

**A STUDY OF THE APPLICATION OF SCIENCE PROCESS
SKILLS TO THE TEACHING OF GEOGRAPHY IN SECONDARY
SCHOOLS IN THE FREE STATE PROVINCE**

by

AWELANI MELVIN RAMBUDA

submitted in fulfilment of the requirements for the degree

**DOCTOR PHILOSOPHIAE
(SUBJECT DIDACTICS)**

in the

**FACULTY OF EDUCATION
UNIVERSITY OF PRETORIA**

ABSTRACT

A STUDY OF THE APPLICATION OF SCIENCE PROCESS SKILLS TO THE TEACHING OF GEOGRAPHY IN SECONDARY SCHOOLS IN THE FREE STATE PROVINCE

BY Awelani Melvin Rambuda
PROMOTER Prof W J Fraser
DEPARTMENT Department of Teaching and Training Studies
DEGREE PhD

The purpose of this study was to examine teacher and learner perceptions of the application of science process skills to the teaching of geography in secondary schools in the Free State province. Based on the literature study, teacher (educator) and learner questionnaires on inquiry teaching and the application science process skills in the geography classrooms were developed. The questionnaires were administered to 150 teachers with 71 returns and 700 learners with 355 returns. Interviews were also conducted with 20 secondary school geography teachers and 50 grade 12 geography learners. Questionnaire data were analysed quantitatively whilst data gathered by means of interviews were analysed qualitatively,

A literature survey revealed that most researchers are of the opinion that science process skills were suitable and effective to the teaching of geography at secondary school level. It also established that there was a link between inquiry teaching and the application of science process skills. It also indicated that science process skills linked specifically to the outcomes of the natural sciences and could be realized and achieved as observable and demonstrable outcomes.

Items on science process skills in the teachers' questionnaire were submitted to a principal component analysis using a varimax rotation method. Two principal components were retained and rotated using the factor matrix solution. Factor 1 was called **Basic Science Process Skills** whilst Factor 2 was called *Integrated Science Process Skills*. This confirmed that the respondents distinguished mentally between the two constructs which implied that geography teachers were comfortable with the fact that science process could be grouped into two main clusters. The homogeneous clustering of items also satisfied that with the fact that science process skills could

be applied to the teaching of geography. The empirical research revealed that teachers and learners were of the opinion that teachers apply *inquiry methods* and *basic science process skills* to the teaching of geography. However, the results also indicated that teachers and learners were of the opinion that teachers were not applying *integrated science process skills* to the teaching of geography.

Interviews also implied that teachers were not applying *integrated science process skills* because geography experiments were rarely conducted in the classroom. Geography learners are also not afforded opportunities to handle equipment which is used to observe meteorological elements such as atmospheric pressure, air temperature, precipitation, wind speed and direction, and humidity.

Several recommendations were made, including that teachers should make provision for experiments in their lessons. Geography learning facilitators (subject advisors) could assist in the identification of materials which teachers might improvise from the environment to conduct geography experiments in their classrooms. Free State Department of Education should provide schools which offer geography with facilities and equipment which would enable teachers to design and conduct experiments. Meteorological equipment would also provide learners with opportunities to observe meteorological elements. Some of the interviewed teachers suggested that universities located in the Free State should be approached to provide workshops as part of their engagement with the communities they serve.

KEYWORDS

Inquiry teaching, inquiry learning, outcomes-based education, outcomes, science process skills, basic science process skills, integrated science process skills, geography teaching, teaching approaches and teacher training.

ACKNOWLEDGEMENTS

This thesis could not have been written if I had not drawn on the knowledge and advice of my promoter Prof. W.J. Fraser. I would like to express my appreciation to him for his encouragement, guidance, patience, constructive ideas and suggestions.

