

https://dspace.org/

Implementation and institutionalization of innovation and change in science education: the case of SEP.

Ntshoe, Isaac Mogapi

2014-03-20
http://hdl.handle.net10539/14241

Downloaded from a DSpace repository. https://dspace.org/

IMPLEMENTATION AND INSTITUTIONALIZATION OF INNOVATION AND CHANGE IN SCIENCE EDUCATION: THE CASE OF SEP

Isaac Mogapi Ntshoe

A thesis submitted to the Faculty of Education, University of the Witwatersrand, Johannesburg, for the degree of Doctor of Philosophy

Johannesburg, 1999.

ABSTRACT

This investigation focuses on the evaluation of the vision, intention, policy implementation and institutionalization of curriculum development, innovation and change undertaken by the Science Education Project (SEP) from 1980 to 1995.

The study yielded the following in relation to the research questions:

It was found that SEP's model and approaches to curriculum development and the usage of implementers were relevant to the conditions in South African education in the 1980s and 1990s. Further, that the introduction of innovation and change adopted by SEP (also known as the project) was effective, enabling and justified. It was also found that SEP had positively influenced the teaching and learning of science when it was still operating in the regions during the 1980s and the majority of the schools and teachers used the project's materials and kits effectively in the late 1980s and 1990s.

The vision, policy and implementation differed during the development, expansion and consolidation phases of the project. It was found that institutionalization (also called sustained implementation) of SEP's innovation and change in education depended mainly on the support it received from the education administrators, the teachers and principals in the regions. The nature of the relationship between SEP and its other stakeholders was also a major determinant of the project's success and a lack thereof contributed to its failure in other circumstances.

This study contributes to knowledge relating to theories and models of curriculum development and educational innovation which suggest that: innovation is likely to be sustained when its clients become advocates of its work and implementation is likely to be sustained when teachers become advocates for its methodology. In particular, implementation is likely to be sustained when it is endorsed by persons working at different levels in the education systems. Further, the study shows that curriculum development is a dynamic process involving interaction between vision, intention and policy on the one hand and implementation or action on the other.

DECLARATION

I declare that apart from the assistance acknowledged, this thesis is my own unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

15th day of February 1999

To my family

with sincere thanks

for their love and encouragement

during the writing of this thesis

ACKNOWLEDGEMENTS

A large number of people have contributed to this thesis, and I would like to thank them for their support, and in many cases, for the work they did.

I had financial support from the Human Sciences Research Council and the Foundation for Research and Development (FRD). Special thanks to the FRD for their generous support of the study. Through this support, I was able to undertake research on SEP in the regions and was able to obtain typing assistance from a number of people.

In relation to the Science Education Project, I wish to acknowledge contributions and support I received from a number of the project staff both at SEP's National Office and in the regions. SEP staff members who provided untiring support include: the former and current Executive Directors, SEP Regional Managers and Implementers, Directors of the various project Units, the project teachers and pupils as well as education administrators in the four regions. Special thanks go to Peter Moodie, Jeremy Routledge and Margaret Keogh who went beyond the call of duty by participating in the verification and confirmation of the findings during the writing-up of the thesis. This study would not have been completed had it not been for the support and cooperation I received from these persons.

I am indebted to SEP's Board of Trustees, the Chairperson of the Board of Trustees, Dr Stephen Anderson and the former Executive Director, Dr Dwight Triegaardt for allowing me to undertake this research. Their openness and contributions in numerous interviews are sincerely acknowledged. Dr Anderson and other policy analysts are sincerely thanked for making themselves available for regular interviews. The current Executive Director, Ms Thembi Ndlalane is sincerely thanked for her continual support and for providing the latest information on the project.

I am also indebted to the following people who typed and proof-read many drafts: Petra Webb, Louise Jeevenantham, Pat Strauss, Dee Pinto and Ms Rosemary Gray.

I owe my greatest debt to my wife, Grace and our children for their support and encouragement throughout.

I wish to express my sincere gratitude to my supervisors, Dr Charles Potter and Dr Dwight Triegaardt for their invaluable assistance and guidance, without which completion of this research would have been impossible. I am indebted to both of them for providing guidance over the years that has helped to focus the research and to bring it to its current format and structure.

Sincere thanks go to Mr Alistair Clacherty for patiently and carefully assisting with editing the final copy of this thesis.

TABLE OF CONTENTS

		PAGE
Abstract		i
Declaration		ii
Dedication		iii
Acknowledgements		iv
Table of Contents		vi
Lists of Tables		xvii
Lists of Figures		xix
List of Appendices		xx
CHAPTER ONE:	**INTRODUCTION TO THE PROBLEM, AND AN OVERVIEW OF THE RESEARCH**	1
1.1	INTRODUCTION	1
1.2	THE PURPOSE OF THE STUDY	1
1.3	THE ORIGIN AND THE DEVELOPMENT OF THE SCIENCE EDUCATION PROJECT	2
1.4	THE CONTEXT OF THE STUDY	6
1.4.1	Relationship between SEP, schools and the education departments	6
1.4.2	The changing relationship with the education departments	7
1.5	THEORETICAL FRAMEWORK AND FOCUS OF THE STUDY	10
1.5.1	The focus of the study	10
	(i) RESEARCH QUESTION ONE (ii) RESEARCH QUESTION TWO (iii) RESEARCH QUESTION THREE (iv) RESEARCH QUESTION FOUR	13

PAGE

1.5.2 Methods, approaches and procedures 14

1.5.3 Theoretical bases of the study 14

1.5.4 Research instruments 15

(i) Format, purpose and the sample in the pilot study 15

(ii) Main Study 15

1.6 DATA ANALYSIS 16

1.7 SIGNIFICANCE OF THE STUDY 16

1.8 LIMITATIONS OF THE RESEARCH 17

1.9 ORGANISATION OF THE REMAINING CHAPTERS 18

1.10 DEFINITION OF TERMS 19

CHAPTER TWO: LITERATURE REVIEW ON INNOVATION AND CHANGE IN SCIENCE EDUCATION 21

2.1 INTRODUCTION 21

2.2 VIEWS ON INNOVATION AND CHANGE IN EDUCATION 22

2.3 THEORIES AND MODELS OF INITIATING AND IMPLEMENTING INNOVATION AND CHANGE 25

2.4 KEY THEMES IN THE IMPLEMENTATION OF INNOVATION AND CHANGE 27

2.4.1 Explanation of the implementation process 27

2.4.2 Problems of measuring implementation 27

2.5 INSTITUTIONALIZATION OF INNOVATION AND CHANGE 29

2.6 LITERATURE SURVEY ON SCIENCE EDUCATION 31

2.6.1 The planning of science education policy in South Africa 31

2.6.2 Policy on science education curriculum development, innovation and change 35

PAGE

2.6.3 INSET for science teachers as a feature of SEP's innovation and change 39

2.6.4 Assessment in science 40

(i) Problems relating to assessment in science 40

(ii) Issues relating to assessment in science in South Africa 41

2.7 SUMMARY FROM THE LITERATURE 44

CHAPTER THREE: RESEARCH DESIGN 46

3.1 INTRODUCTION 46

3.2 THE EVALUATION MODEL 46

3.3 RESEARCH METHODS, APPROACHES AND PROCEDURES IN THE PILOT STUDY 47

3.4 RELIABILITY AND VALIDITY OF INTERVIEWS IN THE PILOT STUDY 48

3.5 RESULTS OF INTERVIEWS IN THE PILOT STUDY 51

RESEARCH QUESTION ONE 51
RESEARCH QUESTION TWO 52
RESEARCH QUESTION THREE 52
RESEARCH QUESTION FOUR 52

3.6 RESEARCH PARADIGMS, APPROACHES AND METHODOLOGY . 53

3.6.1 Research paradigms 53

3.6.2 Assumptions underpinning the paradigm adopted in the current study 55

3.6.3 The nature of reality 55

3.6.4 Inquirer-subject relationship 55

3.7 THEORETICAL FRAMEWORK 56

PAGE

3.8 METHODOLOGICAL CONSIDERATIONS IN THE STUDY 57

3.9 MAIN STUDY 62

3.9.1 Sampling 62

3.9.2 Samples of the project documents and records 65

3.9.3 Samples of Informants 66

3.9.4. Sampling of schools 71

3.9.5 Sampling of photographs 76

3.10 RESEARCH INSTRUMENTS AND DATA SOURCES 77

3.10.1 Interviews 77

3.10.2 Observations 79

3.10.3 Photographs 80

3.11 RELIABILITY AND VALIDITY 80

4. SUMMARY 84

CHAPTER FOUR: DATA REDUCTION AND ANALYSIS 86

4.1 INTRODUCTION 86

4.2 PROCEDURES EMPLOYED IN REDUCING AND ANALYSING THE DATA 86

4.3 MODELS OF CONTENT ANALYSIS USED IN THE INVESTIGATION 89

4.4 DELINEATING AND DEFINING UNITS OF ANALYSIS 90

4.5 UNITS OF ANALYSIS AND CODING SYSTEMS 91

4.6 DATA ANALYSIS 91

4.6.1 Content analysis of interviews 92

PAGE

4.6.2 Procedures adopted in the reduction and analysis of the data obtained from classroom observations and photographs 93

