



**UNIVERSITI PUTRA MALAYSIA**

**SCIENCE LABORATORY DYNAMICS AND ACQUISITION OF  
SCIENCE PROCESS SKILLS AMONG FORM FOUR  
SCIENCE FEMALE STUDENTS**

**SAROJINI DEVI A/P ALGARETNAM**

**FPP 2003 4**



**SCIENCE LABORATORY DYNAMICS AND ACQUISITION OF  
SCIENCE PROCESS SKILLS AMONG FORM FOUR  
SCIENCE FEMALE STUDENTS**

**By**

**SAROJINI DEVI A/P ALGARETNAM**

**Thesis Submitted to the School of Graduate Studies,  
Universiti Putra Malaysia, in Fulfilment of the Requirement for  
the Degree of Doctor of Philosophy**

**June 2003**



**Especially for my late father, Mr. K.Alagaretnam,  
who encouraged me to excel.**



Abstract of thesis presented to the Senate of  
Universiti Putra Malaysia in Fulfilment of the requirements  
for the degree of Doctor of Philosophy

**SCIENCE LABORATORY DYNAMICS AND ACQUISITION OF  
SCIENCE PROCESS SKILLS AMONG FORM FOUR  
SCIENCE FEMALE STUDENTS**

By

**SAROJINI DEVI A/P ALGARETNAM**

**June 2003**

**Chairman: Professor Dr. Kamariah Hj. Abu Bakar**

**Faculty: Educational Studies**

Laboratory activities have been regarded as an integral and essential aspect of learning experience in school science teaching. So to achieve the goals of the science curriculum, there was a need to enhance the diagnostic study of the science laboratory environment. Thus, the general purpose of this study was to investigate the nature of the laboratory dynamics and determine the dominant types of variables existing in a science laboratory. The study also sought to investigate the relationships between variables such as lesson structures, class setting, student interactions and student behaviours in a science laboratory. Besides that, the researcher attempted to examine the relationship between the above variables and student acquisition of science process skills. Hence, a conceptual framework based on an adapted causal model



proposed by Pizzini and Sherpardson (1992) was used in the study.

A correlational design was employed to describe in quantitative terms the relationship between the major variables such as lesson structures, class setting, student interactions, self-on-task (no interactions but on-task) and student behaviours in a science laboratory and achievement of science process skills. A sample of 81 students was selected randomly from three girls schools based on Test of Basic Science Process Skills (Test BSPS). The reliability coefficient of Test BSPS was .80. A power analysis indicated the power achieved by using the selected sample size was within the acceptable range of .75 to .80. Data on the variables was collected through direct observation of the subjects using an observational schedule, used by Pizzini and Shepardson (1992). Once the observations were over, all the observed students in the classes were given a test to assess the acquisition of integrated science process skills (Test ISPS). This test was mainly adapted from TIPS (Dillashaw and Okey, 1980). The reliability coefficient of the final test was .78.

The descriptive analysis of the data showed that among the lesson structures found in a science laboratory, the data collecting lesson structure was the most dominant followed by research

designing, data analysing, evaluating and finally problem finding. Small class setting was also more dominant than a large class setting in a science laboratory. Among the student interactions, it was found self-on-task was more dominant, indicating students very often worked on their own without any interaction. Among the student behaviours, the attending behaviour was most dominant, next being the following behaviour, giving behaviour, responding behaviour and finally soliciting behaviour.

In the inferential analysis, Pearson Correlation analysis was carried out to investigate the relationships between the variables. A number of statistically significant relationships were found between the variables. However, no significant relationships were found between any of the variables in the laboratory and acquisition of integrated science process skills. To derive a possible causal model, path analysis was used. Based on the correlation coefficients and path coefficients, the proposed causal model was revised.

The limitations and the implications of this study were discussed in detail. Suggestions and recommendations for future study were also made.