May I also acknowledge my indebtedness to the following:

- My employer, Vista University for the financial assistance towards this research.
- The Department of Education, Free State province, for granting me permission to conduct the empirical research in their schools.
- Geography teachers and learners who participated in this study.
- Library staff of Vista University (Welkom Campus) and University of Pretoria for their assistance throughout this study.
- Dr. D.K. Selaledi, Dr. M. van der Linde and Mr J. Grimbeek for their valuable advice and input on statistical analysis.
- Dr. W. Smith and Dr. P.L. van der Merwe for reading and editing the manuscripts for this study.
- My wife Moleboheng, relatives and colleagues for their moral support.
- Finally, the Almighty God whose grace allowed me to complete this thesis.

DECLARATION

I declare that

A STUDY OF THE APPLICATION OF SCIENCE PROCESS SKILLS TO THE TEACHING OF GEOGRAPHY IN SECONDARY SCHOOLS IN THE FREE STATE PROVINCE is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of references.

A.M. Rambuda

A.M. Rambuda

02/08/2002

Date

This thesis is dedicated to my son, Hangwani.

ACKNOWLEDGEMENT FOR NRF RESEARCH GRANT

The financial assistance of National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the National Research Foundation.

TABLE OF CONTENTS

Page

CHAPTER ONE

ORIENTATION

1.1	INTRODUCTION.....	1
1.2	GENERAL BACKGROUND OF THE PROBLEM.....	1
1.3	RESEARCH OUTLINE.....	5
1.3.1	The Problem Investigated in this Study.....	5
1.3.2	Questions Investigated.....	7
1.3.3	Aims and Objectives.....	8
1.3.4	Hypotheses.....	10
1.4	SIGNIFICANCE OF THE STUDY.....	11
1.5	RESEARCH METHODOLOGY	17
1.5.1	Literature Survey.....	18
1.5.2	Empirical Investigation.....	18
1.5.2.1	Quantitative Empirical Study.....	19
1.5.2.2	Qualitative Empirical Investigation.....	20
1.6	CONCEPTS AND DEFINITIONS	21

1.6.1	Inquiry Teaching.....	21
1.6.2	Inquiry Learning.....	22
1.6.3	Science Process Skills.....	22
1.6.4	Basic Science Process Skills.....	23
1.6.5	Integrated Science Process Skills.....	24
1.6.6	Outcomes.....	25
1.6.6	Outcomes-based Education.....	27
1.7	DEMARCATON OF THE STUDY.....	27
1.8	CHAPTER OUTLINE.....	27
1.9	CONCLUSION.....	29

CHAPTER TWO

GEOGRAPHY TEACHING APPROACHES AND SCIENCE PROCESS SKILLS

2.1	INTRODUCTION.....	30
2.2	TEACHING APPROACHES IN GEOGRAPHY EDUCATION.....	30
2.2.1	The Holistic Approach.....	33
2.2.2	The Descriptive and the Problem-solving Approaches.....	33
2.2.3	Thematic Approach.....	38
2.2.4	The Interdisciplinary Approach.....	39
2.3	GEOGRAPHIC INQUIRY.....	41
2.3.1	Inductive Inquiry.....	43
2.3.2	Deductive Inquiry.....	50

2.4	REASONS FOR INQUIRY AS A STRATEGY OF TEACHING AND LEARNING GEOGRAPHY.....	54
2.5	SCIENCE PROCESS SKILLS	66
2.5.1	Basic Science Process Skills.....	68
2.5.1.1	Observation.....	68
2.5.1.2	Classification.....	70
2.5.1.3	Communication.....	70
2.5.1.4	Measurement.....	75
2.5.1.5	Prediction.....	76
2.5.1.6	Inferences.....	77
2.5.2	Integrated Science Process Skills.....	77
2.5.2.1	Identifying Variables.....	78
2.5.2.2	Constructing a Table of Data.....	79
2.5.2.3	Plotting a Graph.....	80
2.5.2.4	Describing Relationships between Variables.....	87
2.5.2.5	Acquiring and Processing Data.....	87
2.5.2.6	Analysing Investigations.....	88
2.5.2.7	Constructing Hypotheses.....	89
2.5.2.8	Defining Variables Operationally.....	90
2.5.2.9	Designing Investigations.....	92
2.5.2.10	Experimenting.....	93
2.6	CRITIQUE OF SCIENCE PROCESS SKILLS.....	94
2.7	CONCLUSION.....	96