4.6.3 Procedures followed to generate categories for the analysis of the data 95

4.6.4 Examination of the data 96

4.6.5 Drawing and verifying conclusions 97

5. SUMMARY 100

CHAPTER FIVE: MODELS OF CURRICULUM DEVELOPMENT, INNOVATION AND CHANGE 102

5.1 INTRODUCTION 102

RESEARCH QUESTION ONE 104

5.2 MODELS ADOPTED TO INTRODUCE THE PROJECT TO EDUCATION DEPARTMENTS 105

5.3 THE AIMS AND OBJECTIVES OF SEP'S INNOVATION AND CHANGE 106

5.4 THE PHASES OF INNOVATION AND CHANGE IN THE PROJECT 108

5.5 REASONS FOR ADOPTING THE PACKAGE APPROACH AND THE RESEARCH AND DEVELOPMENT MODEL 109

5.5.1 The package approach in curriculum development 109

5.5.2 The Research Development and Dissemination model 111

5.6 THE CURRICULUM DEVELOPMENT AND RESEARCH AND DEVELOPMENT UNITS IN SEP 113

5.6.1 The role played by the Curriculum Development Unit 113

5.6.2 The role played by the Research and Development Unit 115

5.6.3 Consultative Committees in the project 119

5.7 SEP'S MODEL OF INSET 120

PAGE

5.7.1 The nature of the model 120

5.7.2 The role of the project's implementers and the teachers in SEP's INSET programme 121

5.8 EVALUATION 125

5.8.1 SEP's policy on implementation of innovation and change 125

5.8.2 SEP's innovation and change in science education 126

5.8.3 The pre-package approach in curriculum development 127

5.8.4 Research Development and Dissemination of innovation and change ... 128

5.8.5 The role of Curriculum Development and the Research and Development Units in the project 129

5.8.6 SEP's INSET model 130

5.8.7 Implementation of policy in science and technology 131

5.9 SUMMARY 131

CHAPTER SIX: THE LEARNING AND TEACHING OF SCIENCE IN SEP SCHOOLS 133

6.1 INTRODUCTION 133

RESEARCH QUESTION TWO 133

6.2 IMPLEMENTATION IN THE CLASSROOM 135

6.2.1 SEP methodology 135

6.2.2 Different views on the expansion of SEP 138

6.2.3 Locus of control in SEP classrooms 138

6.2.4 Portable science kits versus formal laboratories 139

6.3 APPROACHES ADOPTED IN SEP CLASSROOMS 142

6.3.1 The process and constructivist approaches followed by SEP 142

6.3.2 Educational implications of the process and constructivist approaches .. 143

PAGE

6.4 TEACHER-PUPIL INTERACTIONS IN SEP CLASSROOMS 144

6.4.1 Variations of teacher-pupil interaction in SEP classrooms 144

6.4.2 Explanation of the differences between teacher-pupil interactions in SEP classrooms 162

6.5 ASSESSMENT OF PRACTICAL WORK IN SCIENCE TEACHING AND LEARNING 163

6.5.1 Practical work in SEP's methodology 163

6.5.2 Differing interpretations of practical work 165

6.5.3 Different views on assessment 167

6.6 EVALUATION AND INTERPRETATION 168

6.6.1 The process and constructivist approaches in SEP 168

6.6.2 SEP's approaches to the teaching and learning of science 169

6.6.3 Locus of control in SEP's classrooms 170

6.6.4 Portable science kit versus formal laboratories 171

6.6.5 SUMMARY 172

CHAPTER SEVEN: SEP AND ITS CONTEXT 173

7.1 INTRODUCTION 173

RESEARCH QUESTION THREE 173

7.2 ISSUES OF ADVOCACY AND IMPLEMENTATION 173

7.3 SEP, THE DONORS AND EDUCATION DEPARTMENTS 175

7.3.1 SEP and the donors 175

7.3.2 SEP and the education departments 177

7.3.3 Structural changes in the education departments 177

7.3.4 Changing relationship with the education departments 180

7.3.5 Changing relationship with the donors 181

7.4 EVALUATION AND ACCOUNTABILITY IN SEP 183

7.4.1 Differing views on accountability 183

7.4.2 Governance and funding of SEP over time 185

7.4.3 Implications 187

7.5 SUMMARY 188

CHAPTER EIGHT: INSTITUTIONALIZATION OF INNOVATION AND CHANGE 189

8.1 INTRODUCTION 189

RESEARCH QUESTION FOUR 189

8.2 INDICATORS OF INSTITUTIONALIZATION IN EDUCATION SYSTEMS 191

8.3 THE INSTITUTIONALIZATION OF SEP'S INNOVATION AND CHANGE DURING THE APARTHEID ERA 192

8.4 INSTITUTIONALIZATION OF INNOVATION AND CHANGE IN THE POST-ELECTION ERA 195

8.5 STRATEGIES ADOPTED TO INSTITUTIONALIZE INNOVATION AND CHANGE 197

8.5.1 Contact with teachers 197

8.5.2 Contact with education administrators 198

8.6 FACTORS WHICH INFLUENCED INSTITUTIONALIZATION OF SEP'S INNOVATION AND CHANGE IN SCIENCE 199

8.7 EVALUATION 200

8.7.1 The meaning of institutionalization 200

8.7.2 Institutionalization of innovation and change by SEP 202

8.8 SUMMARY 203

PAGE

CHAPTER NINE: IMPLICATIONS, LIMITATIONS AND THE NEED FOR FURTHER STUDY 204

9.1 INTRODUCTION 204

9.2 THE FRAMEWORK OF THE INVESTIGATION 204

9.3 FINDINGS 205

9.3.1 Conceptual and analytical frameworks adopted 205

9.3.2 Vision, intention and policy relating to models of curriculum development, innovation and change 206

RESEARCH QUESTION ONE 206

9.3.3 The teaching and learning of science 207

RESEARCH QUESTION TWO 207

9.3.4 Relationship between SEP and the education departments 208

RESEARCH QUESTION THREE 208

9.3.5 Institutionalization of innovation and change 210

RESEARCH QUESTION FOUR 210

9.4 THE PRESENT POSITION OF THE SCIENCE EDUCATION PROJECT 211

9.5 LIMITATIONS OF THIS INVESTIGATION 213

9.5.1 Research paradigms, research methods, approaches and perspectives .. 213

9.5.2 Case study 213

9.5.3 Sampling 214

9.5.4 Instruments 214

9.5.5 The project in the socio-political context of post-election South Africa 215

9.5.6 The role of the NGO/CBO sector in the provision and delivery of innovation and change in education 216

PAGE

9.6 SUMMARY 217

CHAPTER TEN: VALIDATION, VERIFICATION AND CONFIRMATION OF THE FINDINGS 219

10.1 INTRODUCTION 219

10.2 RESEARCH QUESTION ONE 220

10.2.1 Models adopted to introduce the project to the education departments ... 221

10.2.2 The aims and goals of SEP's innovation and change 222

10.2.3 The phases of innovation and change in the project 222

10.2.4 Models and approaches of curriculum development, innovation and change 223

10.2.5 Research development and dissemination of innovation 224

10.2.6 The roles of the Curriculum Development and the Research and Development Units 225

10.2.7 The role of the Research and Development Unit 225

10.2.8 SEP's model of INSET 226

10.3 RESEARCH QUESTION TWO 227

10.3.1 The influence of SEP's innovation and change in the classroom 228

10.3.2 Differing views on the process and constructivist approaches 229

10.3.3 The data on classroom observations 230

10.3.4 Lack of practical work and its assessment 230

10.4 RESEARCH QUESTION THREE 231

10.4.1 Stakeholders' relationships and implementation 234

10.4.2. SEP and the donors 234

10.4.3 SEP and the education departments 236

10.4.4 Structural changes in education 237

PAGE

10.4.5 Changing relationship with the education departments 238

10.4.6 Changing relationship with the donors 239

10.4.7 Evaluation and accountability 240

10.5 RESEARCH QUESTION FOUR 242

10.5.1 Indicators of sustained-implementation in SEP 243

10.5.2 Institutionalization and autonomy during the apartheid era 245

10.5.3 Institutionalization of innovation and change in the post-election era 245

10.5.4 Strategies adopted to institutionalize innovation and change 246

10.5.5 Contact with education administrators 247

10.5.6 Factors which influenced sustained-implementation of innovation and change . . 248

10.6 SUMMARY 248

CHAPTER ELEVEN: SYNOPSIS 249

LIST OF REFERENCES 257

APPENDICES 273

LIST OF TABLES

		PAGE
Table 1:	Clustering of assertions into three categories by two investigators and reliability	50
Table 2:	Assumptions underlying the rationalistic and the constructivist paradigms	54
Table 3:	Research design	63-64
Table 4:	SEP documents and records sampled for the Pietermaritzburg region	67
Table 5	SEP documents and records sampled for the North West region	68
Table 6:	SEP documents and records sampled for the Gauteng region	69
Table 7:	SEP documents and records sampled for the Eastern Cape region	70
Table 8:	Schools, Districts and lessons observed in the Pietermaritzburg region	72
Table 9:	Schools, Districts and lessons observed in the North West region	73
Table 10:	Schools, Districts and lessons observed in the Eastern Cape region	74
Table 11:	Schools, Districts and lessons observed in the Gauteng region	75
Table 12:	Scientific and naturalistic terms appropriate in each of the two research designs	81
Table 13:	Three strands of qualitative inquiry	81
Table 14:	Themes and trends explored in Chapter Five and sources of data	104-105
Table 15:	Themes and trends explored in Chapter Six and sources of data	134

LIST OF TABLES

		PAGE
Table 1:	Clustering of assertions into three categories by two investigators and reliability	50
Table 2:	Assumptions underlying the rationalistic and the constructivist paradigms	54
Table 3:	Research design	63-64
Table 4:	SEP documents and records sampled for the Pietermaritzburg region	67
Table 5	SEP documents and records sampled for the North West region	68
Table 6:	SEP documents and records sampled for the Gauteng region	69
Table 7:	SEP documents and records sampled for the Eastern Cape region	70
Table 8:	Schools, Districts and lessons observed in the Pietermaritzburg region	72
Table 9:	Schools, Districts and lessons observed in the North West region	73
Table 10:	Schools, Districts and lessons observed in the Eastern Cape region	74
Table 11:	Schools, Districts and lessons observed in the Gauteng region	75
Table 12:	Scientific and naturalistic terms appropriate in each of the two research designs	81
Table 13:	Three strands of qualitative inquiry	81
Table 14:	Themes and trends explored in Chapter Five and sources of data	104-105
Table 15:	Themes and trends explored in Chapter Six and sources of data	134

PAGE

Table 16: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the Eastern Cape region 147

Table 17: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the North West region 148

Table 18: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the Gauteng region 149

Table 19: Observation schedule - percentage frequency of occurrence of observations in SEP schools in Pietermaritzburg region 150

Table 20: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Gauteng region 151

Table 21: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the North West region 152

Table 22: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Pietermaritzburg region 153

Table 23 Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Eastern Cape region 154

Table 24 : Themes and trends explored in Chapter Seven and sources of data . 174

Table 25: Themes and trends explored in Chapter Eight and sources of data . . 190

Table 26: Themes and trends explored in Research Question One and sources of data 220-221

Table 27: Themes and trends explored in Research Question Two and sources of data 227-228

Table 28: Themes and trends explored in Research Question Three and sources of data 232-234

Table 29: Themes and trends explored in Research Question Four and sources of data 242

LIST OF FIGURES

		PAGE
Figure 1:	Sources from which the data were collected	61
Figure 2:	Triangulations based on the research instruments and data sources	62
Figure 3:	Data reduction process and analysis model	87
Figure 4:	The 'funnel' approach to reduce the data	88
Figure 5:	A model for verification and confirmation of the findings.....	100

LIST OF APPENDICES

		PAGE
APPENDIX 1:	ELITE POLICY-MAKERS INTERVIEWED	273
APPENDIX 2:	AN INTERVIEW GUIDE DURING THE INITIAL PHASE OF THE CURRENT INVESTIGATION	277
APPENDIX 3 (i):	CLUSTERED RECURRING THEMES WITH RESPECT TO VISION AND POLICY PROPOSALS BY ELITE POLICY-MAKERS	282
APPENDIX 3 (ii):	CLUSTERED RECURRENT THEMES WITH RESPECT TO VISION AND POLICY PROPOSALS BY ELITE POLICY-MAKERS.....	283
APPENDIX 4:	INTERVIEW GUIDE USED AS A FOLLOW-UP TO QUESTIONNAIRES	287
APPENDIX 5:	CLUSTERED RESPONSES OF INTERVIEWS WITH SEP MANAGERS AND IMPLEMENTERS	290
APPENDIX 6:	CLUSTERED RESPONSES FROM THE PROJECT TEACHERS	293
APPENDIX 7:	LEWIN'S ORIGINAL OBSERVATION SCHEDULE ..	295
APPENDIX 8:	GUIDE TO PUPIL INVOLVEMENT (LEWIN'S ORIGINAL SCHEDULE)	298
APPENDIX 9:	GLOSSARY AND ACRONYMS	300

CHAPTER ONE

AN INTRODUCTION TC THE PROBLEM, AND AN OVERVIEW OF THE RESEARCH.

1.1 INTRODUCTION

1.2 THE PURPOSE OF THE STUDY

The purpose of this investigation is to examine and analyse the vision, intention, policy, implementation and institutionalization of curriculum development, innovation and change undertaken by the Science Education Project (SEP) in four selected regions of South Africa. Data analysis in the study covers the period from 1980 to 1995.

The central aim of SEP over this period was to improve the teaching and learning of science in disadvantaged communities in South Africa. Its secondary aim was to initiate change in education in general by changing teachers' attitudes and by empowering them through the introduction of alternative methodologies and intervention strategies.

SEP's mission statement is as follows:

> *"SEP is a system for promoting innovation and change in science education in South Africa by encouraging an activity-based approach to science education in order to advance education in South Africa* (Rogan 1976 (b))".

The mission statement implies that the project explicitly targeted innovation and change in science education and implicitly aimed at the advancement of education. While innovation and change in the context of SEP's mission statement suggest improvement or introduction of change, the advancement aspect seems to encompass innovation and change as well as growth and progress.

1.3 THE ORIGIN AND THE DEVELOPMENT OF THE SCIENCE EDUCATION PROJECT

SEP is a non-governmental organization (NGO) founded in the early 1970s with financial backing from the Anglo American Chairman's Fund (Rogan 1976 (a); Rogan and Macdonald 1985).

The initial proposal to the Urban Foundation for the funding of a science project (Rogan 1976 (a)), as well as the regional and national evaluation reports on the proposal suggest that the idea behind the introduction of the project was to provide an alternative methodology and approaches to the one provided by the National Party Government over the apartheid years (Macdonald 1989).

The project was pioneered and nurtured by John Rogan in the early 1970s and mainly reflected his experience of science teaching in the then Bantu Education Schools around the former Ciskei homeland (Rogan 1976 (b); Schaffer and Morphet 1983 (a); (b); Morphet et al. 1986). Rogan, with the help of colleagues, spent the first five years conducting research on science education and testing the project material by using resources at the neighbouring University of Fort Hare (Dlepu 1984). These materials were based on the existing science syllabus and were directed at the Standard 6, 7 and 8 pupils and the teachers responsible for these classes (Macdonald and Rogan 1981; Moodie 1984).

The explicit intention of SEP designers and subsequent developers was that pupils should *do Science, rather than be shown or told about Science* (Rogan 1976 (b); Macdonald and Rogan 1981; Moodie 1984). It was also agreed that pupils should be equipped with portable apparatus which differed from the conventional science apparatus used in a conventional laboratory similar to those found in some state schools. Portable science apparatus was regarded as more suited for poor areas without electricity and water.

Rogan (1976 (b)) identified three specific problem areas relating to science education which he thought SEP could address. These were:

- The equipping of schools on an economic basis (The word 'economic' is used in the sense of 'good value for money' rather than cheaply).

- A change in teaching strategies, away from rote learning towards an inquiry-based approach.

- The production of tested supplementary materials such as teachers' guides and pupil work sheets.

The first signs of the implementation of SEP's innovation and change became visible in 1977/78 in the former Ciskei region (Macdonald 1980; Moodie 1984). The implementation stage comprised the usage of the project's material and pupils' and teachers' activities in the learning process.

The project expanded to the Johannesburg (Gauteng) region during 1979/80 (Hamlyn 1982). SEP further expanded into newer and smaller regions such as the former Gazankulu (Moodie 1980; 1986), former Lebowa and the Bophuthatswana regions (Gilbert 1984 (a); SEP 1990).

Three phases have been identified relating to the unfolding of SEP's vision, policy and implementation in this thesis. These are: (i) development (1980 to 1989); (ii) expansion (1989 to 1991); (iii) consolidation (1991 to 1995) (SEP 1988/89; Anderson 1990; Macdonald 1993). Changes that occurred during these times are: changes in the culture and ethos of SEP, changes in the size of the project's activities and the number of the regions in which SEP operated, perceptions on the institutionalization of SEP's work, the relationships between the different project staff and their understanding of its vision, policy and implementation, and the extent to which the nature of relationships between SEP and other stakeholders affected the implementation and institutionalization of the project's work.

During the period from 1980 to 1989 SEP was a small organization with a small group of staff characterized by cooperation, family-like support and sharing of the project's vision, policy and implementation. Further, the staff and personnel shared common values and the culture and ethos of SEP. Institutionalization and accountability during this period were largely matters of concern within SEP. This period represents the development phase, also known as the efficiency phase (Macdonald 1993). SEP experienced rapid expansion during 1989 to 1991. The number of implementers increased, the project's expenditure increased and the culture and ethos of the organization also changed.

The period from 1991 to 1995 represents not only the peak of SEP's vision, intention and policy regarding its expansion and consolidation phases but also its demise. During this period, the project expanded threefold by extending its operations in newer regions with significant implications for the numbers of implementers, teachers and staff. Relationships between staff members and personnel in relation to the organizational culture and ethos also changed from one of cooperation and family-like support to one characterized by formal procedures and bureaucratic control. Over this period, SEP also received large sums of money from the Independent Development Trust, which resulted in high levels of expenditure. Institutionalization

and accountability became matters of external concern (Anderson 1990; SEP 1988/89; SEP 1993; Triegaardt 1994 (a)). External concern in the context of this study means that there was a gradual shift from accountability to clients to accountability to funders and the education departments.

In this more bureaucratic context, SEP continued expanding its activities during 1991 through to 1995 and increased the complements of implementers to 63 across the country while the number of staff rose to 100 staff by 1995. These implementers operated in most of the present nine provinces. The relationship between the project's staff and personnel became more formalized and impersonal and the management style changed, accompanied by changes in ways in which stakeholders perceived the culture and ethos of the organization. One of the notable changes relating to the culture and ethos of the organization was that during 1980 to 1989 SEP allowed potential leaders within the project to emerge and to become change agents (Anderson 1990; 1994; Macdonald 1993; SEP 1992; SEP 1993). From 1990 in contrast the culture and ethos of the project had changed completely where the role of individuals as change agents became weak and the notion SEP as an INSET became more prominent.

In addition, wider contextual and socio-political factors influenced the development of SEP over this period. With political changes in South Africa and the new policy governing the funding of NGOs, SEP was unable to continue operating through implementers in the regions and by the time the writing-up of this study was completed, the project had effectively ended. SEP currently operates as a consultancy with very little implementation in the regions.

The results of this study have been affected by these changes in two ways. Firstly, a number of informants (teachers and pupils) who provided the initial data on the project could not be traced in order to comment on the final report because of the change of government officials, the changed governance structures in schools, the

redeployment of teachers and the voluntary early retirement of some of them. Secondly, the majority of former SEP staff including the Executive Director, project managers, implementers and the Research and Development Unit had moved to other employment following SEP's decision to stop operations in the regions. This made the task of collecting and substantiating data a difficult one. Changes in personal circumstances may also have influenced the perceptions of a number of informants used in the study towards the project and its work.

1.4 THE CONTEXT OF THE STUDY

1.4.1 Relationship between SEP, schools and the education departments

Macdonald (1989) observed that within SEP there was no consensus on the nature and extent of its relationship with educational authorities. Consequently, since 1983 questions raised about SEP's policy related to how the project was to cooperate with the education authorities (Gilbert 1984 (b); Schaffer and Morphet 1983 (a); 1983 (b) Morphet et al. 1986). Central to this debate was whether the project should work fully inside or outside the education system or whether it should remain somewhere in between the two extremes . However, the political changes of the late 1980s led to two levels of relationships between SEP and the education authorities. The first one comprised the official level of negotiations between the project and the education authorities. The second consisted of a situation where the project operated within schools long before formal agreements were reached between the project and the education authorities in some regions.

Moodie (1984) and Rogan and Macdonald (1985) commented on the dilemma the project faced of working inside or outside the system. They argued that working fully inside the system meant working through the existing bureaucratic system and in conformity with the political goals of the National Party. This was unacceptable because the move was in stark contrast with SEP's policy and methodology on

innovation and change in science education. On the other hand, working outside the system would deny the project access to schools and the prescribed science syllabus. However, Rogan and Macdonald (1985) argued that, despite the fact that SEP materials had to conform to the syllabus, the project had nonetheless managed to establish that it was neither part of the then Bantu education system, nor an attempt to develop inferior materials for Black students. The question of whether SEP should operate inside or outside the education system was resolved by a compromise that the project should cooperate with the education authorities without becoming part of them (Morphet et al. 1986; Hartshorne 1989; 1992).

