strategies in L2 reading research	99
3.10	Chapter summary	102

## **CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY**

4.1	Overview	103
4.2	Research design	104
4.3	Research sample	105
4.3.1	Sampling criteria	105
4.3.2	Research population	107
4.3.3	Research sample for quantitative survey	107
4.3.4	Research sample for qualitative study	109
4.4	Research instruments	111
4.4.1	Selections of scientific texts	111
4.4.1.1	Criteria for text selection	112
4.4.1.2	Reliability and validity of scientific texts as research instruments	117
4.4.1.3	Piloting three selected scientific texts	119
4.4.2	Reading comprehension assessments	121
4.4.2.1	Rationale for choosing types of reading comprehension tests	123
4.4.2.2	Free recall protocol versus written summary Protocol	124
4.4.2.3	MC questions and MTF statements	126
4.4.3	Metacognitive Awareness Inventory (MAI)	129
4.4.4	Scientific Prior Knowledge Inventory (SPKI)	131
4.4.4.1	Rationale for using true-false statements for SPKI	133
4.4.5	Malaysian University English Language Test (MUET)	135
4.4.6	Scientific Texts Academic Reading Strategies Inventory (STARS)	136
4.4.6.1	Items assessing metacognitive strategies	137
4.4.6.2	Items assessing higher and lower cognitive strategies	138

4.5	Research instruments for qualitative data	139
4.5.1	Overview of qualitative data collection technique	139
4.5.1.1	Think aloud training session	141
4.5.1.2	Think aloud procedure & semi structured retrospective interview	143
4.6	Research procedures and administrations of tests	144
4.6.1	Quantitative data collection	145
4.6.2	Rationale for the order of research instruments	147
4.6.3	Qualitative data collection	149
4.7	Pilot study	150
4.7.1	Quantitative study	151
4.7.1.1	Reliability and validity of research instruments	152
(a)	Reading comprehension assessment of texts A (RCA) and text B (RCB)	152
(b)	Metacognitive Awareness Inventory	153
(c)	Scientific Prior Knowledge Inventory	155
(d)	Malaysian University English Test (MUET)	156
(e)	STARS Inventory	157
4.7.2	Qualitative study	160
4.7.2.1	Think aloud training session, think aloud procedure & semi structured retrospective interview	160
4.7.2.2	Pilot think aloud procedure & semi structured retrospective interview	162
4.8	Procedures of data analyses	164
4.8.1	Screening of data and assessing normality	164
4.8.1.1	Identifying missing data	164
4.8.1.2	Determining univariate & multivariate outliers	164
4.8.1.3	Assessing normality	167

4.8.2	Descriptive and inferential statistics for quantitative data	170
4.8.3	Transcribing and coding protocols	175
4.9	Chapter summary	178

## **CHAPTER 5: DATA ANALYSES AND FINDINGS OF QUANTITATIVE DATA**

5.1	Overview	180
5.2	Preliminary issues and considerations: Allocating respondents into two L2 proficiency groups and three university groupings	182
5.2.1	Issue 1: L2 proficiency groups	183
5.2.2	Issue 2: Lack of correlations between strategy use and reading comprehension in HP and LP learners (n=336)	184
5.2.3	Allocating respondents into universities PQ, R, and S	188
5.3	Research Question 1: The contribution of metacognition to strategy use and reading comprehension of two scientific texts	192
5.3.1	Metacognitive awareness possessed by HP and LP learners in three university groupings	192
5.3.2	The relationship between metacognitive awareness and reading strategies	195
	Summary of findings	
5.3.3	The relationship between metacognitive awareness and specific reading strategies	198
	Summary of findings	
5.3.4	Reading comprehension scores of two scientific texts among HP and LP learners in three university groupings	203
5.3.5	The relationship between metacognitive awareness and reading comprehension of two scientific texts	206
	Summary of findings	
5.4	Research Question 2: The contribution of scientific prior knowledge to strategy use and reading comprehension of two scientific texts	209
5.4.1	Scientific prior knowledge possessed by learners in three university groupings	210
5.4.2	Scientific prior knowledge possessed by HP and LP learners in three university groupings	213