CHAPTER THREE

THE NATURE AND STRUCTURE OF GEOGRAPHY AND ITS IMPLICATIONS ON THE APPLICATION OF OUTCOMES-BASED GEOGRAPHY TEACHING

3.1	INTRODUCTION.....	99
3.2	THE NATURE OF GEOGRAPHY.....	99
3.3	THE STRUCTURE OF GEOGRAPHY.....	103
	3.3.1 The Substantive Structure of Geography.....	104
	3.3.2 The Syntactical Structure of Geography.....	105
3.4	REASONS FOR A PARADIGM SHIFT TO OUTCOMES-BASED EDUCATION.....	109
3.5	CURRICULUM 2005.....	112
	3.7.1 The General and Training Band.....	115
	3.7.2 Further Education and Training Band.....	115
	3.7.3 Higher Education and Training Band.....	116
3.6	THE NATURE OF OUTCOMES-BASED EDUCATION.....	116
3.7	SHORTCOMINGS OF OUTCOMES-BASED EDUCATION.....	120
3.8	CRITICAL AND DEVELOPMENTAL OUTCOMES	125
3.9	NATURAL SCIENCES LEARNING AREA'S OUTCOMES THAT ARE ASSOCIATED WITH SCIENCE PROCESS SKILLS.....	127

3.10	THE IMPLICATIONS OF THE CRITICAL AND DEVELOPMENTAL OUTCOMES AND THE NATURAL SCIENCES LEARNING AREA'S OUTCOMES ON THE TEACHING OF GEOGRAPHY.....	129
3.11	CONCLUSION.....	131

CHAPTER FOUR

THE APPLICATION OF SCIENCE PROCESS SKILLS TO THE TEACHING AND LEARNING OF GEOGRAPHY

4.1	INTRODUCTION.....	133
4.2	THE NEED TO APPLY SCIENCE PROCESS SKILLS TO THE TEACHING OF GEOGRAPHY.....	134
4.3	PIAGET'S THEORY OF LEARNING AND SCIENCE PROCESS SKILLS.....	135
4.3.1	The Sensorimotor Stage.....	136
4.3.2	The Preoperational Stage.....	139
4.3.2.1	Egocentrism.....	140
4.3.2.2	Conservation.....	141
4.3.2.3	Centring.....	142
4.3.2.4	Reversibility.....	143
4.3.2.5	Transductive Reasoning.....	144
4.3.2.6	Concreteness.....	144
4.3.2.7	Animism.....	145
4.3.3	The Concrete Operational Stage.....	146

4.3.3.1	Seriation.....	148
4.3.3.2	Transitivity.....	150
4.3.3.3	Class Inclusion.....	151
4.3.4	Formal Operational Stage.....	152
4.3.4.1	Propositional Reasoning.....	156
4.3.4.2	Hypothetico-deductive Reasoning.....	156
4.3.4.3	Combinatorial Reasoning.....	157
4.3.4.4	Proportional Reasoning.....	160
4.3.5	Application of Science Process Skills to the Teaching of Geography.....	161
4.4	BASIC SCIENCE PROCESS SKILLS AND THE TEACHING OF GEOGRAPHY...	163
4.4.1	Observing as a Process Skill Applied to the Teaching of Geography.....	164
4.4.2	Measuring as a Process Skill Applied to the Teaching of Geography.....	166
4.4.3	Inferring as a Process Skill Applied to the Teaching of Geography.....	166
4.4.4	Classifying as a Process Skill Applied to the Teaching of Geography.....	168
4.4.5	Predicting as a Process Skill Applied to the Teaching of Geography.	171
4.4.6	Communicating as a Process Skill Applied to the Teaching of Geography.....	172
4.5	INTEGRATED SCIENCE PROCESS SKILLS AND THE TEACHING OF GEOGRAPHY.....	173
4.5.1	Defining Variables Operationally as a Process Skill Applied to the Teaching of Geography.....	174
4.5.2	Hypothesizing as a Process Skill Applied to the Teaching of Geography...	177
4.5.3	Manipulating and Controlling of variables as a Process Skill Applied to the Teaching of Geography.....	179
4.5.4	Acquiring and Processing Data as a Process Skill Applied to the Teaching of Geography.....	182