What was never agreed upon, however, was the criteria to be used in establishing whether the project was successful or not. According to one of the former Executive Directors of the project, Peter Gilbert, the education authorities during that time operated from a value system that stressed the improvement of examination results as an indicator of the success of the project (Macdonald 1989). However, other stakeholders relied more on changes that were difficult to measure quantitatively as indicators of whether the project was effective or not (Gilbert 1984 (b); SEP 1990). The debate was complicated by the types of relationships that existed between SEP and education authorities which depended largely on individual education officials who, in many cases, did not necessarily represent the departments' policy. Consequently, steady negotiations with one official regarding the project's innovation initiatives could be rapidly overturned by a newly appointed official who held a different perception of what SEP was doing.

1.4.2 The changing relationship with the education departments

The present government, unlike the previous one, has expressed an intention to work in close cooperation with the NGOs and the business sector in the provision and delivery of educational services as part of the reconstruction and development process (ANC 1994 (a)). The intention of the government to work cooperatively

with all the interested parties in education is contained in the government's policy document on Education and Training in Democratic South Africa (Republic of South Africa 1995). However, the situation regarding the government's commitment to support NGOs is different in reality because many NGOs have, in fact, closed down under the present government. Others have had to change their operations considerably in order to comply with the Not-for-Profit-Making Organizations Act (Republic of South Africa 1997) which currently governs the administration of government funds allocated to NGOs in South Africa. The Not-for-Profit-Making Organizations Act of 1997 also requires the Board of Directors of an NGO be registered and the government reserves the right to audit the accounts of such an NGO should this be necessary. Furthermore, this Act requires that all NGOs should be subjected to more stringent accountability procedures and should comply with the provisions of section 21 of the South African Company Act (Republic of South Africa 1973). Section 21 regulates procedures to be followed in raising funds by non profit organizations and the need for proper accountability.

Paragraphs 47 to 51 of the draft White Paper make reference to issues of the provision and delivery of educational services by the government through its various departments (Republic of South Africa 1995). However, the need for cooperation in rebuilding the education sector by inviting the support and active participation of parents, students, community leaders and NGOs is also acknowledged. Paragraph 5 of the White Paper states the following in respect of provision and delivery of educational services:

> "*The state has the responsibility in the provision of education and training, but the state should also provide a framework in which learning opportunities may be provided on as wide a scale as possible by many other agencies in civil society.*" (Republic of South Africa 1995:11).

The intention of the White Paper was to spell out more clearly the responsibilities and roles of the NGOs and the state in respect of teacher development, INSET and curriculum development in a democratic society. Curriculum issues that arose as a result of the changing political environment and the role of NGOs in South Africa have been: accountability of NGOs, their effectiveness and efficiency, their intervention strategies and the possible provision and delivery role they could play. Kahn (1993:39) asserts that one of the major problems facing NGOs is that "*there are too many of them and therefore they tend to compete for clients.*" The result of this unhealthy competition, he argues, is further compounded by the fact that the NGO sector is uncoordinated which makes it difficult to measure their effectiveness in the system (Kahn 1993). However, this view is not unanimously supported by SEP personnel, donors and members of the Board of Trustees who were of the opinion that Kahn's claim was an overgeneralization.

Debate over the last few years has revolved around the role of the NGOs as deliverers of innovation and change in education and the need for those NGOs involved in science to consider forming a coalition. An objective of the coalition would be to act as a conduit to obtain funds from the Independent Development Trust (IDT) which currently administers the funds ear marked for NGOs in the new system of education.

The formation of a trust was precipitated by the recent inclination of the foreign donors to channel money to the government's Reconstruction and Development Programme (RDP) (ANC 1994 (b)) rather than giving it to individual NGOs, as was the case in the past. The creation of a coordinating trust coupled with the donors' contributions to the RDP (government-to-government as opposed to direct government-to-NGO funding) has resulted in the closure of many NGOs. This includes even those which have had a good track record in delivering innovation and change in science and mathematics. Currently the funds from foreign donors are channelled through the Transitional National Development Trust (TNDT) (Douglas 1995 (a)). However, the British government remained one of the few foreign donors that funded SEP directly during the period under review. This funding was channelled through the ODA and the British Council.

In early 1995, the government called a meeting of NGOs to dispel newspaper reports that it was appropriating foreign funding and denying NGOs the opportunity to choose their own terms of operations (Douglas 1995 (b)). The government's representatives promised that the NGOs were going to have their fair share of the money donated by foreign donors. However, despite these promises in 1995, many older NGOs involved in innovation and change in science and mathematics have been either forced to close down completely, or to curtail their operations drastically because of financial constraints. SEP has been equally affected by developments on how the money is allocated to the various NGOs by the IDT and TNDT. This has also affected this study in that its focus was broadened to include these contextual influences on SEP's work.

1.5 THEORETICAL FRAMEWORK AND FOCUS OF THE STUDY

1.5.1 The focus of the study

The focus of this study is on the implementation and institutionalization of curriculum development, innovation and change introduced by SEP in science teaching and learning. Curriculum in the context of the study relates to what pupils should learn and what should be taught, as well as how the teaching and learning should take place in science.

Stenhouse's (1975) distinction between curriculum as 'intention' and curriculum in 'action' is employed to analyse the project's policies (intentions) on the one hand, and its implementation (action) on the other. This distinction has been further used to analyse innovation and change in science education introduced by SEP as intentions of the project's developers on the one hand, in contrast to what actually happened in the schools and the regions that formed the sample of the study on the other. Furthermore, an examination of intended and unintended outcomes of implementing and institutionalizing innovation and change by SEP formed part of the study. The evaluation model employed in this study is described in detail in Chapter Three of the research report.

The chosen framework illuminates the interconnections between the orientation, initiation, implementation and institutionalization stages of innovation and change as essential features of one indivisible process. It has also aided in explaining themes and trends that may have arisen when investigating the project in the four regions. The following areas of focus were developed:

Vision, intentions and policy relating to:

- Curriculum development, innovation and change in science education.
- Conceptualization of teaching and learning of science in SEP.
- The nature of relationship within SEP and the nature of relationship between the project and the education departments and donors at the implementation level of innovation and change.
- The meanings and conceptualization of institutionalization level of implementation (continued-implementation) relating to the project's work during the different time-periods.

In view of the fact that the data in this research report was obtained from a variety of stakeholders with differing experiences in SEP, it was necessary for the researcher to conduct a pilot study. The purpose of the pilot study was to narrow the focus of the study, clarify issues and to develop relevant research questions. Consequently, the pilot study resulted in the emergence of trends, themes and issues from which the research questions in the main study were derived. The pilot interviews also helped the investigator to develop and solidify rapport with participants in the project and enhanced effective communication patterns (Janesick 1994). The details of the pilot study are described in Chapter Three of this report. The pilot study comprised pre-interviews with selected elite policy makers in science education in general, selected

former and current SEP staff, as well as a brief survey of some selected project documents and memoranda that were written or compiled during the early development of the pilot study.

The research questions which guided the pilot study were as follows:

i) Research Question One

What are your views on the models of curriculum development and innovation during the apartheid era?

ii) Research Question Two

The teaching and learning of science has been a major concern in South Africa especially in disadvantaged communities. What in your view are the issues and problems in this regard?

iii) Research Question Three

What role did NGOs and the business sector play in curriculum development and innovation in science education during the apartheid era? What role could these sectors play in the post-apartheid society?

iv) Research Question Four

What do you understand by institutionalization of innovation and change and what factors do you think may promote or retard institutionalization of innovation and change?

In light of the analysis of the result of the pilot study and the researcher's continual interaction with the project, the pilot research questions were modified as follows:

i) RESEARCH QUESTION ONE

How effective and enabling were SEP's models of curriculum development and approaches to innovation and change?

The first question examines vision, intention and policy of curriculum development and approaches to innovation and change in SEP.

ii) RESEARCH QUESTION TWO

How was the teaching and learning of science conceptualized in SEP?

This question focuses on the vision, intention and policy relating to the conceptualization of the teaching and learning of science in SEP.

iii) RESEARCH QUESTION THREE

How did the nature of the relationship between SEP and other stakeholders affect the implementation of the project's work during the period under review?

The third question examines the implementation level, or action within the project.

iv) RESEARCH QUESTION FOUR

How did SEP deal with the issue of institutionalizing its innovation and change?

The fourth question focuses on the institutionalization (also known as sustained-implementation) of innovation and change.

1.5.2 Methods, approaches and procedures

A summary of methods, approaches and procedures employed in both the pilot and main study followed in this investigation is outlined below. Detailed discussions on these issues are found in Chapter Three, which describes the research design.

1.5.3 Theoretical bases of the study

The study is conducted within the interpretive paradigm, also called constructivist paradigm by Denzin and Lincoln (1994). In terms of this paradigm, the present study included the usage of inductive analysis based on data collected in the field, personal contacts with informants and the gathering of their insights into SEP. This implied that the study sought knowledge about SEP in the experiences, meanings and insights of the unique and personal nature of the stakeholders.

The investigator adopted the interpretive paradigm because it was deemed suitable to deal with the collection of the data about SEP in the field. This paradigm enabled the investigator to understand the work of the project from the perspectives of the various stakeholders who were associated with it.

In the light of the chosen interpretive paradigm the following procedures were adopted in the study:

- The use of case study as a method of research;
- The adoption of a variety of methods in collecting the data, and
- The cross-comparison and linking of the data obtained from the various sources.

This study is further guided by the theory-driven perspective suggested by Chen (1990) which provided a useful theoretical framework for the analysis of data. The theory-driven perspective is discussed in more detail in Chapter Three of this report.

The investigator adopted a grounded theory methodology as proposed by Henwood (1996) and Pidgeon and Henwood (1996). The grounded theory methodology employed in the study is also outlined in Chapter Three of this report.

1.5.4 Research instruments

(i) Format, purpose and the sample in the pilot study

The pilot study comprised twenty-eight interviews with elite policy-makers from the public and private sectors, NGOs, parastatal organizations, political organizations, donors, university academics and research institutions in South Africa. The purposes of the pilot interviews were to obtain trends, themes and issues on science education in South Africa held by the elite policy makers and SEP's staff as well as to help develop the research questions.

Interviews were analysed by the investigator and a research assistant. Assertions, themes and issues that emerged were recorded and analysed according to procedures used by Potter (1987). Reliability tests on the coded data were conducted by means of a formula proposed by Osgood (1959) and used by Potter (1987).

(ii) Main study

The main study included analysis of a sample of thirty-two SEP documents and records as well as interviews. The sample of documents was drawn from SEP archives while interview data were provided by elite policy makers, former and current SEP executive Directors, former and current project managers and implementers, former and current researchers who worked for SEP, and teachers in the four regions.

Additional data were obtained by means of classroom observations and photographs taken during classroom observation, questionnaires administered to SEP staff and interviews with them over a period of four years. Further information relevant to the main study was also obtained from the literature on curriculum development, innovation and change in science education. Procedures followed to analyse and interpret the results are described below.

1.6 DATA ANALYSIS

The process of reducing and analysing the data were carried out within the analytical framework proposed by Miles and Huberman (1984;1994). Their proposal for qualitative data analysis comprises data reduction, examination and conclusion drawing as well as verifying and confirming results. The project documents and records as well as interviews were subjected to content analysis as part of the reduction and analysis of data. Results of classroom observations were subjected to qualitative analysis using frequency counts. Results were also subjected to the various cross-checks involving what Geertz (1973) and Miles and Huberman (1994) called 'thick description', peer briefing, negative case analysis, triangulation and member checks. The purpose of cross-checking was to confirm results, thereby enhancing their credibility and dependability, transferability and confirmability.

1.7 SIGNIFICANCE OF THE STUDY

Implementation and institutionalization of curriculum development, innovation and change have different meanings to different people. The various stakeholders within SEP held different and sometimes divergent perspectives and perceptions on the project's role in improving science education in South Africa. The identification and examination of the intended and unintended, as well as the positive and negative outcomes of implementing and institutionalizing SEP's work in the four regions could provide valuable information for curriculum developers and change agents.

This study is significant because the transactional framework used to evaluate SEP proved useful in the understanding of the transactions in the vision, intention and policy into the implementation of innovation and change. Further, the conceptual framework that recognizes the different levels of use of innovation and change may be of use to other researchers. This framework could be useful in guiding the analysis of curriculum issues. The adoption of the paradigms chosen and the variety of methods and approaches could also be employed by other researchers involved in collecting data from a non-controlled, non-experimental context. The paradigms, approaches and methods employed in this study could provide a useful analytical framework for researchers and change agents in order to understand the individual meanings and perspectives of curriculum and innovation in education. Furthermore, the chosen theoretical framework where the research was investigated within grounded theory methodology, makes a special contribution to the elaboration and modification of existing substantive grounded theories on curriculum development, innovation and change.

1.8 LIMITATIONS OF THE RESEARCH

The investigation into SEP in this study took the form of a case study involving the Pietermaritzburg, North West (former Bophuthatswana), Eastern Cape (former Ciskei) and Gauteng (former Witwatersrand) regions. Its limitations relate to the extent to which results from the four regions can inform implementation and institutionalization of the project's work as a whole. Consequently some aspects of implementation of innovation and change practice may be generalized while others cannot. As a case study, the investigation is written for policy-makers, implementers and materials writers within SEP. However, there are certain findings from this case study that can be used to guide policy and practice in other curriculum innovation projects.

This case study focuses on an evaluative review of SEP from 1980 to 1995. Major political, economic and educational changes of the 1990s have inevitably affected the results of the current investigation.

The other limitation is created by the fact that some of the data on the project's policy and practice were coded from the project's documents written and completed:

- By staff members who were involved in the initial development of SEP and its material during the early 1970s and 1980s.

- Some documents were compiled by staff members who had joined the project in the 1990s.

In view of the fact that the project documents were compiled during different times in the history of the project the results have been influenced by the contexts within which the documents were written. Lastly, although the ideal situation to confirm the results of the research was to go back to all the regions where research was conducted and to give all participants the opportunity to comment on them, this was not possible because the project ceased operations in the regions during the writing-up process.

1.9 ORGANIZATION OF THE REMAINING CHAPTERS

The thesis comprises eleven chapters. Chapter Two describes the literature review while research design is provided in Chapter Three. Procedures followed to analyse the findings are presented in Chapter Four. The analytical case study of the Science Education Project is presented in Chapters Five, Six, Seven and Eight. Implications, limitations and the need for further study are analysed in Chapter Nine. Validation verification and confirmation of findings are presented in Chapter Ten and the synopsis in Chapter Eleven.

1.10 DEFINITION OF TERMS

SEP:	SEP is an acronym for the Science Education Project started by John Rogan.
SEP National:	SEP National refers to the Head Office of the project situated at the Science Education Project building in Jorissen Street in Bruamfontein, Johannesburg.
The Project:	The project means the Science Education Project.
SEP students/pupils:	Students/pupils who were using the project's material, science equipment and its philosophy.
Project Implementers:	Qualified science teachers implementing the project in the various regions/provinces.
Consultative Committee:	SEP committees comprising stakeholders in the regions that help the implementation of the project.
SEP Regional:	The Regional/Provincial projects of the Science Education project.
R and D Unit:	A Research and Development unit situated at SEP National Office and responsible for research on the project.
CD Unit:	A unit situated at SEP National office and responsible for designing of the project's material.
Implementers' conference: (MPCO)	A conference designed for SEP implementers.
Education Departments:	Education departments as they existed in the old system.
NGOs:	Non-Governmental Organizations which provide and deliver educational and other services.