5.4.3	The relationship between scientific prior knowledge and reading strategies	216
	Summary of findings	
5.4.4	The relationship between scientific prior knowledge and specific reading strategies possessed by LP learners in Univ R and S	221
	Summary of findings	
5.4.5	The relationship between scientific prior knowledge and reading comprehension of two scientific texts	226
	Summary of findings	
5.5	Research Question 3: The contribution of L2 proficiency to strategy use and reading comprehension of two scientific texts	233
5.5.1	Cognitive and metacognitive strategies used by ESL learners with different L2 proficiency levels	233
5.5.2	The relationship between L2 proficiency and Reading Strategies among ESL undergraduates (N = 336)	236
	Summary of findings	
5.5.3	The relationship between L2 proficiency and specific strategies in among ESL learners in the three university groupings	239
	Summary of findings	
5.5.4	The relationship between L2 proficiency and reading comprehension of two scientific texts	245
	Summary of findings	
5.6	Research Question 4: The contribution of specific cognitive and metacognitive strategies to reading comprehension of the two scientific texts	253
5.6.1	Overall metacognitive, higher cognitive and lower cognitive strategies used by HP and LP learners	254
	Summary of findings	
5.6.2	The contribution of specific cognitive and metacognitive strategies to reading comprehension of scientific texts	263
	Summary of findings	

5.7	Research Question 5: The independent variable(s) that contributed to reading comprehension of two scientific texts	275
	Summary of findings	
5.8	Research Question 6: Characteristics of good ESL readers of scientific texts	281
5.8.1	Characteristics of good readers of text A and good readers of text B	281
5.8.2	Characteristics of good readers of scientific texts	290
5.8.3	Characteristics of HP good readers versus LP good readers	297
	Summary of findings	
5.9	Chapter summary	305

## **CHAPTER 6: DATA ANALYSES AND FINDINGS OF FIVE CASE STUDIES**

6.1	Overview	306
6.2	Respondents' profile	307
6.2.1	Respondent # 1: Az	308
6.2.2	Respondent # 2: Zeti	310
6.2.3	Respondent # 3: Di	313
6.2.4	Respondent # 4: Wan	315
6.2.5	Respondent # 5: Riz	318
6.3	Research Question 7: Reading strategies used by five ESL science undergraduates as revealed by the Think Aloud Protocol	322
6.3.1	General strategy use to read two scientific texts	322
6.3.2	Strategy shift while reading scientific text A and scientific text B	326
6.3.3	Reading strategies used by five ESL science undergraduates	329

6.3.4	The interactions of L2 proficiency, reading strategies and reading comprehension of the five ESL undergraduates	338
	(a) L2 proficiency and reading comprehension scores	339
	(b) Metacognitive strategies and reading comprehension scores	341
	(c) Cognitive strategies and reading comprehension scores	342
	(d) Synthesis on the interplay of all strategies and the effects on reading comprehension scores	344
	(e) Common HC strategies frequently used by good and poor readers of scientific texts A and B	346
	Summary of findings	
6.4	Research Question 8: Difficulties and problems faced by the five ESL readers while reading two scientific texts	352
6.4.1	Problematic general English words and familiar scientific terminology	352
6.4.2	Long and complex general and scientific English sentences	360
6.4.3	Unfamiliar scientific concepts	373
	Summary of findings	
6.5	Chapter summary	380
 <b>CHAPTER 7: DISCUSSION AND CONCLUSION</b>		
7.1	Overview	381
7.2	Summary of research design	381
7.3	Discussion of research findings	383
7.3.1	The role of metacognitive awareness in strategy use and reading comprehension of scientific texts	384
7.3.2	The contribution of scientific prior knowledge on strategy use and reading comprehension of scientific texts	388
7.3.3	The contribution of L2 proficiency on strategy use and reading comprehension of scientific texts	396
7.3.4	Variables that predict L2 reading comprehension of scientific texts	403