Abstrak tesis yang dikemukakan kepada  
Senat Universiti Putra Malaysia sebagai memenuhi keperluan  
untuk ijazah Doktor Falsafah

**DINAMIKS MAKMAL SAINS DAN PEROLEHAN  
KEMAHIRAN PROSES SAINS DI KALANGAN PELAJAR  
PEREMPUAN TINGKATAN EMPAT**

Oleh

**SAROJINI DEVI A/P ALGARETNAM**

**Jun 2003**

**Pengerusi: Profesor Dr. Kamariah Hj. Abu Bakar**

**Fakulti: Pengajian Pendidikan**

Aktiviti makmal dianggap sebagai satu aspek yang perlu dan penting untuk pengalaman belajar dalam pengajaran sains sekolah. Jadi, untuk mencapai matlamat kurikulum sains, adalah perlu mengadakan satu kajian diagnostik suasana makmal sains. Oleh itu, tujuan umum kajian ini ialah menyiasat keadaan dinamik makmal dan menentukan jenis-jenis pembolehubah dominan yang wujud dalam satu makmal sains. Kajian ini juga telah cuba mengkaji hubungan di antara pembolehubah-pembolehubah seperti struktur pengajaran, susunan kelas, interaksi pelajar dan kelakuan pelajar dalam sesuatu makmal sains. Selain itu, penyelidik telah cuba meneliti hubungan di antara pembolehubah-pembolehubah di

atas dan perolehan kemahiran proses sains pelajar. Justera itu, suatu rangka konseptual berdasarkan satu model yang telah diadaptasikan dar

Shepardson (1992) telah digunakan dalam kajian ini.

Reka bentuk korelasi telah digunakan untuk menerangkan secara kuantitatif hubungan antara pembolehubah-pembolehubah utama seperti struktur pengajaran, susunan kelas, interaksi pelajar, kerja-sendiri (tiada interaksi), tingkah laku pelajar dalam satu makmal sains dan penguasaan kemahiran proses sains. Satu sampel sebanyak 81 pelajar telah dipilih secara rawak dari tiga buah sekolah perempuan berdasarkan Ujian Basic Science Process Skills (Ujian BSPS). Nilai koefisien kebolehpercayaan ujian ini ialah .80. Satu analisis kuasa memperlihatkan nilai kuasa bagi saiz sampel yang dipilih di antara julat yang boleh diterima, iaitu .75 ke .80. Data pembolehubah-pembolehubah dikumpulkan melalui pencerapan subjek-subjek dengan menggunakan satu instrumen pencerapan yang telah dipakai oleh Pizzini dan Shepardson (1992). Apabila pencerapan selesai, semua pelajar dalam kelas telah menduduki satu ujian untuk mentaksir perolehan kemahiran proses sains sepadu. Ujian ini iaitu Ujian ISPS sebahagian besar telah diadaptasikan daripada TIPS (Dillashaw and Okey, 1980). Nilai koefisien kebolehpercayaan ujian ini ialah .78.



Analisis keperihalan data memperlihatkan di kalangan struktur pengajaran yang terdapat dalam makmal sains, pengumpulan data ialah yang paling dominan di antara semua struktur pengajaran, diikuti dengan mereka bentuk eksperimen, menganalisis data, penilaian and akhir sekali, mendapatkan penyelesaian masalah. Susunan kelas kecil juga lebih dominan daripada susunan kelas besar dalam makmal sains. Antara interaksi pelajar pula, didapati kerja-sendiri adalah paling dominan, menunjukkan pelajar selalu menjalankan tugas bersendirian tanpa sebarang interaksi. Bagi tingkah laku pelajar pula, yang paling dominan adalah memerhati, diikuti dengan tingkah laku mengikut, tingkah laku memberi, tingkah laku merespons, dan akhir sekali tingkah laku meminta.

Dalam analisis pentakbiran, analisis Kolerasi Pearson telah digunakan untuk mengkaji hubungan di antara pembolehubah-pembolehubah. Didapati beberapa hubungan yang signifikan dari segi statistik antara pembolehubah wujud. Walau bagaimana, tiada hubungan yang signifikan terdapat di antara pembolehubah-pembolehubah dalam makmal sains and perolehan kemahiran proses sains sepadu. Untuk memperoleh satu model yang mungkin wujud, analisis path telah digunakan. Berdasarkan koefisien kolerasi dan koefisien path, model yang dicadangkan diubahsuai.

Limitasi dan implikasi kajian telah dibincang secara terperinci. Syor dan cadangan untuk kajian masa hadapan turut diberikan.

## ACKNOWLEDGEMENTS

I wish to express my heartfelt gratitude to all who have in one way or another contributed towards the completion of this academic research. I am certain that without each and everyone's role, this task would have been insurmountable.

Firstly, I am deeply indebted to the members of my supervisory committee for their encouragement, ever ready advice, understanding and guidance given so generously throughout each phase of this research that made it possible to become a reality.