CBOs:	Community-Based Organizations.
The Project Managers:	Persons who were appointed by SEP National to look after and administer the project's policy and implementation.
The Project's Kit:	The science kit provided by SEP and used by the project's schooling.
The project's teachers:	The teachers using SEP material and equipment.
INSET:	In Service Teacher Training.
TNDT:	Transitional National Development Trust

CHAPTER TWO

LITERATURE REVIEW ON INNOVATION AND CHANGE IN SCIENCE EDUCATION

2.1 INTRODUCTION

This chapter is a literature review of innovation and change in science education. The chapter focuses firstly on the literature review and concludes by discussing how the literature has affected the research design and the focus of this study.

There are four broad functions which a literature review serves in research (Marshall and Rossman 1989). *"First, it may be used to highlight assumptions underlying research questions. Secondly, it may serve as a theoretical background relating to research and as a basis of the intellectual tradition which surrounds and supports the study. Thirdly, it may help to indicate any gaps in previous research and, fourthly, it may assist to refine and redefine the research questions and related tentative hypotheses"* (Marshall and Rossman 1989: 35).

The review of the literature in this thesis has served all four functions outlined above. In addition, the literature review helped to identify a number of broad areas, themes and trends are classified as follows:

- The education context within which SEP has been operating since its inception.

- The literature on innovation and change in education, curriculum policy and issues, implementation and institutionalization.

- Data reduction and analysis procedures.
- Methodological issues.
- Issues in science education in general and in South Africa in particular.
- Research design.
- SEP documents including its evaluation reports, records of meetings, dissertations, monographs and quarterly reports in the four regions selected for study.

According to Rogan (1976 (a)), SEP has had as its overall aim the improvement of the teaching of science. This aim was to be achieved by providing a 'package' comprising science equipment, teacher development, science materials and the teachers' guides. Following this description, SEP in the context of this thesis is perceived as an innovation and change project in science education. However, both the positive and negative unintended consequences of its implementation were also taken into account in the investigation.

2.2 VIEWS ON INNOVATION AND CHANGE IN EDUCATION

Change comprises a family of concepts such as innovation, development and renewal and can also be planned or unplanned, intentional or unintentional (Bolam 1975; Marsh 1992). Miles (1964) argues that innovation is always deliberate and planned compared to change. Consequently through planning, one can deliberately increase the chances of introducing desired change (Havelock and Huberman 1977). This distinction between innovation and change suggested by Bolam (1975) and Miles (1964) indicates that the former can be used to examine intentions while the latter may be used to explore what actually happens in practice, including the unintended consequences of the implementation of a particular project. Intended and

unintended outcomes are central to an analysis of implementation and evaluation of innovation and change.

Many authors (Havelock 1973; Berman and McLaughlin 1975; Berman and McLaughlin 1976; 1978; Bishop 1986; Marsh 1992) suggest that four phases or stages of innovation and planned change can be distinguished. These are: Orientation or needs phase, initiation or adoption, implementation or initial use phase and incorporation or continued implementation or institutionalization.

Giacquinta (1973) argues that these phases of innovation and change do not necessarily appear in this order in practice. Thus, successful initiation does not inevitably lead to successful implementation. Successful orientation, initiation and implementation do not automatically lead to sustained and effective incorporation of innovation into the system. Studies conducted in different settings by Miner (1960), Carlson (1965), Gross et al. (1971) and Giacquinta (1973) suggest that it may be misleading to assume that the occurrence of one stage automatically leads to the next.

A core insight derived from the literature was that the process of innovation and change is multidimensional in nature. According to Fullan and Stiegelbauer (1991:37) it comprises the followir components:

- *"The use of new or revised materials;*
- *The use of new teaching approaches (i.e. new teaching strategies or activities), and*
- *The positive alteration of beliefs (i.e. pedagogical assumptions and theories underlying particular new policies or programmes)"* (ibid:37).

Furthermore, an inference drawn from the literature is that the three participants in making innovation work and bringing about change at the local level are the pupils, teachers and principals. It also became apparent that the administrators and education authorities can encourage or even discourage innovation at regional and central levels respectively.

Fullan and Stiegelbauer (1991) argue that because teachers are closer to realities in schools, they are in a better position to know whether they should accept, modify or reject innovation and change. First, they want to know whether the envisaged change is introduced from inside or outside, whether it addresses important needs and whether the practice has worked elsewhere. Second, the teachers ascertain whether the administrators are endorsing the change and why. This is an important consideration because some form of active commitment by administrators is necessary for the innovation and change to succeed. Third, they assess whether fellow teachers are likely to show an interest in the envisaged innovation and change. Fourth, regardless of outside pressures or opportunities, individual teachers have the responsibility of making some contributions to the development of a collective work culture. However, it is observed that, *"even when the source of change is elsewhere in the system, a powerful determining factor is how central office administrators view the change. Accordingly, innovation and change stands a chance of spreading beyond the classroom or school if it is supported by the administrators"* (Fullan and Stiegelbauer 1991:185).

The above thus indicates that successful innovation and change must be supported at various levels by the relevant stakeholders. This insight was incorporated into this study.

2.3 THEORIES AND MODELS OF INITIATING AND IMPLEMENTING INNOVATION AND CHANGE

The theories and the models of initiating and implementing innovation and change include "*those that originated from rural and industrial sociology, psychotherapy and organisational psychology as well as those from political science*" (Dalin 1978:60). The first is known by various names including: Research, Development and Dissemination Model (RD and D) (Havelock 1969; Havelock 1973), or the Centre-Periphery Model (Schon, 1971). The second one is the Social Interaction (Havelock 1973) or Periphery Model (Schon 1971). The third and last, is the Problem Solving Model (Havelock 1973) or Periphery-Centre model (Schon 1971). The three models are not mutually incompatible, but rather start from different philosophical positions (O.E.C.D. 1975).

RD and D has been the most common in situations where the relationship between the change agents and the users have been unequal (Brickell 1961; Guba and Clark 1967; Schon 1971; Bennis et al. 1976). The two weaknesses of this model are first, its general bias towards the neo-evolutionist and modernist traditions in situations where the power between the change agents and the users is an unequal one in the model. In this situation, the change agents and the need to change are introduced by 'experts' from Developed Countries while the users of change have always been people in Developing Countries. The second weakness is that the model tends to overemphasize technical aspects of innovation and change (Dalin 1978).

In the field of dissemination of innovation and change in education, the Centre-Periphery Model found expression in the notion of a 'pre-package', 'package' or 'product' approach (Grundy 1987; Cornbleth 1990; Ruddick 1991). The approach postulates a logical sequence of actions. It assumes the application of research, the design of prototype, field trials, revision, mass production, dissemination and eventual implementation and evaluation (O.E.C.D. 1975; Stenhouse 1975; Cornbleth 1990). This model further asserts:

- The division and coordination of labour in accordance with a rational sequence and planning.

- More-or-less passive, rational consumers or users who are willing to attempt innovation if it is offered to them at the right place, time and form (Dalin 1978).

- *"That the acceptance of new ideas depends on rational persuasion, i.e. if a practical solution can be developed for a problem, those concerned will accept the given solution"* (O.E.C.D. 1975:31).

- *"That the applicability of the solution is independent of individual differences between users."* (ibid:31).

Lastly the 'pre-package' approach also gives an impression that *"there is the right way of stating plans, arranging material and evaluating them"* (Hawes 1979: 6).

The 'pre-package' approach to disseminating innovation and change has some weaknesses that need to be borne in mind whenever it is adopted (Havelock 1973; Stenhouse 1975; Grundy 1987). Stenhouse (1975:219) argues that *"the 'package' approach is inappropriate when used to disseminate innovation and change in education but quite appropriate in disseminating information to reach geographically dispersed users"*. Havelock (1973) concurs that although consumers' needs are implied in the RD and D/Centre-Periphery, they are not regarded as prime creators and generators of new ideas. It seems equally useful when examining the implications of change to keep in mind a distinction between 'official' intentions and policies, and practice or what is actually happening in practice (Stenhouse 1975). This distinction sheds light on the policy and intentions of the change agents on the one hand, and ways in which the users interpret those intentions during the implementation stage, on the other.

Blenkin et al. (1992) argue that sustainable innovation and change need to be analysed within the framework of linguistic and discursive practices which have direct relevance to changes in policy and practices.

2.4 KEY THEMES IN THE IMPLEMENTATION OF INNOVATION AND CHANGE

2.4.1 Explanation of the implementation process

Implementation can be described as a process of putting into practice intentions, ideas or a set of activities that are new to the people attempting or expected to change (Berman and McLaughlin 1975; Fullan and Pomfret 1977; Fullan 1982; Common 1985). Tornatzky and Johnson (1982:15) have this to say about implementation:

> *"Implementation is the installation of any tool or technique, process or method of doing, from knowledge to practice. It encompasses that range of activities which take place between 'adoption' of a tool (defined as a decision or intent to use the technology) and its stable incorporation into ongoing organisational practice."*

However, this description does not assist with the practicalities of implementation (Berman 1981). For example, it does not say whether the focus should be on curriculum materials, the philosophy of a particular innovation or teacher activities, or measuring pupils' activities and performances.

2.4.2 Problems of measuring implementation

Fullan and Stiegelbauer (1991) identify the following aspects that should be borne in mind when measuring the effectiveness of innovation.

- Whether the school, region or users have or have not received the recommended material and whether they are using it.

- Assessment of the teachers', pupils' and administrators' attitude towards innovation.

- Students' outcomes / performance in the examinations.

It also became evident that these criteria tend to be adopted in isolation, focusing on the various aspects of the implementation process and not on these components as integral parts of the whole.

When examination outcomes are used as criterion for measuring implementation results may be unreliable when the pupils have just been introduced into the project. Moreover, even if innovation is not recent, student outcomes are not always regarded as a valuable criterion to measure implementation since the change agents and stakeholder have diverse goals and ambitions about the project (Berman and McLaughlin 1978; Marsh 1992). Rubin (1983) argues that qualitative benefits or changes in the success of participants should be assessed and not only the quantifiable and observable benefits of the project.

Hall et al. (1975) have developed a framework that can be used to establish the levels of use of innovation and change. It is asserted that adoption of innovation and change is not accomplished merely because a decision maker has announced it. It is suggested that *"the various members of the user system, such as teachers and professors, demonstrate a wide variation in the type and degree of their use of innovation"*(Hall et al. 1975:52*)*.

Although the 'levels of use' is a useful consideration when analysing implementation, it is necessary to guard against adopting it as a universality (Leithwood 1981), because movement from 'lower' to 'higher' stages of implementation will differ.

For example, the amount of change required by a user to move from one level to another may be too large for that particular user to cope with (Hall et al. 1975:52).

In addition to the 'levels of use' framework, Miles and Louise (1987) identify major themes that are useful in understanding successful implementation of innovation and change. These are: vision-building; evolutionary planning and development; initiative-taking and empowerment; resources and assistance mobilization; and problem-coping.

The idea of 'levels of use' was employed to investigate the intentions of SEP's developers and what actually happens when these are implemented in the regions. This framework enabled the researcher to focus on the variations which might exist between implementing the project in new and older regions. It also helped to capture the variations that may exist not only between the regions, but also those that exist within a particular region.

2.5 INSTITUTIONALIZATION OF INNOVATION AND CHANGE

Institutionalization (Miles and Louise 1987) is also known as sustained-implementation and incorporation (Berman and McLaughlin 1975; 1978).

However, a more important question is not so much in the name as in when it can be said that a project has reached or should reach this stage (Berman and McLaughlin 1975; Marsh 1992). Fullan and Stiegelbauer (1991) highlight the problem of conceptualizing innovation in terms of stages when they argue that although institutionalization is commonly perceived as a final phase in a planned change process in theory, the process is, in fact, not linear in practice. That is, all the phases (initiation, implementation and institutionalization) constitute an integrated process (Berman 1981).

Two observations can be made with respect to whether the process of innovation and change is being sustained. First, one can examine what happens when people who were involved in the project's initial developments withdraw (Berman 1981). The second observation is to ask whether the users who are expected to replace those who were involved in initial development and implementation have been trained to cope with their new roles (Fullan 1991).

Another issue that complicates the institutionalization process is that it can occur or fail at a variety of levels including classroom, regional and national levels. Furthermore, institutionalization may occur at many levels in a school. At classroom level or school level, the teacher or principal may assimilate parts of the project with or without formal sanction from the education authorities (Berman and McLaughlin 1978).

Berman and McLaughlin (1975; 1978) identify the following four patterns which are closely associated with the levels of institutionalization and often followed by projects during the phase of continued-implementation of innovation and change.

- **Discontinuation** which occurs when neither the officials nor the users choose to continue project operation.

- **Isolated continuation,** a pattern occurring when district officials do not actively or explicitly turn the project off, but give inadequate support, if any.

- **Pro-forma continuation,** a pattern experienced when the district authorities establish the innovation or some aspects of it as official policy, but users do not use the project very extensively in their classrooms. The officials may be aware of the pro-forma ritual but may still believe that the mere existence of the formal district mandate would help modify the concerns of everybody. Pro-forma continuation is an example of the top-down project

implementation whereby it is mainly the authorities rather than users who feel the need to change. Implied in this pattern of institutionalization is the assumption that teachers are likely to use innovation if it is part of the school policy.

- **Institutionalized change,** which refers to a situation where changes which are part of the project become part of the standard educational repertoire at both the district and classroom level.

Berman and McLaughlin's patterns describe well how the institutionalization of innovation and change unfolds in practice. These patterns also appear to indicate the purpose of introducing innovation and change as well as what the change agents are looking for or should be expected to anticipate. However, Hoyle (1975) warns that care should be taken that institutionalized change should not be watered-down and adapted to prevailing practice resulting in it being robbed of its innovative flavour.

Furthermore, Miles (1983) makes a valuable observation that, "*whether or not a programme becomes a durable part of the curriculum depends on teacher mastery and commitment and administrative action as well as other factors*" (Miles 1983:18). Sikes (1992) argues that teachers are able to resist even legally imposed changes if they so wish. Further, that it is crucial that the expertise and strengths of teachers of different ages and generations be used to make innovation a desirable part of the system.

2.6 LITERATURE SURVEY ON SCIENCE EDUCATION

2.6.1 The planning of science education policy in South Africa

The optimism that science education and technology will play a crucial role in national development in South Africa has grown rapidly over the last ten years

(Levy 1992; Associated Scientific and Technical Society of South Africa 1993; McMillan 1993). However, this confidence is not unique to South Africa because many newly industrializing countries around the Pacific rim are investing heavily in science and technological education. Consequently, science education is universally taught at secondary level in these countries and more important, the quality of teaching and material resources there compare well with those found in industrialized countries (Lewin 1993).

The debate on science and development in South Africa and the need to reform policies around it became more intense in the 1990s with the setting up of the National Education Policy Initiative (Levy 1993/4; NEPI 1993).