4.5.5	Interpreting Data as a Process Skill Applied to the Teaching of Geography.....	183
4.5.6	Experimenting as a Process Skill Applied to the Teaching of Geography..	185
4.6	BASIC SCIENCE PROCESS SKILL AND THE TEACHING OF MAPWORK.....	186
4.6.1	Observing as a Science Process Skill Applied to the Teaching of Mapwork.....	187
4.6.2	Measuring as a Science Process Skill Applied to the Teaching of Mapwork.....	189
4.6.3	Inferring as a Science Process Skill Applied to the Teaching of Mapwork.....	190
4.6.4	Classifying as a Science Process Skill Applied to the Teaching of Mapwork.....	192
4.6.5	Predicting as a Science Process Skill Applied to the Teaching of Mapwork.....	193
4.6.6	Communicating as a Science Process Skill Applied to the Teaching of Mapwork.....	193
4.7	CONCLUSION.....	194

CHAPTER 5

REVIEW OF THE DATA PROCESSING PROCEDURES AND THE DESCRIPTION OF STATISTICAL TECHNIQUES APPLIED

5.1	INTRODUCTION.....	196
5.2	DATA COLLECTION TECHNIQUES.....	196
5.3	DATA COLLECTION PROCEDURE.....	198

5.3.1	Permission to Conduct Research in the Free State	
	Department of Education.....	199
5.3.2	The Pilot Study.....	199
5.4	POPULATION AND RESEARCH SAMPLE.....	201
5.4.1	Geography Teacher Sample.....	202
5.4.2	Geography Learner Sample.....	204
5.5	ARRANGEMENT FOR CONDUCTING INTERVIEWS.....	206
5.6	CONSTRUCTION OF QUESTIONNAIRES.....	207
5.6.1	The Content Validation of the Questionnaires.....	210
5.6.2	Instructions for the Complete of the Questionnaires.....	219
5.7	PROCEDURES FOR ANALYSING QUESTIONNAIRE DATA.....	220
5.7.1	Descriptive Statistics.....	220
5.7.1.1	Factor Analysis.....	221
5.7.1.2	Frequency Tabulation.....	222
5.7.1.3	Measures of Central Tendency.....	223
5.7.2	Inferential Statistics.....	225
5.8	CONCLUSION.....	226

CHAPTER 6

RESULTS OF THE EMPIRICAL INVESTIGATION

6.1	INTRODUCTION.....	227
6.2	DESCRIPTIVE STATISTICS.....	228
	6.2.1 Biographical Data Analysis.....	228
	6.2.1.1 Biographical Data for Geography Teachers.....	228
	6.2.1.2 Biographical Data for Geography Learners.....	230
	6.2.2 Data Analysis for Inquiry Teaching Methods.....	233
	6.2.2.1 Geography Teachers' Perception of their Application of Inquiry Methods to the Teaching of Geography.....	233
	6.2.2.2 Teacher Application of the Inquiry Teaching Methods According to Geography Learners' Responses.....	236
	6.2.3 Data Analysis for the Application of Science Process Skills to the Teaching of Geography.....	240
	6.2.3.1 Factor Analysis.....	240
	6.2.3.2 Basic Science Process Skills.....	246
	6.2.3.3 Integrated Science Process Skills.....	250
6.3	INFERENTIAL STATISTICS.....	255
	6.3.1 Sample Mean Differences.....	255
	6.3.1.1 One-way ANOVA for Inquiry Teaching Methods.....	256
	6.3.1.2 One-way ANOVA for Basic Science Process Skills.....	259