7.3.5	The characteristics of good ESL readers of scientific texts	407
7.3.6	Reading comprehension difficulties and strategies employed to overcome comprehension problems	412
7.4	Significance and implications	417
7.4.1	Theoretical significance	417
7.4.2	Pedagogical implications	419
7.5	Limitations, suggestions, and conclusion	423
7.5.1	Limitations of the study	423
7.5.2	Suggestions for future research	424
7.6	Chapter summary	426
	<b>REFERENCES</b>	427
	<b>APPENDICES</b>	488

## LIST OF TABLES

Table 4.1	Respondent Turn Over Based on Institution, Age, Gender and Degree Programme	108
Table 4.2	Profile of the Ten Selected Respondents for the Qualitative Study	110
Table 4.3	Flesch Reading Ease, U.S Educational Level and Reading Materials	114
Table 4.4	Flesch Reading Ease, Flesch-Kincaid Grade Level and Easy-Difficult Reading Scale	114
Table 4.5	Seven Scientific Texts for Selection	115
Table 4.6	Subscales and Item Numbers Assessing Metacognitive Strategies	137
Table 4.7	Subscales and Item Numbers Assessing HC and LC Strategies	138
Table 4.8	Source of Items for STARS Inventory	157
Table 4.9	Multivariate Outliers Based on Mahalanobis Distance across 33 Independent Variables	165
Table 4.10	Cases Deleted for Incomplete Information	167
Table 4.11	The Results of Skewness, Kurtosis and z-Scores of 7 Independent Variables	168
Table 5.1	Frequency and Percentage of English Language (L2) Proficiency among First Year ESL Science Undergraduates	183
Table 5.2	Descriptive Statistics and Independent T-tests on Strategies Used by HP and LP Learners to Read Two Scientific Texts (n=336)	185
Table 5.3	Paired Samples T-Test on Strategies Used to Read Texts A and B	186
Table 5.4	Correlations between Types of Strategies and Reading Comprehension Scores	187
Table 5.5	Common Traits of Respondents in Four Universities	189
Table 5.6	Correlations between Strategies and Reading Comprehension Scores in Univ PQ, R, and S	190
Table 5.7	Means and Standard Deviations of Three Measures of Metacognition for Collective Group (n=334) and in Univ PQ, R and S	193
Table 5.8	Metacognitive Awareness Scores of Undergraduates Reported in Previous Studies	194

Table 5.9	MANOVA for Metacognition Scores in HP and LP Learners in Univ PQ, R and S	195
Table 5.10	Correlations between Metacognition and Reading Strategies Among HP and LP Learners	196
Table 5.11	Pearson Correlations between Metacognition and Specific Reading Strategies (Text A) among HP and LP Learners	200
Table 5.12	Pearson Correlations between Metacognition and Specific Reading Strategies (Text B) among HP and LP Learners	201
Table 5.13	MANOVA and Mean Scores of Reading Comprehension Measures Obtained by HP and LP Learners in Univ PQ, R and S	204
Table 5.14	Pearson Correlations between Metacognition and Reading Comprehension Among HP and LP Learners	207
Table 5.15	Descriptive Statistics on Means of Scientific Prior knowledge of Texts A and B	211
Table 5.16	Means of SPK Possessed by ESL Learners in Univ PQ, R and S	211
Table 5.17	Means of SPKI and Its Sub Categories Possessed by HP and LP Learners in Univ PQ, R and S	213
Table 5.18	Correlations between Three Types of Strategies Used by HP and LP Learners and Four Measures of SPK (N = 336)	216
Table 5.19	Correlations between Strategy Use and Measures of SPK among HP and LP Learners in Univ PQ, R and S	218
Table 5.20	Pearson Correlations between Specific HC Strategies Used by Univ R/LP learners (N = 37) and Measures of SPK	221
Table 5.21	Correlations between Specific Strategies Used by S/LP Learners (N = 71) and Measures of SPK	224
Table 5.22	Independent T-test on SPK Possessed and Reading Comprehension Scores Obtained by HP and LP Learners	226
Table 5.23	Correlations between the Measures of SPK and Reading Comprehension Scores in the Collective Group (n=336)	228
Table 5.24	Correlations between the Measures of SPK and Reading Comprehension Scores in HP and LP Learners	228
Table 5.25	Descriptive Statistics and Results of MANOVA on Reading Comprehension Scores and SPK across Three University groupings	230