The main focus in NEPI was to devise science education policy which addressed the issues of the social demand for education, open access and especially the equitable distribution of educational resources. These developments seem logical because the political attraction of open access, free education and universal enrolment have been irresistible in the majority of developing countries, not withstanding the limited resources available (Lewin 1990). Lewin further observes that there is currently a greater awareness in newly industrializing countries of the fact that a larger proportion of their labour force is going to be employed in the non-agricultural, scientific and technological industries (1990). Experience over the last three years suggests that South Africa is rapidly moving into a scientific and technological era where electronic consumer products will be more important in fuelling growth. This has the implication of promoting reform in the science education curricula in such a way that it reflects these changes in the economy.

The planning of science education normally takes two forms. The first option is to plan curriculum in such a way that science education is provided to all students up to a certain point. The alternative is to select into special tracks or special institutions at the end of primary school a few students who will benefit from such a programme (Lewin 1993).

Despite a consensus that all children should be exposed to science up to a certain level in South Africa, the idea of selecting students and schools to act as role models has been criticised on the grounds that this might perpetuate elitism already plaguing science education (Levy 1992; Kahn 1993). There is a contradiction between calls for high-cost institutions and low-cost 'science for all', the latter being promoted within political cultures that publicly stress equal access to all subjects in secondary education. Lewin argues that the high-cost and lowcost idea:

> *"... may be uncomfortable, but is preferable to planning on the basis of what may be desirable but is unattainable. It does not have to compromise attempts to extend access to mass scientific literacy if balanced judgements are made about the distribution of resources"* (Lewin 1993: 4).

The implication of Lewin's work in South Africa is *inter alia*: equitable selection and identification of students who may benefit most from science and technological education. Accordingly, *"... investigating the feasibility of concentrating resources in fewer institutions when it is impossible to provide these for the whole student population, ensuring that opportunities to acquire science-based literacy and numeracy in the population as a whole is not overshadowed by the needs of the minority who require specific high level skills in science"* (Lewin 1993:12).

The other consideration from the literature survey is the need to plan the science education curriculum in such a way that it is cost-effective, efficient and equitable (Ross and Lewin 1992; Manana 1994). Lewin (1993) recommends that investment in non-salary costs including equipment and laboratories be borne in mind in planning. There has also been a demand for a systematic analysis of investment in non-salary costs of science education in the form of equipment and laboratories as well as lack of maintenance and replenishment of equipment (Ross and Lewin 1992).

The issues of inadequate laboratories, learning material and science equipment has been part of the debate surrounding the provision of good quality science education in South Africa and are part of SEP's objectives. Rogan (1976 (a); (b)) had this policy in mind when he argued that SEP's policy was to equip schools on an economical basis with science kits and equipment and indicated that the word 'economical' was used in the sense of 'good value for money' rather than 'cheaply'. Manana explains this intention thus:

> *"The Science Education Project is the equivalent of a low-cost approach to science education provision with its materials largely manufactured locally and tailor-made to the existing education departments' syllabi"* (Manana 1994: 64).

Another issue relating to the provision of low-cost equipment is the notion of practical work in science. Manana asserts that SEP's portable science kits enable teachers to do practical work even in circumstances where there are no laboratories (Manana 1994). In addition to the issue of lowcost science equipment and kits is the investment in equipment and apparatus relative to their maintenance and replenishment. Lynch (1994) observes that strategies for maintaining science equipment were entirely absent, at least in terms of any central policy in South Africa in the 1990s. Spargo (1994) concurs that the recurring theme in the teaching of science is "*the absence of mechanisms of restoring faulty equipment resulting in the accumulation of large numbers of items which are not useable, but which are perfectly repairable*" (Spargo 1994: 22). Spargo argues that since South Africa is unlikely to be able to supply schools with laboratory technicians, teachers themselves should be prepared for this task and that the assistance with the maintenance of science equipment be provided by Colleges of Education rather than creating new institutions for this purpose (ibid:22).

2.6.2 Policy on science education curriculum development, innovation and change

The main concern in this area has always been that the science curriculum is foreign to the majority of learners and that it is determined by requirements outside the classroom (Yager 1986; Jansen 1992; ANC 1994 (b); Gray 1995).

Jansen attributes the above problem to the oppressive application of scientific knowledge in South African schools over the last few decades (Jansen 1992). He suggests that a radical change in the practice of science education in the classroom be made in order to achieve the quality and quantity of science graduates required for successful economic development and emancipatory political change. One of the suggestions is increasing the number of science students and ensuring that science has a place in the education of all pupils of compulsory school-going age, regardless of whether they are likely to go on to follow a career in science or not (Pouris 1991). In terms of these views, "*the science education curriculum should prepare individuals for education careers that will provide all members of a society with an understanding about scientific knowledge and skills that every citizen needs to exist meaningfully in that society*" (Pouris 1991:98). Such a curriculum must "*target the majority of the children rather than providing for a minority*" (Yager 1986:98). A suggestion has been made that a curriculum that contains a core and some options are more relevant than one that is more centralised. The core is justified on the grounds that it ensures that all pupils have sufficient grounding in the knowledge and skills which form part of their general knowledge (Layton 1986).

However, it is equally important to devise a coherent policy with respect to curriculum options that cater for local needs. Issues that need to be addressed are inter alia:

- What kind of science will form the core and how will this be related to the options?

- How common will the core science be? i.e. will the core be developed for the entire society or not?

- Should the core be taught as integrated science or as separate science?.

- How much time will be required for the core and options and how will the core and options be examined?

While upholding the principle of science for all, reconsideration should be made for those who are going to continue to university and those who will not, urban and rural students, girls and boys, those from minority groups, etc. (Fuller 1987; Lewin 1990; Colclough and Lewin 1992). Similarly, such a programme should take cognisance of disparities in access to science education between the different sectors of the community. This element is important in a newly democratic country such as South Africa. Lewin (1990) also argues for an integrated approach to science education, technology and environmental issues.

The literature review revealed other recurring themes in the field of science education such as perceptions, images and views held by science curriculum developers, decision-makers, teachers and students. There is a misleading, but commonly held assumption that pupils do not bring any relevant ideas of their own to science lessons, but rather that they act simply as recipients. According to Levy (1992) and Jansen (1992) science education in South Africa had at that time, no relevance to real life. This characteristic of science education is reinforced by the transmission approach to teaching which by nature is limited to teacher rote learning methodologies. Teacher

demonstration is used for practical work in order to prove and establish theory with pupils being guided to observe certain features which seem to be interpreted in one way only (Scott et al. 1987). An important question in the debate relating to the balance between process and content in teaching and learning of science has been whether science courses should emphasise the skills and processes of science such as measuring, observing, hypothesising, etc. or whether the emphasis should be on the content of science, its laws and theories (Gott and Mashiter 1991; Scaife 1991). The process approach has been criticised on the grounds that *"... it portrays the methods of science as a sequence or hierarchy process, beginning with observing and leading on, via classification, to inference and hypothesis"* (Millar 1991:46). The transmission approach to practical work in science tends to be characterized by teachers doing textbook practicals or doing practicals 'theoretically'.

An alternative is the constructivist approach. According to this view, conceptions, images and views about science revolve around the learners as active participants who bring their own knowledge to science lessons (Driver *et al.* 1985; Driver and Bell 1986).

Novak (1988) describes an evolutionary change in the field of learning psychology and epistemology on which this alternative to the learning and teaching of science is founded. He argues that the new learning psychology has moved away from the dominance of behavioural psychology which emphasises the role of concepts and conceptual frameworks in meaning construction. According to Novak, the nature of epistemology has shifted away from earlier empirical and positivist views that revolved around experimentation, towards constructivist views of learning. The latter accentuates the compliment between concepts, principles and theories which people ar[illegible]y to observe events (Novak 1988).

Novak (1988) also expresses a concern that the majority of college students and professors still hold an obsolete epistemology that lurks behind inquiry oriented science. The problem with this version of epistemology according to him is that *"experiments are ways of proving or falsifying hypotheses rather than methods to construct new conceptual-theoretical meaning as in the Gowins VCE epistemological model of learning"* (Novak 1988:4).

A pertinent question about the 'doing' of science and the process approach is whether children learn science better as individuals or whether they learn better when they are in a group.

A related assertion in connection with meaningful learning of science, is that the 'doing' of science can only happen in the laboratory. However, this argument is questionable following research findings which show that the value of the laboratory for learning science is not greater than the lecture-demonstration. On the contrary, the findings in this regard have shown that science students in the laboratory gained little insight regarding either the key science concepts involved or the construction of knowledge (Heyneman and Loxley 1983; Fuller and Heyneman 1989; Ross and Lewin 1992).

Another pertinent issue raised in the new psychology of learning is the extent to which the identification of common misconceptions by teachers and science curriculum developers is regarded as helpful in a meaningful learning of science (Driver and Oldman 1986). Novak (1988) is sceptical about the claim that once teachers are armed with knowledge of students' misconceptions, further misconception could be avoided. On the contrary, he argues that meaningful science learning can be realized by focusing on the 'why' questions and not primarily on methodological questions as is often thought.

2.6.3 INSET and support for science teachers as a feature of SEP's innovation and change

Meaningful science education policy and practice need to begin with the retraining, development, and continuous support of teachers who are going to implement the changes (Gray 1988; Levy 1992; Gray 1993).

Firstly, there has been very little serious professional assistance to teachers in the form of an ongoing professional development accompanying science teaching and curriculum thinking (Gray 1995). Professional development is crucial because the practical component of science teaching makes certain demands on the science teacher. Moreover, the bulk of teaching takes place in large classes often with very limited facilities (Gray 1993; 1995).

Levy (1993) argues that because of the lack of support, even where schools have been supplied with science apparatus, teachers are not confident or experienced enough to handle them. In some instances evidence has shown that science teachers are also fearful of the difficulties associated with explosions that might occur and the replacement of equipment should it get damaged while in use.

The lack of the kind of teacher support outlined above is, according to Levy (1992), even more of an issue in rural areas where the majority of the school going population is to be found and where provision of facilities and the level of teacher education is inadequate.

Secondly, Gray (1988) makes an observation that support itself will not prove effective unless it is coupled with the retraining and upgrading of science teachers by means of INSET. The feature of meaningful INSET programmes was that participation in the project was voluntary but subject to criteria worked out by

teachers over time (Gray 1993). However, Gray (1988) argued that many of the people involved in the innovation of the project often had an inadequate understanding of the nature of the change. Specific problems and difficulties relating to INSET in rural areas in science education have been: high rate of teacher turnover, low base of training teachers and communication difficulties (Gray 1993).

2.6.4 Assessment in science

i) Problems relating to assessment in science

The assessment of science remains a top priority in science education which should ideally not be done for its own sake, but rather as a means of supporting education change (Erickson 1985). The incorporation of assessment of practical work into the broader examination structure in science requires clear guidelines whereby practical work counts towards the final mark (Ross and Lewin, 1992). Torrance has this to say about the guiding policy in assessing practical work in the British system:

> *"All schemes of assessment must allocate not less than 20% of the total marks to experiments and observational work in the laboratory or its equivalent."* (Torrance 1985: 41).

The need to assess practical work as a component of curriculum innovation and change raises questions of the influence of the public examination and the level of achievement in science. Firstly, it needs to be admitted that, although teachers might be willing to change, public examinations and assessment systems generally change more slowly than the curriculum (Lewin 1990; 1993; Ross and Lewin 1992). Moreover, the change of materials, syllabus, teachers' attitudes and methods of instruction do not guarantee any significant change unless the examination system is changed. This is so because examinations severely narrow the curriculum and

tend to emphasise examinable knowledge at the expense of exploration, understanding, practical skills, interest and motivation (Lewin 1990; Ross and Lewin 1992).

Secondly, the rapid expansion of science education is unfortunately often coupled with declining average levels of achievement and deteriorating standards in what students at a particular grade are capable of in terms of understanding and skills. Lewin (1993) maintains that substantial proportions of candidates score little above chance guessing levels on multiple-choice items in national science examinations after several years of instruction. This is so because *"the provision of resources, development of material with little or negligible effect on student performance is often mistakenly accepted as reasonable criteria of achievement"* (Lewin 1993:12). This view needs to be examined carefully because the raw score as opposed to pass rates and grades is an equally helpful indicator of actual student performance. It also helps identify the quality of the students who enter the school as well as the distribution of levels of performance among those who pass (ibid:12). In addition to the issues raised above, Gray (1995) warns against the practice of setting questions from the previous years' examination papers and from textbooks. He proposes that practical work be made reputable in the eyes of the pupils and teachers by making it internally and externally examinable. The other issue which needs careful analysis is the assessment of science in the laboratories (Giddings, Hofstein and Lunetta 1991). Diyane (1991) in this regard argues that assessment of laboratory work often depends on written tests which do not usually reflect actual performance in the real situation.

ii) Issues relating to assessment in science in South Africa

The problem of pupil ass ssment and practical work is an ongoing debate in the area of science education in South Africa as well (Kahn 1993; Naik 1994; O'Neil 1994). There is general agreement that, although practical work is a cornerstone in science learning and teaching, the status and attention given to this aspect is far from satisfactory especially in historically Black schools. Naik (1994) and O'Neil (1994)

observed that practical work had generally been part of science teaching in historically white and Indian schools when compared to schools that were attended by black students.

A trend that emerges from the literature internationally and in South Africa is that *"the science curriculum has been largely exam-dominated and that the system never rewarded practical work"* (O'Neil 1994:31). The trend in this respect seems to be making practical work part of science learning and teaching by making it examinable. Apparently the examination of practical work has been part of the science curriculum in the former Indian schools but has never been the case in Black schools (O'Neil 1994).

Manana has this to say about practical work within SEP:

> *"In 'old' SEP regions teacher demonstrations constituted practical work, while in the 'new' SEP regions attempts have been made to reintroduce hands-on practicals"* (1993:4).

However, he acknowledges that there is less practical work than teacher demonstration in the SEP classrooms and further concedes that very little is known about how the "*pupils perceive practical work and how the teachers use practical experiments in teaching concepts*" (ibid:4).

The literature review has influenced the research design of this study as follows:

- A view that the innovation and change process is not linear provided the researcher with a conceptual framework to analyse SEP's innovation and change in the region.

- An observation in the literature that success in one stage of innovation does not necessarily lead to the next stage provided an analytical framework in examining the stages of SEP in the regions.

- The suggestion in the literature about the multidimensional nature of innovation and change provided the framework for the analysis of SEP's innovation and change in terms of two aspects, namely, the use of materials and alternative methodology.

- The idea expressed in the literature that successful implementation depends on the support and commitment from the teachers and education administrators furnished the researcher with a useful theory to analyse the extent to which SEP's successes and failures could be attributed to these variables.

- An awareness of the limitations of the 'package' approach assisted the researcher's analysis of assumptions underlying SEP's approaches and their implications for practice. Furthermore, the assumption that innovation and change in education is likely to be accepted if it is defined in terms of the users' everyday experiences provided a useful framework to analyse the ways in which the stakeholders interpreted SEP's work.

- The literature made the researcher aware of the possibility of a gap that might have existed between SEP's intended goals and their implementation.

- The idea of 'levels of use' in the literature helped to evaluate the intentions of SEP's developers and what actually happened when these were implemented in the regions. This framework enabled the researcher to focus on the variations which might exist between implementing the project in new and older regions. It also helped in analysing the variations that might have

existed not only between the regions, but also those that existed within a particular region.