6.3.1.3	One-way ANOVA for Integrated Science Process Skills....	261
6.4	INTERVIEWS.....	264
6.4.1	Interview Data Analyses.....	264
6.4.2	Interview Results.....	265
6.4.2.1	Difficulties Geography Teachers Experience When Developing Inquiry Teaching.....	265
6.4.2.2	Suggested Solutions to Difficulties Geography Teachers Experience When Developing Inquiry Teaching.....	267
6.4.2.3	Difficulties Learners Experience When They are Involved in Inquiry Learning.....	268
6.4.2.4	Suggested Solutions to Difficulties Learners Experience When They are Involved in Inquiry Learning.....	270
6.4.2.5	Problems That Learners Experience When Science Process Skills are Applied to the Teaching of Geography.....	271
6.4.2.6	Suggested Solutions to Problems That Learners Experience When Science Process Skills are Applied to the Teaching of Geography.....	273
6.4.2.7	Problems That Teachers Experience When Applying Science Process Skills to the Teaching of Geography.....	274
6.4.2.8	Suggested Solutions to Problems That Teachers Experience When Applying Science Process Skills to the Teaching of Geography.....	275
6.5	CONCLUSION.....	277

CHAPTER 7

SUMMARISED FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

7.1	INTRODUCTION.....	278
7.2	SUMMARISED FINDINGS OF THE STUDY.....	280
7.2.1	Summarised Findings and Implications of Literature Survey.....	280
7.2.2	Summarised Findings and Implications of Questionnaire Survey.....	282
7.2.3	Summarised Findings and Implications of Interviews.....	289
7.2.4	Summarised Findings and Implications of Factor Analysis.....	294
7.3	RECOMMENDATIONS.....	295
7.3.1	Incorporation of Science Process Skills in OBE Training.....	295
7.3.2	Provisioning of Self-instructional Material.....	296
7.3.3	Encourage Teacher Improvement of their Qualifications.....	297
7.3.4	Introduction of Geography Experiments in the Classrooms.....	298
7.3.5	Teacher Knowledge of Science Process Skills and the Teaching of These.....	299
7.4	PROBLEMS EXPERIENCED WITH THIS STUDY.....	299
7.4.1	Problems Experienced with the Literature Study.....	300
7.4.2	Problems Experienced during Empirical Research.....	300
7.5	LIMITATIONS OF THE STUDY.....	301
7.6	FUTURE RESEARCH.....	302

7.7	CONCLUSION.....	303
	Bibliography.....	304
	List of Appendices.....	327

List of Tables

	Page
Table 1.1 Grade 12 Learners' Performance in 1998 and 1999 Examinations in the Free State.....	11
Table 2.1 Mean Annual Rainfall in Cape Town over a Period of 12 Months.....	79
Table 2.2 Average Monthly Temperatures in Bloemfontein over a Period of 12 months.....	82
Table 2.3 South Africa's Mineral Production in 2001.....	84
Table 3.1 Association of Competencies and Science Process Skills.....	106
Table 3.2 National Qualifications Framework.....	114
Table 4.1 Types of Settlement.....	149
Table 4.2 Seriation of Settlements.....	149
Table 4.3 Operational Definitions.....	176
Table 6.1 Summary of Teacher Personal Data, Experienced in the Teaching of Geography and School Details Expressed as Percentage Scores	230
Table 6.2 Summary of Learner Personal Data and School Details Expressed as Percentage Scores	231
Table 6.3 Geography Teachers' Perception of their Application of Inquiry Teaching Methods Expressed as Percentage Scores	234

Table 6.4	The Means Procedure for Teachers' Perception of their Application of Inquiring Teaching Methods	236
Table 6.5	Teacher Application of Inquiry Teaching Methods According to Geography Learners' Responses Expressed as Percentage Scores	237
Table 6.6	The Means Procedure for Teacher Application of Inquiry Teaching Methods According to the Learners' Responses.....	239
Table 6.7	Eigenvalues of the Correlation Matrix for Science Process Skills	241
Table 6.8	Orthogonal Transformation Matrix.....	244
Table 6.9	Geography Teachers' Perception of their Application of Basic Science Process Skills Expressed as Percentage Scores.....	247
Table 6.10	The Means Procedure for Teachers' Perception of their Application of Basic Science Process Skills	248
Table 6.11	Geography Teacher Application of Basic Science Process Skills According to Geography Learners' Responses Expressed as Percentage Scores	249
Table 6.12	The Means Procedure for Teacher Application of Basic Science Process Skills According to Learners' Responses.....	250
Table 6.13	Geography Teachers' Perception of their Application of Integrated Science Process Skills Expressed as Percentage Scores	251
Table 6.14	The Means Procedure for Teacher Application of Integrated Science Process Skills According to Geography Teachers' Responses.....	252