Table 5.26	Correlations between the Measures of SPK and Reading Comprehension Scores in Univ PQ, R and S	231
Table 5.27	Descriptive Statistics and MANOVA on Strategies Used by ESL Science Undergraduates (N=336) with Different Levels of L2 Proficiency	234
Table 5.28	Correlations between L2 Proficiency and Strategy Use in Two Reading Tasks	236
Table 5.29	Correlations between L2 Proficiency and Specific LC Strategies	238
Table 5.30	Correlations between L2 Proficiency and Specific LC Strategies across Three University Groupings	240
Table 5.31	Descriptive Statistics and One-Way ANOVA on L2 Proficiency across Three University Groupings	243
Table 5.32	Reading Comprehension Scores and MANOVA among Four L2 Proficiency Groups	245
Table 5.33	Correlations between L2 Proficiency and Four Measures of Reading Comprehension	248
Table 5.34	The Means of L2 Proficiency and Four Measures of SPK Obtained by HP and LP Learners in Univ PQ, R and S	250
Table 5.35	Descriptive Statistics and Independent T-Tests on MC, HC and LC Strategies Used by the HP and LP Groups When Reading Two Scientific Texts	255
Table 5.36	MANOVA for MC, HC and LC Strategies Used to Read Scientific Texts A and B across Three University Groupings	257
Table 5.37	Post Hoc Test for HC Strategies Used in Reading Text A (LSD test) among LP Learners across Three University Groupings	258
Table 5.38	Paired Samples T-Test on the Mean Scores of Strategies Used to Read texts A and B	260
Table 5.39	Correlations between Three Types of Strategies and RCA and RCB in HP and LP Learners in Univ PQ, R and S	264
Table 5.40	Pearson Correlations between Specific Strategies Utilized by HP Learners and RCA and RCB	265
Table 5.41	Pearson Correlations between Specific Strategies Utilized by LP Learners and RCA and RCB	268
Table 5.42	Summary of Stepwise Multiple Regression Analysis for Variables Predicting Reading Comprehension Scores of Scientific Text A (RCA)	275

Table 5.43	Summary of Stepwise Multiple Regression Analysis for Variables Predicting Reading Comprehension Scores of Scientific Text B	277
Table 5.44	Means and Independent T-Tests on Variables of LP Good and HP Poor Readers While Reading Scientific Text A	285
Table 5.45	Means and Independent T-Tests on Variables of LP Good and HP Poor Readers While Reading Scientific Text B	287
Table 5.46	Means and Independent T-Tests on Variables of Good and Poor Readers of Scientific Texts	292
Table 5.47	Means and Independent T-Tests on MC and HC Strategies Utilized by Good and Poor Readers	294
Table 5.48	Means and Independent T-Tests on LC Strategies Utilized by Good and Poor Readers of Scientific Texts	296
Table 5.49	Descriptive Statistics and Independent T-Tests on Variables Possessed and Utilized by HP and LP Good Readers of Scientific Texts	300
Table 5.50	Means of Specific Strategies Utilized by HP and LP Good Readers to Read Two Scientific Texts	301
Table 6.1	Respondents' Profile	307
Table 6.2	Frequency and Percentage of Specific Types of Strategies Used to Read Scientific Texts A and B	323
Table 6.3	The Most to the Least Frequently Used Strategies while Reading Scientific Texts A and B	327
Table 6.4	Specific Strategies Employed by Five ESL Undergraduates When Reading Scientific Texts A and B	330
Table 6.5	Reading Comprehension Scores and Summary of Strategies Used by Five ESL Undergraduates	339
Table 6.6	Frequently Used HC Strategies to Read Texts A and B by Good and Poor ESL Readers	347
Table 6.7	Reported Easy and Difficult Word/Phrases in Scientific Texts A and B	353
Table 6.8	Difficult Sentences in Scientific Texts A and B Identified by Five ESL Respondents	361