Special thanks to Chairman of my Supervisory Committee, Professor Dr. Kamariah Hj Abu Bakar for allowing me to pursue my field of interest and guiding me through with lots of patience and support. Many a times it was her gentle words of motivation and optimism that encouraged me to focus at critical times. I am also thankful to her for her insightful comments and creative suggestions that assisted me tremendously towards the completion of this exercise.

I am also very grateful to my two committee members, Professor Madya Dr. Mohd. Majid Konting and Dr. Rohani Ahmad Tarmizi. Their deep comments on substantive statistical issues helped to broaden my perspective on crucial analytical aspects of



this research. They rendered support and advice without which this academic exercise would have been impossible.

I would also say a very special thank you to Dr. Jegak Uli who assisted me to work on AMOS Statistical Package during the analysis of my data. Special thanks are also due to all lecturers of the Faculty of Educational Studies for providing guidance and assistance during my course of study.

I would like to sincerely thank the Scholarship Division, Ministry of Education for trusting and granting me a scholarship to pursue a research of my interest. I sincerely hope the findings of this study will assist in improving or developing a better science educational system for our students.

In addition, I would like to thank the Educational, Planning and Research Division, Ministry of Education and the Wilayah Persekutuan State Education Department for providing opportunities for my data collection. My sincere thanks also go to the principals of the Sekolah Menengah Kebangsaan Convent Bukit Nanas, Sekolah Menengah Kebangsaan (P) Jalan Ipoh and Sekolah Menengah Kebangsaan (P) Air Panas; the teachers and all the students who participated in this study for their co-operation and assistance.



I wish to express my sincere gratitude and appreciation to my family, mother and father-in-law for all the encouragement, support and the sacrifices they had to make so that I could complete my research. Special thanks to my husband, Kailaivasan, who not only made sure that I had the best of facilities to work in but also ensured he filled in for me in taking care of my daughters, Dharishini Devi and Vinoshini Devi. His encouragement, support and love throughout my research study made it possible for me to complete it. To him, my heartfelt gratitude and love.

Finally, I remain solely responsible for any errors and shortcomings contained in this study.



## TABLE OF CONTENTS

	<b>Page</b>
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vi
ACKNOWLEDGEMENTS	x
APPROVAL	xiii
DECLARATION	xv
LIST OF TABLES	xxii
LIST OF FIGURES	xxvi
LIST OF ABBREVIATIONS	xxxii
<b>CHAPTER</b>	<b>Page</b>
<b>1 INTRODUCTION</b>	
1.1 Background of the Study	1
1.2 Malaysian Science Educational System	5
1.3 Statement of the Problem	21
1.4 Research Objectives	23
1.5 Research Questions	24
1.6 Research Hypotheses	28
1.6.1 Lesson Structures and Class Setting	28
1.6.2 Lesson Structures and Student-Student Interactions	29
1.6.3 Lesson Structures and Teacher-Student Interactions.	29
1.6.4 Lesson Structures and Self-On-Task (No interactions)	30
1.6.5 Class Setting and Student-Student Interactions	31
1.6.6 Class Setting and Teacher-Student Interactions.	31
1.6.7 Class Setting and Self-On-Task	31
1.6.8 Student-Student Interactions and Student Behaviours	31
1.6.9 Teacher-Student Interactions and Student Behaviours	32
1.6.10 Self-On-Task and Student Behaviours	33
1.6.11 Class Setting and Student Behaviours	34



	1.6.12 Student Behaviours and Acquisition of Science Process Skills	34
	1.6.13 Variables influencing Student Acquisition of Science Process Skills	35
1.7	Significance of the Study	
	1.7.1 A General Perspective	36
	1.7.2 A Specific Perspective	40
1.8	The Limitations of the Study	42
1.9	Definitions of Terms	45
<b>2</b>	<b>REVIEW OF LITERATURE</b>	
2.1	Introduction	58
2.2	Learning of Science	60
	2.2.1 Constructivist Theory	62
	2.2.2 Social Interaction Theory	68
2.3	Laboratory Work in the Learning of Science	
	2.3.1 History of Laboratory Approach	72
	2.3.2 Role of Laboratory in the Learning	79
2.4	Factors Affecting Learning in a Science Laboratory	87
	2.4.1 Lesson Structures	88
	2.4.2 Class Setting	95
	2.4.3 Student Interactions	114
	2.4.4 Self-On-Task	127
2.5	Acquisition of Science Process Skills	132
2.6	Models for Classroom Teaching	150
2.7	Theoretical Framework of Study	165
2.8	Summary	170
<b>3</b>	<b>METHODOLOGY</b>	
3.1	Introduction	171
3.2	Research Design	172
3.3	Population	179
3.4	Sample	179
3.5	Sampling Procedures	182
3.6	Data Collection Procedures	184
3.7	Instrumentation	187
3.8	Pilot Test	188
	3.8.1 Development of Test BSPS (Ujian BSPS)	189