- Issues on institutionalization provided the investigator with a useful theoretical base to investigate the problems relating to the institutionalization of SEPs' innovation and change. Consequently, the extent to which SEP's innovation and change was continued especially in those regions where it had been in operation for a longer time, guided the analysis in this investigation.

- A view in the literature that institutionalization could happen at different levels and that it may vary from region to region, from schools to school and from teacher to teacher assisted the researcher in analysing SEP's institutionalization in the regions selected in the study.

- Patterns of institutionalization in the literature helped in developing a system whereby the various assertions were categorized into those that represented intentions of developers and those that indicated what happened in practice.

- Theories on constructivist and process approaches in the literature provided the basis for analysing the process of learning and teaching in SEP during the various stages of its development.

- The theories on assessment in science, in particular, of practical work in science learning and teaching, assisted the researcher with the analysis of these aspects of the study.

2.7 SUMMARY FROM THE LITERATURE

This chapter focused on a literature review and how it influenced the design of this study. The areas covered in it are views on innovation and change, theories and

models of initiating and implementing innovation and change, complexities of analysing and measuring implementation and the complexities of analysing the institutionalization of innovation and change. The literature helped to focus the research design in respect of innovation and change in science education as follows:

First, it provided theories on the process of innovation and change in education and how these theories applied to SEP in the regions selected for study. The notion of 'intended' and 'unintended' consequences when implementing innovation and change provided a useful analytical framework to deal with these aspects of SEP.

Second, the theories that suggested that innovation and change is a multidimensional process influenced the design of this study. Third, the literature provided the researcher with theories to review different approaches to curriculum development as well as strategies of innovation and change in science education.

Fourth, the literature furnished the researcher with theories that highlighted the importance of being aware of the levels of use of innovation and change as well as the notion of the institutionalization process in evaluation of SEP's work.

Lastly, the chapter helped to provide the researcher with theories on problems with the assessment in science and the assessment of practical work which formed part of SEP's work.

CHAPTER THREE

RESEARCH DESIGN

3.1 INTRODUCTION

The preceding chapter was devoted to a review of the literature on curriculum development, innovation and change in science education. Chapter Three describes the research design developed for this investigation. Initially, a pilot study was conducted to help focus the study and develop research questions. This is described in this chapter. An analysis of the paradigms, approaches and methodologies used by the researcher then follows. The manner in which the discussion influenced the research design is pointed out immediately after each section.

3.2 THE EVALUATION MODEL

In view of the fact that the study focuses on the evaluation of curriculum development, innovation and change, the researcher surveyed various models that could be of use in the study. After exploring the literature, it was decided to employ a transactional framework on curriculum developrnent based on Walker's model (1969; 1971; 1980) which was used by Potter (1991) and Potter and Moodie (1991; 1992) in the evaluation of the Primary Science Project (PSP). Walker conceptualizes curriculum as a dynamic between the vision brought by the various role-players involved in curriculum development process on the one hand and the deliberation which then ensues as competing visions guide further curriculum development work on the other. Potter and Moodie's (1991) framework was extended in this study by Stenhouse's (1975) distinction between curriculum as intention and curriculum in action as well as Hall et al's (1975) notion of levels of use in evaluating the implementation of innovation and change.

Potter and Moodie (1991) adapted Walker's model in the evaluation PSP and suggest that three levels need to be identified in constructing an evaluation model. The first level relates to vision, intentions and policy of the stakeholders involved in the project, the second level refers to curriculum conceptualization, policy and planning, and the third level refers to implementation, or action. Potter and Moodie's (1991) model of evaluation shares many similarities with the present study and was adopted as a framework for evaluating SEP in the four selected regions.

3.3 RESEARCH METHODS, APPROACHES AND PROCEDURES IN THE PILOT STUDY

The investigator enlisted the assistance of a colleague who holds a Masters degree in science education to pilot the interviews. The two initially worked independently to code the themes, issues and patterns that could have emerged when interviews were content analysed. The analysis began only after an in-depth discussion of what the two investigators were to look for and record.

Each investigator identified issues and patterns that emerged with respect to policy statements and proposals expressed by individual interviewees.

The convergence of emerging trends and issues from the pilot study was established through cross-checks and detailed discussion by the investigators. In particular, the investigators also examined overlaps in policy statements from SEP documents and interviews.

Policy issues in science education, and specific actions that needed to be taken into account in this regard were ranked from highest to lowest and the aggregated frequencies worked out. This step was taken to establish what, according to interviewees, were policy issues and proposals in science education. The results of the pilot study are reported below.

3.4 RELIABILITY AND VALIDITY OF INTERVIEWS IN THE PILOT STUDY

A total of two hundred and forty-nine themes and assertions were coded from twenty -eight interview transcripts. Eighty-seven were coded by investigator B and one hundred and sixty-two by investigator A.

The general picture suggests that investigator A tended to code many more assertions than investigator B. This is attributed to the fact that investigator B was confined to analysing transcripts and did not meet the informants personally. Conversely, investigator A had the opportunity of not only coding written transcripts, but was also able to capture some nonverbal cues from the informants during interview encounters.

The number of assertions and themes coded by each investigator in respect of the 'vision' principles and policy proposals (actions) is shown in Table 1. The reliability of the data were determined by employing the reliability formula in the following manner:

$$\text{Reliability} = \frac{2\ (AO1, 2)}{AO1+AO2}$$

Where

AO1 = the total number of assertions coded by investigator A in each category.

AO2 = the total number of assertions coded by investigator B in each category, and

AO1, 2 = the total number of assertions agreed on by both coders.

Reliability coefficients were calculated by using Osgood's (1959) original framework. Initially, the reliability coefficients were as low as 0,39 and 0,48. The reason for this low reliability could be attributed to the unfamiliarity with the coding procedures by the investigators but more significantly, the meaning and perceptions of each investigator extracted from the interviews.

In view of the low reliability, it became necessary to establish and cross-compare the conclusions reached by the two investigators. The cross-checks meant that the investigators had to meet at least twice a week in order to raise the reliability to a minimum acceptable level which is 0,80 and above as Nunnally (1972) argued (Potter 1987).

However, despite repeated cross-checking of data by the two investigators with a view to raising reliability, it was only possible to arrive at 0,80 reliability relating to the 'principle' category. Repeated cross-checking however, helped raise the reliability to 0,91 and 0,87 respectively with respect to 'vision' and 'policy proposals' (see Table 1).

Repeated exercises to improve reliability to an acceptable level and the failure to achieve this in one instance, necessitated the development of an alternative coding and categorising system.

This system involved establishing trends, patterns and issues in the data.

Table 1: Clustering of assertions into three categories by two investigators and reliability

	ASSERTIONS THEMES	TOTAL NO. CODED	AGREEMENTS		RELIABILITY
INVESTIGATOR A	Vision	65	Vision	40	0.91
	Principles	57	Principles	33	0.74
	Policy proposals	40	Policy proposals	31	0.87
	Sub Total	**162**			
INVESTIGATOR B	Vision	22			
	Principles	32			
	Policy proposals	33			
	Sub Total	**87**			
	GRAND TOTAL	**249**			

Procedures to determine validity and reliability in the pilot and the main study had the following weakness: The varying experiences of the informants from SEP and in science education tended to affect the validity and reliability of the findings in various ways. Some informants were better qualified in science education than others which meant that those who were better qualified were able to articulate certain perspectives more clearly than those who were not. With respect to informants from SEP, some had spent more time, had better insight and were more familiar with the historical development of its policy and practice than others.

3.5 RESULTS OF INTERVIEWS IN THE PILOT STUDY

The findings revealed the need to develop science education policy that encourages the aspirations of the provinces and those in rural-urban communities in South Africa. Informants further agreed that the examination of the science curriculum needed to be reviewed and that General Science should be given the same status as other subjects such as Chemistry and Physics. The issue concerning the nature and climate within which change and innovation must be seen ranked lowest. The urgency of restructuring science education so that it addresses historical imbalances in South Africa ranked high. The need for an inclusive process of restructuring the policy on science education ranked the lowest.

However, the fact that some themes occurred more frequently than others did not imply that they are more important than those that occurred less frequently. On the contrary, the differences merely indicated the consensus among the interviewees about a particular issue in science education. Conversely, themes that occurred more frequently were those of a general nature with respect to science education while those that occurred less frequently were of a specific nature. Furthermore, the frequency with which some themes recurred could also be attributed to the current debate about the restructuring of science education policy and practice.

Research questions developed from the literature review and the pilot study are outlined and described below.

RESEARCH QUESTION ONE

How effective and enabling were SEP's models of curriculum development and its approaches to innovation and change?

The first question examines vision, intention and policy of curriculum development and approaches to innovation and change SEP.

RESEARCH QUESTION TWO

How was the teaching and learning of science conceptualized in SEP?

This question focuses on the vision, intention and policy relating to the conceptualization of the teaching and learning of science in SEP.

RESEARCH QUESTION THREE

How did the nature of the relationship between SEP and other stakeholders affect the implementation of the project's work during the period under review?

The third question examines the implementation level, or action within the project.

RESEARCH QUESTION FOUR

How did SEP deal with the issue of institutionalizing its innovation and change?

The fourth question focuses on the institutionalization of innovation and change. Institutionalization in the context of this study refers to a situation where the project's work becomes part of the teachers' daily routine. Consequently, institutionalization was explored as an extension of the implementation level of innovation and change. The discussion on this aspect was guided mainly by the research undertaken by Berman and McLaughlin (1975; 1978; Fullan and Stiegelbauer 1991).

This section examines the linkages between adoption, implementation and institutionalization stages of SEP. It also analysed the meaning of institutionalization and what the term meant to people inside SEP: whether the project's philosophy and practice were accepted by the teachers and the education authorities and whether institutionalization was ever a declared intention of the project's development. Factors which delay or promote continued institutionalization of innovation and change were also examined.

3.6 RESEARCH PARADIGMS, APPROACHES AND METHODOLOGY

3.6.1 Research paradigms

This research is undertaken within the qualitative research methods that are embedded within the constructivist paradigm. This represents a contemporary intellectual trend and movement in social research. Denzin and Lincoln (1994:1) argue that qualitative research *"is a field of inquiry in its own right surrounded by a complex, interconnected family of terms, concepts and assumptions and methods"*. Perspectives and methods associated with this intellectual tradition include: a post-structuralist, interpretive status of culture, content analysis, grounded theory, discourse analysis, context-sensitivity and meaning-sensitive methods (Strauss and Corbin 1994; Guba and Lincoln 1994; Henwood 1996).

Shipman (1982) describes a paradigm as a system of meaning through which scientists not only organize their work, but also guide the choice of techniques for investigation and validation.

Assumptions underlying competing paradigms are illustrated in Table 2.

Table 2: Assumptions underlying the rationalistic and the constructivist paradigms

	STRUCTURALIST	POST-STRUCTURALIST
1. Nature of Reality	- Single, tangible, fragmented into dependent and independent variables - Accentuates the controlling variables	- Multiple, intangible reality which can only be understood holistically - Reality cannot be described in terms of separate independent variables
2. Inquirer-Subject Relationship	- Inquirer will have no effect on the phenomenon being studied	- Presupposes mutual interaction between the phenomenon and the inquirer
3. The "truth" of Statements	- Development of a nomothetic body of knowledge - Similarities among exemplars of the phenomenon	- Development of an idiographic body of knowledge - Differences rather than similarities
4. Relation to Values	- Value free enquiry guaranteed by the objective methodology	- Value laden social scientific values - Impinges upon an enquiry

3.6.2 Assumptions underpinning the paradigm adopted in the current study

In the context of this investigation, a variety of methods and triangulations were used as follows. First, the researcher developed initial familiarity with the project and produced preliminary theories on it. These theories were acquired through prolonged involvement and included: a preview of SEP documents/records, literature on innovation and change in science education, and pre-interviews with project members. Second, triangulation was used to contrast the data from the stakeholders from that of SEP staff. A variety of methods and triangulation were utilized because, as Patton (1990) observes, it is common for different stakeholders to disagree about the programme purposes, goals and means of attaining them. These differences represent different themes of action that cast findings in a different light.

3.6.3 The nature of reality

In light of the research paradigm adopted for the study, the researcher assumed that SEP existed in multiple, intangible realities that should be studied holistically. The researcher therefore employed various strategies and methods in order to deal with qualitative data that emerged from the fieldwork. This step signifies a fundamental deviation from the scientific paradigm which accentuates the need to control dependent and independent variables (Guba 1981; Guba and Lincoln 1983; 1994; Patton 1990). In accordance with the adopted paradigm, realities about SEP could not be described and understood in terms of separate independent and dependent variables (Burgess 1982; Mouton and Marais 1993).

3.6.4 Inquirer-subject relationship

The prolonged involvement of the researcher with SEP included mutual interaction with project members. This is a key feature of grounded theory (Guba 1981; Guba and Lincoln 1983; 1994; Strauss and Corbin 1994) which enabled the researcher to

identify objectivity and subjectivity in the data obtained about SEP. Consequently, the entire process was conducted in such a way that meaning about the project was constructed by the informants themselves in interaction with the researcher. However, the researcher's own interpretation of the constructed meanings was part of the analysis.

The implication of electing the qualitative inquiry procedures was that the theory on SEP was allowed to emerge from practice (Glaser and Strauss 1967; Denzin 1970; Cohen and Manion 1989; 1994; Strauss and Corbin 1994; Henwood 1996; Pidgeon and Henwood 1996).

3.7 THEORETICAL FRAMEWORK

The current case study is underpinned by the theory-driven perspective to research and evaluation proposed by Chen (1990). According to Chen (1990), theory-driven evaluation contrasts with traditional method-driven evaluation.

Theory-driven evaluation emphasises the recognition of multiple values and issues when evaluating a programme. Theory is described as a *"set of interrelated assumptions, principles and/or propositions to explain or guide social actions"*(Chen 1990:40).

The theory-driven perspective described above guided this report as follows:

- It provided the researcher with a conceptual framework to deal with intended and unintended outcomes of SEP.

- It assisted in the analysis of SEP's theoretical premises and specifications of its process.

- It provided a framework to examine the project's implementation of innovation and change.

- It furnished a framework to understand which aspects of the project were effective.

The theory-driven model created the opportunity for the researcher to analyse both the project's intended goals whether official or operative as well as unintended outcomes (Potter 1991).

3.8 METHODOLOGICAL CONSIDERATIONS IN THE STUDY

The ontological, epistemological and methodological procedures of grounded theory were used as organizing foci in the current analysis. Ontology relates to the form and nature of reality while epistemology refers to the nature of the relationship between the knower or would-be knower and what can be known. Methodological questions on the other hand impact on how the inquirer goes about finding out whatever he/she believes can be known (Guba and Lincoln 1994).

Grounded theory as a general methodology proposed by Glaser and Strauss (1967) and reviewed by Corbin and Strauss (1990) and also by Strauss and Corbin (1994), Henwood (1996) and Pidgeon and Henwood (1996) was employed in the study. Glaser and Strauss argued that generating a theory from data means that most hypotheses and concepts in the interpretive paradigm emerge from the data themselves and:

> *"... are systematically worked out in relation to the data during the course of research. Generating a theory involves a process of research ..."* (Glaser and Strauss 1967: 6).

Grounded theory, therefore, depends on methodologies and approaches that take the researcher into and close to the real world so that the results of the findings are 'grounded' in the empirical world (Patton 1990; Pidgeon and Henwood 1996).