Table 6.15	Geography Teacher Application of Integrated Science Process Skills According to Learners' Responses Expressed as Percentage Scores	253
Table 6.16	The Means Procedure for Teacher Application of Integrated Science Process Skills According to Learners' Responses.....	254

List of Figures

	Page
Figure 1.1 Programme of the Study	28
Figure 2.1 Teaching Strategies: A Model for New Geography in South Africa.....	31
Figure 2.2 Gott and Murphy's Problem-solving Model.....	35
Figure 2.3 The Elements of Classroom Inquiry.....	42
Figure 2.4 If Warm Air Rises Why is it Cold at the Top of the Mountain.....	45
Figure 2.5 Karst Scenery of the Mountain.....	46
Figure 2.6 Sequence of Events in Inductive Inquiry.....	49
Figure 2.7 Scientific Inquiry: Hypothesis Testing.....	61
Figure 2.8 Inquiry Teaching and Learning Approaches.....	62
Figure 2.9 The Route for Geography Inquiry.....	63
Figure 2.10 The Route for Geography Inquiry, Science Process Skills and Outcomes...	65
Figure 2.11 Sub-categories of 'Practical Skills'.....	67
Figure 2.12 Five Senses Used to Observe Objects.....	69
Figure 2.13 Communication Tools.....	71

Figure 2.14	Point Symbols.....	72
Figure 2.15	Line Symbols.....	63
Figure 2.16	Area Symbols.....	74
Figure 2.17	Bar Graph: Mean Annual Rainfall in Cape Town over a Period of 12 Months.....	81
Figure 2.18	Line Graph: Average Monthly Temperatures in Bloemfontein over a Period of 12 Months.....	82
Figure 2.19	Pie Diagram Graph: South Africa's Mineral Production in 2001.....	84
Figure 2.20	Air Pressure.....	91
Figure 4.1	A Hierarchy of Science Process Skills.....	163
Figure 4.2	Curious Currents.....	167
Figure 4.3	The Water Cycle.....	173
Figure 4.4	When Salt is Poured on Crushed Ice, What Happens to the Temperature?.....	180
Figure 6.1	Scree Plot of Eigenvalues.....	243

List of Appendices

	Page
Appendix 1	Guideline Document and Interim Syllabus for Geography for Grade 10, 11 and 12..... 327
Appendix 2	Grade 12 Geography Learners' Performance in 1998 & 1999 Examinations in the Free State province..... 338
Appendix 3	Geography Teacher Questionnaire..... 340
Appendix 4	Geography Learner Questionnaire..... 351
Appendix 5	A Letter from the Human Sciences Research Council with regard to Research on Teacher Application of Science Process Skills to the Teaching of Geography in Secondary Schools in South Africa..... 363
Appendix 6	A List of Schools That Offered Geography in the Free State Education Department in 1999..... 365
Appendix 7	A Table of Uniform Random Numbers..... 374
Appendix 8	A Letter for Application to Undertake Research at Secondary Schools in the Free State..... 377
Appendix 9	An Approval Letter from Free State Department of Education..... 382
Appendix 10	A Letter to the Principals Requesting for Permission to Undertake Research at Their Schools..... 385
Appendix 11	Interview Schedule for Geography Teachers..... 387

Appendix 12	Interview Schedule for Geography Learners.	390
Appendix 13	Synoptic Weather Chart	393
Appendix 14	3318CD Cape Town Topographical Map.....	396