3.8.2	Pilot testing of Test BSPS (Ujian BSPS)	191
3.8.3	Reliability of Test BSPS (Ujian BSPS)	196
3.8.4	Development of Instrument 2	197
3.8.5	Validity and Reliability of Instrument 2	198
3.8.6	Variable-Weighting Scoring System	199
3.8.7	Development of Test ISPS (Ujian ISPS)	204
3.8.8	Pilot testing of Test ISPS (Ujian ISPS)	206
3.8.9	Reliability of Test ISPS (Ujian ISPS)	211
3.9	Techniques of Data Analysis	213
3.9.1	Descriptive Statistics	214
3.9.2	Pearson Product-Moment Correlation	215
3.9.3	Path Analysis	215

#### **4 ANALYSIS OF DATA AND FINDINGS**

4.1	Introduction	221
4.2	Descriptive Analysis	226
4.2.1	Distribution of Episodes of Each Subcategory	227
4.3	Inferential Analysis	293
4.3.1	The Relationships between Lesson Structures and Class Settings	316
4.3.2	The Relationships between Lesson Structures and Student-Student Interactions	319
4.3.3	The Relationships between Lesson Structures and Teacher-Student Interactions	323
4.3.4	The Relationships between Lesson Structures and Self- On-Task (No Interactions)	326
4.3.5	The Relationships between Class Setting, Student Interactions and Self-On-Task	329
4.3.6	The Relationships between Student-Student Interactions and Student Behaviours	331





4.3.7	The Relationships between Teacher-Student Interactions and Student Behaviours	334
4.3.8	The Relationships between Self-On-Task and Student Behaviours	338
4.3.9	The Relationships between Class Setting and Student Behaviours	341
4.3.10	The Relationships between Student Behaviours and Acquisition of Process Skills	344
4.3.11	The Influence of Lesson Structures, Class Settings, Student-Student Interactions, Teacher-Student interactions, Self-On-Task and Student Behaviours on Student Acquisition of Science Process Skills	347
<b>5</b>	<b>DISCUSSION AND RECOMMENDATIONS</b>	
5.1	Introduction	375
5.2	Descriptive Analysis	375
5.3	Inferential Analysis	383
5.3.1	The Relationships between Lesson Structures, Class Settings, Student Interactions, Student Behaviours and Student Acquisition of Science Process Skills	383
5.3.2	A Possible Causal Model That Depicts The Independent Variables Affecting Student Acquisition of Science Process Skills	418
5.4	The Implications of the Study	426
5.5	Recommendations for Further Research	429
5.6	Conclusion	430
	<b>BIBLIOGRAPHY</b>	<b>433</b>



<b>APPENDICES</b>		458
APPENDIX A	: 7th Malaysian Plan Tables	459
APPENDIX A-1	: Employment by Major Occupational Group 1990-2000	460
APPENDIX A-2	: Employment by Selected Occupation 1990- 2000	461
APPENDIX B	: Instrumentation	462
APPENDIX B-1	: Construction of Test BSPS	463
APPENDIX B-2	: Ujian BSPS (B.M)	465
APPENDIX B-3	: Test BSPS (B.I)	470
APPENDIX B-4	: Observational Schedule	475
APPENDIX B-5	: Construction of Test ISPS	476
APPENDIX B-6	: Ujian ISPS (B.M)	479
APPENDIX B-7	: Test ISPS (B.I)	489
APPENDIX C	: Credentials of Panel	498
APPENDIX C-1	: Credentials of Panel for Content-Validation of Test BSPS	499
APPENDIX C-2	: Credentials of Panel for Translation of Test BSPS and Test ISPS	500
APPENDIX C-3	: Credentials of Panel for Validation of Observational Schedule	501
APPENDIX C-4	: Credentials of Panel for Content-Validation of Test ISPS	502
APPENDIX D	: Data Tables	503
APPENDIX D-1	: Frequency Table for Observation Codes	504
APPENDIX D-2	: Percentage Table for Observation Codes	508
APPENDIX D-3	: Weighted Scores for the Variables	512
APPENDIX E	: Letters of Application and Letters of Approval	516
APPENDIX E-1	: Application to EPRD for Permission to carry out Research in Schools	517
APPENDIX E-2	: Letter of Approval from EPRD	520