Grounded theory suggests the process of interactions and meaning-making of people in particular contexts (Denzin 1994; Henwood 1996; Pidgeon 1996). In their review of this methodology, Strauss and Corbin (1994) highlight the reasons for adopting grounded theory as follows: First, that the researcher adopting this approach may wish to generate theory from the data. Second, that if existing theories seem appropriate, then these may be elaborated and modified.

Grounded theory in this research is interpreted within the conceptual framework proposed by Strauss and Corbin (1990; 1994) and revised by Henwood (1996) and Pidgeon (1996). Pidgeon describes the grounded theory used in this study in this way:

> *"... grounded theory is an interactive process involving the continual sampling and analysis of qualitative data obtained from interviews, participant observation and archival research."* (1996:78).

The constructivist revision of grounded theory used in this investigation developed from a critique of Strauss and Corbin's (1994) original views. Pidgeon (1996) criticises Strauss and Corbin's (1994) version of grounded theory on the grounds that it tends to incorporate hypothesis-testing:

> *"... it makes no sense to claim that research can proceed either from testing prior theory alone or from a 'pure' inductive analysis of data."* (Pidgeon 1996:82).

Furthermore, a revised constructivist grounded theory encourages the creative dynamic character of the research process and *"emphasises the active and constitutive analytical process of inserting new discourse into an old system of meaning"* (ibid:83).

Following this framework, grounded theory is used in this research as a methodology for developing data that has been systematically gathered and analysed (Strauss and Corbin 1994). Furthermore, the grounded theory methodologies employed were specifically intended to extend theories being developed and stated within SEP. The notion of theory elaboration is used in the same way as Vaughan (1992) described it, namely, *"taking off from extant theories and developing them further"*. Following her conceptual framework, theory in this research means 'theoretical' tools in general including formal theory, models and concepts. Elaboration therefore refers to the process of refining the theories, models or concepts in order to specify more carefully the circumstances in which these do or do not offer potential for explanation (Vaughan 1992).

Following revised constructivist grounded theory, this research did not follow the inductive approach or the testing of any hypotheses. On the contrary, the researcher constantly compared the data with emerging trends, and sampling of groups of informants and the project's documents/records (Creswell 1994).

In light of the chosen methodology, the researcher used the following methodological approaches: a variety of methods, multiple-reality, multi perception, multiple informants and triangulation, as proposed by Denzin (1990). In line with the multiple strategies employed, analytical inductive sampling was employed with respect to the various aspects of SEP.

Accordingly, a variety of methods were used to collect data and to guide the selection of instruments including interviews, questionnaires, documentary analysis, observation and photographs of science lessons conducted using SEP equipment (Cohen and Manion 1994). In each of the regions selected for the study, several methods of investigation and more than one instrument was utilized to describe, analyse and examine the different aspects of the project.

Further, the researcher assumed that the social phenomenon of SEP existed as multiple realities. This implied that the participants in, and the users of, SEP's innovation and change were allowed to reconstruct reality on the various aspects of the project.

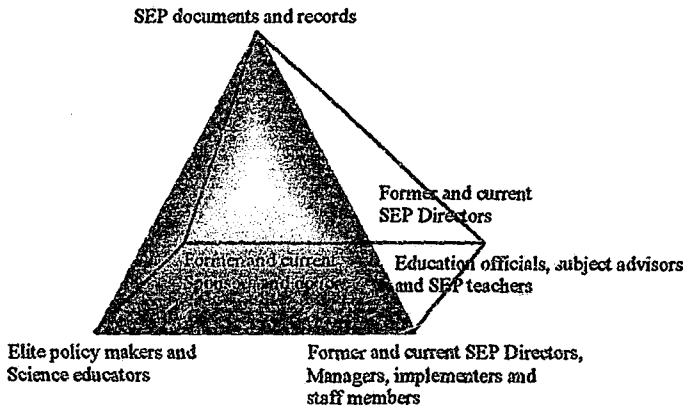
Triangulation was used extensively in the design (Janesick 1994, Morse 1994). The decision to use them was prompted by Denzin's advice that:

> *"... by combining multiple observers, theories, methods and data sources, researchers can hope to overcome the intrusive bias that comes from single-method, single theory studies."* (Denzin 1970:315).

One use of triangulation involved the collection of qualitative data through interviews and observations. By triangulating the data from the various sources and through the various instruments, the investigator was able to examine a range of issues within SEP in the regions and nationally (Yin 1994). Furthermore, a multiple-source technique helped to establish agreements and disagreements in the analysis of the data. The sources which provided the data are shown in Figure 1.

Furthermore, data triangulation was employed whereby the investigator cross-checked the data collected on the project at different times of its operation. This took the form of comparing data from the observations of science lessons with that from interviews, photographs and from the project documents and records.

Figure 1: Sources from which the data were collected.



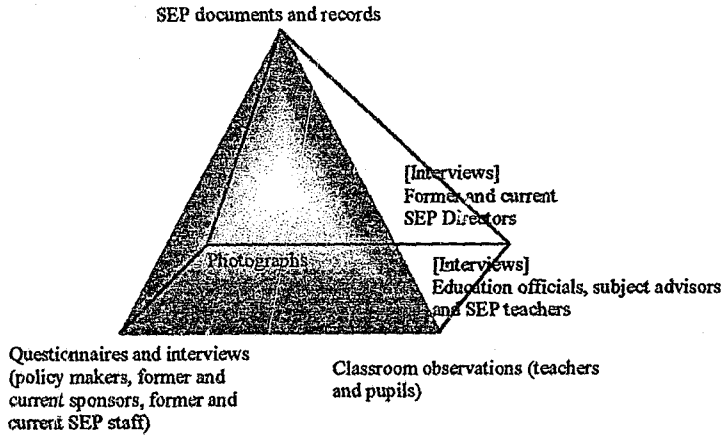
The project documents and records therefore provided information that was not directly observable in the lessons and the information which the investigator might not have sought in both the pilot interview and the main study.

This process also implied collating what the different stakeholders had to say (their perceptions) on the same aspects of SEP over time, and contrasting the perspectives of different users of the project.

The data needed for this research was collected through fieldwork using procedures of the chosen paradigms and the general methodology pertinent to them. By adopting these procedures, the researcher became involved in obtaining the data from the sites in order to penetrate the perspectives and meanings for the participants (Cohen and Manion 1989; 1994; Bogdan and Biklen 1982; Carr and Kemmis 1986; Vulliamy 1990). Consequently, both the multi-method approach and triangulation were not used as ends in themselves, but as ways of generating new theories or modifying existing ones about SEP.

Triangulation carried out in the current investigation is illustrated in Figure 2.

Figure 2: Triangulations based on the research instruments and data sources



3.9 MAIN STUDY

3.9.1 Sampling

Purposeful or purposive sampling strategy suggested by Denzin (1970; Bogdan and Biklen 1982; Glaser and Strauss 1967; Lewin 1990; Patton 1990; Silverman 1985; Cohen and Manion 1989; 1994; Anderson 1990; Vulliamy 1990; Strauss and Corbin 1994; Morse 1994; Creswell 1994; Pidgeon and Henwood 1996) was employed to select documents and informants for analysis. This type of sampling was selected because of the kind of data that was collected, the data collection instruments used, and the data sources which did not lend themselves to random sampling (Denzin 1970).

Table 3: Research design

RESEARCH QUESTION	DATA SOURCES	DATA COLLECTION	SAMPLING	DATA ANALYSIS
1. How effective and enabling were SEP's models of curriculum development and its approaches to innovation and change in science education?	- Former and current directors - Former and current SEP staff - Elite policy makers - Stakeholders - SEP documents and records	- Interviews with a former and current Director - Interviews with former and current staff - Interviews with policy makers - Analysis of documents and records - Observations - Questionnaires	- 5 SEP schools - 5-7 documents and records - Former and current senior staff - Other stakeholders - Elite policy makers - Teachers	- Analysis according to hemes and issues from documents and records - Analysis according to themes and issues from interviews
2. How was the teaching and learning of science conceptualized in SEP	- Former and current staff - Project documents and records - Literature on science education	- Interviews with elite policy makers - Interviews with former and current staff - Observation of lessons - Analysis of documents and records - Interviews with teachers	- 1 former and one current Director - All former senior and current researchers - All current implementers - All teachers in sample schools	- Analysis according to themes and issues from interviews - Analysis according to themes and issues in the observation schedule - Analysis according to themes and issues from documents and records - Thematic analysis of issues and patterns from the literature

	RESEARCH QUESTION	DATA SOURCES	DATA COLLECTION	SAMPLING	DATA ANALYSIS
3	How did the nature of the relationship between SEP and other stakeholders affected the implementation of the project's work during the period under review?	- 1 former and the current Executive Director - Former and all current project managers and Implementers - 5 - 7 Project documents and records in each region - Education officials - Teachers - Subject advisors	- Interviews with former and current Executive Directors - Interviews with project implementers - Interviews with teachers in project schools - Interviews with material developers	- 1 former and current Executive Directors - All teachers in SEP schools in the 4 regions - All the project managers and implementers - 2 subject advisors in each region 5 Board of Directors 2 sponsors in each region	- Analysis according to issues and themes from interviews - Analysis against themes and issues the project documents and records - Analysis according to themes and issues observations
4	How did SEP deal with the issue of institutionalizing its innovation and change ?	- 1 former and the current Executive Directors - Former and all current senior project managers and researchers - 5 Board of Directors and Trustees - All research team - Material development team	- Interviews with Board of Directors - Interviews with 1 - former and the current -Executive Directors - Interviews with former and all current implementers - Observation of science lessons - Analysis of the project documents - Interviews with researchers	- 7 Board of Directors - 2 Trustees - 1 former and the current Executive Director - 3 former and all senior researchers - All current implementers - 20 teachers	- Analysis according to themes from interviews - Analysis against themes from documents and records - Analysis in terms of themes from observation

3.9.2 Samples of the project documents and records

In view of the purposeful sampling strategy chosen, the project documents were sampled according to:

- Titles that focussed on the issues outlined in the research questions and the relevance of content regarding the topic.

- The dates of the titles. Consequently, only documents and records written between 1980 and 1995 were selected as samples.

- Geographical areas in which SEP operated and those regions chosen as a sample.

- Presumed audience a particular document was intended for and the editorial positions of writers in the project (Berelson 1954). Consequently, the documents selected for analysis were those that were written by former SEP Executive Directors, the project's managers in the four regions, implementers, internal and external evaluators of SEP as well as records of meetings held by staff in the selected regions.

The effects of adopting purposive sampling were that:

- All four regions were represented in terms of documents and records chosen;

- Although it was intended that the documents and records be those compiled or written between 1980 and 1993, very little of those that had been written recently could be found, e.g. nothing could be coded in minutes of the Consultative Committees in the 1990s;

- The documents and records included those compiled by people at SEP National and SEP Regional.

Tables 4 to 7 reflect the project documents and records analysed for the four selected regions, namely, Pietermaritzburg, North West, Gauteng and Eastern Cape respectively.

3.9.3 Samples of informants

Two categories of informant were sampled in the study. The first comprised elite policy makers in and outside SEP while the second targeted SEP staff and personnel. (Appendix 1 reflects elite policy-makers interviewed). An elite policy maker is, according to Anderson (1990), a respondent or informant who has a particular experience and knowledge about a policy relating to a particular field. Anderson also calls an interview which involves elite policy makers, an elite interview. The purpose of elite interviews in this study was to probe the views of a small number of elite policy makers rather than a statistical analysis of a large number of respondents. Consequently, the sample comprised firstly, SEP's former and current Executive Directors, the project's managers, researchers, material developers, implementers, education officials and the users in the four regions selected for this study and secondly, science educators and policy makers outside SEP. These interviews were conducted to obtain views from a small number of people who might have differing opinions on science education. In both instances informal, general guides and standard open-ended interviews were utilized (Cohen and Manion 1989;1994).

Table 4: SEP documents and records sampled for the Pietermaritzburg region

TITLE OF DOCUMENTS AND RECORDS	TYPES OF DOCUMENTS AND RECORDS	SAMPLE LENGTH PAGES
Proposed agreement between SEP and the Kwazulu Department of Education (undated)	A record of an agreement concluded between SEP and the Education Department in Kwazulu. BY SEP National	5
SEP in Pietermaritzburg 1980-1985	A Master of Education dissertation. By B. Gray (Former SEP implementer, Former SEP regional manager and former member of the Board of Trustees for SEP)	280
A review of the Science Education Project (Natal) for the period, July 1985 to April 1991. (1991)	A document set up by the National Office to review the project during the period specified. By R. Mackie (An external evaluator of the project in the Pietermaritzburg region)	56
Proposal for additional implementers for SEP Pietermaritzburg Project. (Undated)	A proposal document compiled by the project coordinator. By R.Underwood (Human Resources development staff in the Pietermaritzburg)	5
Orientation courses document. A report	The project's coordinators report. By C. Mkhwanazi (Former SEP implementer and regional manager in the Pietermaritzburg region)	4
The survey of Pietermaritzburg SEP Schools (Undated)	An in-house report compiled by the implementer and manager. By Z. Dlangulala (SEP's implementer) and M. Ntombela (SEP's regional manager and former deputy Executive Director)	6
Pietermaritzburg Quarterly Report July-September 1994. (1994)	A quarterly report compiled. By C. Mkhwanazi (Acting manager of the project in the Pietermaritzburg region)	5

Table 5: SEP documents and records sampled for the North West region

TITLE OF DOCUMENTS AND RECORDS	TYPES OF DOCUMENTS AND RECORDS	SAMPLE LENGTH PAGES
Agreement between Bophuthatswana Ministry of Education 1989	Agreement between Bophuthatswana Ministry and the project in 1989. By SEP National	6
Bophuthatswana Science Education Project Report. Bop SEP teachers Conference 1990.	A report on the project by an implementer. By M. Maepe (SEP's implementer and a subsequent regional manager in the North West region)	7
Summary of implementers' comments 1990	This is an internal evaluation report. By M. Maepe (SEP's regional manager)	2
Science Education Project in Bophuthatswana	An MED dissertation. By M. Maepe (former SEP implementer in the North West region)	79
Report of a meeting between the department of Education and SEP 13 May 1993	A report of a meeting between SEP and the Education department. By SEP National	3
Minutes of a meeting of Consultative Committee of SEP Bophuthatswana. 3 March 1994	Consultative Committee (CC) meeting of SEP. By SEP staff in the North West region	7
Minutes of a meeting of Consultative Committee 5 May 1994	Consultative Committee (CC) meeting of SEP. By SEP staff in the Pietermaritzburg region	6

Table 6: SEP documents and records sampled for the Gauteng region

TITLE OF DOCUMENT	TIMES OF DOCUMENT	SAMPLE LENGTH PAPERS
Science Education Project	Annual Report for 1984	13
Science Education Project	Annual Report for 1985	21
SEP Wits Region	Quarterly Report for 1985	6
SEP Regional Consultative Committee	Second Quarter April-June 1984	2
Quarterly report for submission to the Witwatersrand Regional Consultative Committee	Minutes of the Consultative Committee of the 19th November 1992	3
Report of a meeting of the Wits Regional Consulttative Committee of Wits	Quarterly Report Third Quarter 1992	3
Report of a meeting of the Wits Consultative Committee	Minutes of the Consultative Committee of 4 May 1994	4
Report of the Consultative Committee	Report on the Consultative Committee of SEP 24 November 1993	2
An evaluation of selected implementer-run courses in the PWV area	An internal evaluation report May-August 1993. By SEP	3

Table 7: SEP documents and records sampled for the Eastern Cape region

TITLE OF DOCUMENTS	TYPE OF DOCUMENTS	SAMPLE LENGTH PAGES
The Science Education Project in the Ciskei 1980.	Published article in the South African Journal of Science. By A.M. MacDonald (SEP's first implementer) and J.Rogan (SEP's first Executive director)	3
The Science Education Project in the Ciskei. Materials, Training, Content and Outcome.	Internal trial evaluation of the project by one of its developers and an implementer 1981. By A.M. MacDonald (SEP's first implementer)	73
Teacher Reaction to Innovation	Internal trial evaluation of the project 1980	58
The Science Education Project: An assessment of the ability to do practical work and the comparison of this ability with that of recall and reasoning	Internal trial evaluation of the project by developer and an implementer 1982	70
The Effects of Science Education Project Materials and Training on the teaching methods of Junior Secondary Science Teachers in the Ciskei	Internal trial evaluation of the project by a developer and an implementer. By by A.M. MacDonald 1980 (SEP's first implementer)	14
The response of Ciskei pupils to the Science Education Project, 1980.	Internal trial evaluation of the project by a developer and implementers. By A.M.MacDonald (SEP's first Implementer)	4
The Science Education Project by 1985.	An implementer's report. By F. Dlepu (SEP's first implementer and subsequent regional manager)	2

3.9.4 Sampling of schools

Five schools in each region were chosen from those that were provided with SEP science equipment and where there was an effort to implement the project's methodology. In addition, the geographical location of schools and the number of science teachers in a particular school also influenced the decisions to sample schools.