## LIST OF FIGURES

Figure 2.1	Theoretical framework of the study	43
Figure 3.1	Model of an ESL reader (Coady, 1979; p. 7)	100
Figure 4.1	Variables and research instruments in the research construct of L2 reading comprehension of scientific texts	111
Figure 5.1	SPK scores possessed by HP and LP learners in Univ PQ, R and S	215
Figure 5.2	Estimated mean from MANOVA of MC, HC and LC Strategies while Reading Scientific Text A	235
Figure 5.3	Estimated mean from MANOVA of MC, HC and LC strategies while reading scientific text B	235
Figure 5.4	Estimated mean from MANOVA of four measures of reading comprehension among four L2 proficiency groups	247
Figure 5.5	Estimated mean of four measures of reading comprehension of scientific texts A and B in HP and LP learners	249
Figure 5.6	Estimated mean of MC, HC and LC strategies used by HP and LP learners while reading scientific text A	259
Figure 5.7	Estimated mean of MC, HC and LC strategies used by HP and LP learners while reading scientific text B	259
Figure 5.8	Mean scores of reading comprehension of text A (RCA) and text B (RCB) obtained by good and poor readers in HP and LP groups	282
Figure 5.9	MC, HC, and LC strategies utilized by HP/LP good readers and HP/LP poor readers in reading scientific texts A and B	284
Figure 5.10	Mean scores of reading comprehension measures of text A (RCA, WSA) and text B (RCB, WSB) obtained by good and ESL poor readers	290
Figure 5.11	Mean scores of reading comprehension of text A (RCA) and text B (RCB) obtained by good HP and LP readers	298

## LIST OF APPENDICES

A1	Government circular on the implementation of EST paper in all secondary schools	488
A2	Government circular on the announcement of teaching science and mathematics in English	489
B1	Sample letter requesting expert advice	492
B2	Assessment of scientific texts	494
C1	Text A: Auxins and Elongation of Cells	497
C2	Text B: Hormones and Signal Transduction	502
D1	Written summary instruction for RCA and RCB & mark scheme for inter-raters	507
D2	MCQ and MTF for RCA and RCB	513
E	Metacognitive Awareness Inventory	521
F	Scientific Prior Knowledge Inventory (SPKI)	528
G	Scientific Texts Academic Reading Strategies (STARS) Inventory	533
H	Semi Structured Retrospective Interview Questionnaire	544
I	Transcript on Think Aloud Procedure	548
I2	Practice 1 - <i>Innate Biological Clocks and Photoperiod of Plants</i>	554
J	Letters of Permission from UM, USM, UKM, UMT	558
L	Email correspondence with Dr Roy and Dr Rossiter	563
	Dr. Koshy Philips assessments of instruments	
M	Table 1 factor loading for each item in MAI	567
	Table 2 factor loading for each item in STARS inventory	
N	Letter requesting back translation	569
O	Letters to Malay language experts	570
P1	Short Practice Text 1 with stop sign (⊖)	572
P3	Texts A and B used for TAP with stop sign (⊖)	573

Q	Sample of TAP transcript with 5 columns for inter-raters	578
R1	Coding Scheme for TAP	579
R2	Detailed description of coding scheme	581
R3	Inter-raters and inter-coders' qualifications	586
R4	Coding sample (respondent Yusuf Majid)	587
S	Table 5S1 Independent t-test on L2 Proficiency between HP and LP learners	588
T	Tables 5T1 – 5T4 Pearson correlation analysis between metacognitive awareness and specific reading strategies in HP and LP learners	589
U	Table 5U1 Post hoc LSD test for HP learners in Univ PQ, R, and S	597
V	Tables 5V1 -5V5 On Scientific Prior Knowledge	603
W	Table 5W1 Post-hoc LSD test for LC strategies across four L2 proficiency groups	609
	Table 5W2 Post Hoc Test for Three Measures of Reading Comprehension	610
X	Table 5X1 Independent T-Tests on Strategies Used to Read Scientific Text A between HP Good and LP Good readers	612
	Table 5X2 Independent T-Tests on Strategies Used to Read Scientific Text B between HP Good and LP Good Readers	613