APPENDIX E-3	: Application to Wilayah Persekutuan Education Department for Permission to carry out Research in Schools	522
APPENDIX E-4	: Letter of Approval from Wilayah Persekutuan Education Department to carry out Research in Schools	524
APPENDIX E-5	: Application for permission to carry out research in SMK Convent Bukit Nanas	525
APPENDIX E-6	: Application to Wilayah Persekutuan Education Department for Permission to carry out Research in Schools	526
APPENDIX E-7	: Letter of Approval from Wilayah Persekutuan Education Department to carry out Research in Schools	528
APPENDIX E-8	: Application for permission to carry out research in SMK (P) Jalan Ipoh	529
APPENDIX E-9	: Application for permission to carry out research in SMK (P) Air Panas	530
<b>VITA</b>		531



## LIST OF TABLES

Table		Page
1.	Format of Science Subjects at the S.P.M. Level	9
2.	Overall Streaming in Form Four	37
3.	Performance Improvement for Students in Classroom Using ESS, SCIS or SAPA as Compared to Students in Traditional Classrooms	78
4.	The Role of Practical Work in Science	79
5.	Ten Possible Aims of Science Practical Work	80
6.	Goals of Laboratory Activity	83
7.	Sample Selection Matrix	181
8.	Difficulty and Discrimination Indices of the 40 items in Test BSPS	193
9.	Reliability Coefficients of the Basic Science Process Skills in Test BSPS	197
10.	Difficulty and Discrimination Indices of the 40 items in Test ISPS	208
11.	Reliability Coefficients of the Basic Science Process Skills in Test ISPS	212
12.	Descriptive Statistics for Lesson Structures	229
13.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Lesson Structures	243
14.	Descriptive Statistics for Class Setting	245
15.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Class Setting	251



16.	Descriptive Statistics for Student-Student Interactions	253
17.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Student-Student Interactions	261
18.	Descriptive Statistics for Teacher-Student Interactions	263
19.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Teacher-Student Interactions	269
20.	Descriptive Statistics for Self-On-Task	271
21.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Self-On-Task	276
22.	Descriptive Statistics for Student Behaviours.	279
23.	Total Frequency of Episodes, Mean Percentages and Standard Deviations for Student Behaviours	291
24.	Index of Strength of Correlation Coefficients	295
25.	Distribution of Weighted-Scores of Problem Finding Lesson Structure	297
26.	Distribution of Weighted-Scores of Research Designing Lesson Structure	298
27.	Distribution of Weighted-Scores of Data Collecting Lesson Structure	299
28.	Distribution of Weighted-Scores of Data Analysing Lesson Structure	300
29.	Distribution of Weighted-Scores of Evaluating Lesson Structure	301
30.	Distribution of Weighted-Scores of Class Setting	303
31.	Distribution of Weighted-Scores of Student-Student Interactions	306



32.	Distribution of Weighted-Scores of Teacher-Student Interactions	308
33.	Distribution of Weighted-Scores of Self-On-Task	310
34.	Distribution of Weighted-Scores of Attending Behaviour	311
35.	Distribution of Weighted-Scores of Responding Behaviour	312
36.	Distribution of Weighted-Scores of Following Behaviour	313
37.	Distribution of Weighted-Scores of Soliciting Behaviour	314
38.	Distribution of Weighted-Scores of Giving Behaviour	315
39.	The Correlation Coefficients for $H_1$ to $H_5$	317
40.	The Correlation Coefficients for $H_6$ to $H_{10}$	320
41.	The Correlation Coefficients for $H_{11}$ to $H_{15}$	323
42.	The Correlation Coefficients for $H_{16}$ to $H_{20}$	326
43.	The Correlation Coefficients for $H_{21}$ to $H_{23}$	329
44.	The Correlation Coefficients for $H_{24}$ to $H_{28}$	331
45.	The Correlation Coefficients for $H_{29}$ to $H_{33}$	335
46.	The Correlation Coefficients for $H_{34}$ to $H_{38}$	338
47.	The Correlation Coefficients for $H_{39}$ to $H_{43}$	341
48.	The Correlation Coefficients for $H_{44}$ to $H_{48}$	344
49.	The Cook's Distance Values of the Dependent Variables	349
50.	Tests of Normality	354
51.	Collinearity Diagnostics	358