Schools and districts that formed the sample in the Pietermaritzburg region are reflected in Table 8. Observations in this region were conducted in schools under the jurisdiction of the erstwhile Department of Education and Training and were limited to the Pietermaritzburg district. Most of them were within the Imbali Circuit. However, two other schools, one in a village and one on a farm, were also observed, bringing the total number of schools to seven.

Five schools in the Molopo district in the North West region formed the sample of schools from this region. (See Table 9).

Two lessons in each school taught by different teachers were observed. This gives a sample of ten lessons in the North West region. Molopo district comprised urban/townships and village schools. All schools observed fell under the jurisdiction of the former Bophuthatswana Department of Education and Culture.

Schools and districts in the Eastern Cape region where observations were conducted are: Alice, Middeldrift and Peddie (see Table 10). Two observations were also conducted in two village schools around Alice in the urban areas, while others were observed in villages further away. The other consideration in choosing schools was to include one of the schools where SEP was first introduced by Rogan and his team in the early 1970s and one other where the project had been introduced in the 1980s and 1990s.

Schools observed in the Gauteng province were all situated in the Johannesburg and Pretoria district. Owing to the political instability in Gauteng schools when the field work was done, observations were postponed and delayed for several months as the three schools visited were all situated in violence-torn townships.

Table 8: Schools, Districts and lessons observed in the Pietermaritzburg region

SCHOOLS	DISTRICTS	LESSON TOPIC	STD.
Kwa Pata High School	Imbali Area	a) Separation of solubles and insolubles. b) Separation of mixtures.	6A 6B
Mehlokazi High School	Imbali Area	a) Particles of solids and liquids. b) Soil conservation.	6A 6B
Sukuma High School	Imbali Area	a) Separation of solubles and insolubles b) Solubles.	7 9
Michaelhouse Senior Secondary School	Farm Area	a) Acid and gases. b) Properties of Oxygen.	8 6
Bongudunga High School	Imbali Area	a) Solubles and insolubles. b) Particles of solvents and liquids.	8 6
Sqongweni High School	Imbali Area	a) Testing for CO_2 and H_2O. b) Types of roots.	8 6
Sibukezulu High School	Imbali Area	a) Hydrogen as (H_2). Testing the highest gas.	6

Table 9: Schools, Districts and lessons observed in the North West region

SCHOOLS	DISTRICTS	LESSON TOPIC	STD.
Banogeng Middle School	Village School around Itsoseng	a) Separation of liquids b) Current measurements of a circuit	6 7
Bodibe Middle School	Village School in Itsoseng	a) Expansion and contraction. b) Heating of metals.	6 6
Ramatlakana Middle School	Urban School in Itsoseng	a) Separation of solubles and insolubles b) Solubles.	7 7
Opelang Middle	Urban School in Itsoseng	a) Acids and bases. b) Properties of Oxygen. c) Temperature	6 6 6

Table 16: Schools, Districts and lessons observed in the Eastern Cape region

SCHOOLS	DISTRICTS	LESSON TOPIC	STD
Emndeni Junior School	Middeldrift (Village)	Separation of solubles and insolubles	7
Zanesiwe Junior School	Alice (Village)	Separation of mixtures	7
Phandulwazi Agricultural Comprehensive School	Alice (Village)	Separation of solubles and insolubles	7
Sibongile	Alice (Village)	Particles of solids and liquids	6
Enkwenkwezi Junior School	Alice (Village)	Particles of solubles and insolubles	6
Jinqai Junior School	Middeldrift (Village)	Separation of solubles and insolubles	6

In contrast with the other three regions where the project had been operating for some years, schools in this province started with SEP work in the early 1990s (Table 11).

Table 11: Schools, Districts and lessons observed in the Gauteng region

SCHOOLS	DISTRICTS	LESSONS	STDS
Mamelo High School	Thokoza	Hydrostatic pressure	7
Lesiba High School	Daveyton	Understanding of electron p essure	8
Esser Maloka High School	Thokoza	Hydrostatic pressure	7

In addition to the criteria for choosing the lessons outlined above, other considerations were applied to individual regions. In the Pietermaritzburg region, one lesson was observed in a prestigious boarding school with a fully equipped laboratory, but which had SEP kits and material as well as SEP-trained science teachers. The other two lessons were observed in schools which did not have any laboratories and were not provided with science equipment from the Department. In the North West province, lessons were observed in urban and village schools. In the Eastern Cape province, lessons were observed in schools in villages near the township and those found in typical villages. One lesson was observed in one of the schools where SEP started its activities in the 1970s. Lessons chosen for detailed analysis in Gauteng came from schools in East Rand townships.

Visits to all schools in the four regions were pre-planned and discussed with the project managers and implementers in each region. The investigator was therefore accompanied by the project manager or the implementer on all the visits because the latter had to negotiate access to schools and science lessons with the teachers and the principal.

On the practical side, schools and their teachers were informed about the visits so as to ensure suitable science classes would be running on those days. Failure to confirm the visits in a few cases influenced results because of unforeseen circumstances such as conflicts that affected schools on that day, class boycotts, athletic meetings and similar events. Confirmation of visits was also necessary because observations were done during the normal science lessons and the schools' time tables were to be followed with the fewest possible disruptions. Moreover, the teachers were expected to be teaching during observation and not conducting tests. Despite the fact that the teachers were informed of the visit, the data collected during observations could still be regarded as reliable because, although the teachers were informed about the visit, they were not aware of specific activities the researcher was going to observe and record. For example, they did not know that the researcher was going to observe whether such schools had the necessary SEP kits and worksheets as was assumed by the national office of SEP, whether the teachers were using SEP kits and worksheets or traditional textbooks, whether they were incorporating SEP's process and constructivist approaches in their teaching, whether the pupils could recognize the name of the apparatus, whether they were familiar with them and what they are used for, and whether the pupils could handle the apparatus. The assumption the researcher made in this regard was that all teacher pupil activities outlined could not have been mastered in one lesson which a teacher could have prepared and taught differently from how s/he normally taught in the absence of the researcher.

3.9.5 Sampling of photographs

Purposive sampling strategy was also followed to select photographs for classroom observations. These photographs were included to exemplify the data on the different aspects or components of SEP such as teacher demonstrations, pupil experiments, classroom seating arrangements, a class where science lessons were taught etc. Thirty photographs were taken during observations in the four regions.

However, only seven photographs out of thirty were selected by the researcher for further analysis and interpretation. The seven photographs were selected because they provided further information about some of the items that formed part of the observation schedules eg. experimentation and teacher demonstration, seating arrangements and conditions under which the project's science kits were used.

3.10 RESEARCH INSTRUMENTS AND DATA SOURCES

The data were collected through interviews, observations, questionnaires and photographs taken during observations.

3.10.1 Interviews

The interview as a tool for collecting data was an ongoing process in this study. Initial interviews were conducted as early as 990 (see Appendix 2 for the content of the initial interviews conducted with SEP personnel. Recurring themes with respect to policy proposals that emerged from policy-makers are contained in Appendix 3. These interviews focussed on broad policy and practice of the project in the regions. The second set of interviews used in this study consisted of focus group interviews. Focus group interviews involve bringing together a small group of people who share the same experiences on a particular issue (Anderson 1990; Lewin 1990). This group comprised: SEP Executive Director in 1993, the project's human resources manager, equipment and kits manager, SEP Gauteng regional manager and four Research and Development Unit staff. The purpose of the focus group was to give SEP personnel an opportunity to share their experiences and to modify their original perceptions about the project if necessary. Group interviews did not replace individual interviews but served to provide another level of data gathering. These interviews were conducted as part of the qualitative slant of this investigation (Miller and Crabtree 1994). The project managers and implementers

were grouped together in a particular region while the teachers/users formed their own groups in these four regions. Four group interviews were organized for this purpose. Following Patton's (1990) advice a maximum of eight people were included in each group and the interviews lasted two hours at the most. The decision on the number of interviewees was guided by Anderson's view that:

> "... *focus groups generally range from six to twelve participants ... The exception is where the topic needs to be explored in great depths, and where people have had great experiences related to it. In these cases, mini-focus groups are often the best...*" (Anderson 1990:244).

The number varied and depended largely on the available number of implementers nationally or in the region and the number of SEP teachers in the region. Group interviews also helped clarify divergent views articulated by people involved in the project. The open-ended interviews were used in the pilot study and in the group interviews. Open-ended interviews were recorded, clustered and then analysed in order to establish meanings SEP personnel held about the project.

The third set of interviews were conducted with all the project implementers and managers in the four regions. The teachers/users were also interviewed asking them questions within their experience about SEP. An interview guide was used for this purpose. An interview guide developed by Potter and Moodie (1991) was adapted and used in the main investigation. The guide enabled the researcher to ask stakeholders different questions in accordance with their experiences, their roles and responsibilities on the project (see Appendix 4 for a detailed content of the follow-up interview guide used in the main study). The interviews guide was chosen because it was regarded by the investigator as suitable for gathering data from stakeholders who had different experiences about SEP. Appendix 5 contains clustered responses of interviews by SEP implementers and managers while Appendix 6 reflects clustered responses from the project teachers.

3.10.2 Observations

The researcher adopted the role of a participant-as-observer in some instances and that of an observer-as-participant in others (Denzin 1970; Burgess 1982; Burgess 1984). Observations varied from informal or unstructured to formal and structured (Burgess 1984). These roles were adopted as a compromise to the so-called complete participation and complete objective observer.

Although informing schools about the envisaged observations did create an artificial situation, it was difficult not to disclose the purpose of the visits since prior permission had to be granted by the relevant education authorities, the principals and the teachers.

Two types of observation schedules were considered for possible usage in observing science lessons in the selected regions. One of these was the Science Teaching Observation Schedule (STOS) developed by Eggleston 1980; Eggleston et al. 1975).

The other, which is a modification of the STOS, was Lewin's observation schedule comprising a three level scale to indicate the degree of pupil participation in a lesson (1990). The latter was chosen because it addressed some of the weaknesses of the original STOS and therefore was considered a compromise between frequent sampling and manageable rates of making judgements and recording (Lewin 1990). (Appendix 7 shows the differences between Lewin's schedule and the original STOS).

In the schedule, responses were recorded as 1, 2 or 3 rather than as ticks as is the case in the original STOS. The lessons were therefore coded as either being dominated by the teacher's activity (1), or being at an intermediate level (2) or pupil activity (3). A two-minute time period was used for observations and behaviour that

occurred was marked with corresponding pupil interaction (Appendix 8 describes how the teacher-pupil activities were coded in Lewin's schedule).

The schedule was specifically used because it captures, as far as possible, interactions of the whole class, of groups and individuals, and also because it distinguishes between main and subsidiary categories (processes) which were treated by the investigator as mutually inclusive.

3.10.3 Photographs

Photographs were taken during classroom observation to exemplify the data that were collected through interviews (Burgess 1982; 1984; Walker 1993). Photographs were thus used as part of converting data collected through field research to field texts (Clandinin and Connelly 1994). Photographs also helped to:

- *"provide a general sense of a setting in conjunction with interviews and other types of observation;*

- *to probe as to how the teachers and pupils define their world, and revealed silent messages relating to the learning of science using SEP apparatus and material"* (Bogdan and Biklen 1982:102).

3.11 RELIABILITY AND VALIDITY

Guba (1981); Guba and Lincoln (1983); Marshall and Rossman (1989); (1994); Pidgeon and Henwood (1996) and Henwood (1996) argue that appropriate terms and concepts need to be carefully thought out and need to be consistent with one's paradigm. In line with this, a number of authors, Lincoln and Guba (1985); Miles and Huberman (1984; 1994); Huberman and Miles (1994); Janesick (1994) and Henwood (1996) espousing the constructivist paradigm have developed concepts and alternative strategies to deal with the issues of validity and reliability in a qualitative mode of inquiry. Table 12 illustrates the terms suggested by Guba and Lincoln

(1983) and Huberman and Miles (1994) to justify the validity and reliability within a qualitative inquiry. Table 13 outlines the recommended terms proposed by Henwood (1996) when dealing with a qualitative inquiry.

The following discussion deals with the central terms in this context. Tables 12 and 13 give this.

Table 12: Scientific and naturalistic terms appropriate in each of the two research designs

TERMS	SCIENTIFIC	NATURALISTIC
Truth value	Internal Validity	Credibility
Applicability	External Validity	Transferability
	Generalisability	Dependability
Consistency	Reliability	
Neutrality	Objectivity	Confirmability

Source: Guba and Lincoln 1983 and Huberman and Miles 1994.

Table 13: Three strands of qualitative inquiry

BROAD STRAND	EPISTEMOLOGY	METHODOLOGICAL PRINCIPLES
Strand 1		
Reliability and validity	Empiricism	Discovery of valid representations (using induction)
Strand 2		
Generativity and grounding	Contextualism	Construction of inter-subjective meaning (or *verstehen*)
Strand 3		
Discursive and reflective	Constructivism	Interpretive analysis (highlighting deconstruction of text)

Source: Henwood (1996)

The need to ensure the ***credibility*** of results implies that the researcher should remain conscious of the dangers of pretending to be purely 'objective' or purely 'subjective'. The other issue in this regard is the extent to which the findings can be used by other researchers. The term used to describe this aspect of validity and reliability is ***transferability***. Thus, ***transferability*** seeks to establish the extent to which findings from a study can be used by another investigator rather than insisting on external validity as is usually the case in the positivist paradigm. The main feature of this construct is that the burden of demonstrating the ***applicability*** of one set of findings to another context rests with the second investigator who would make that transfer rather than with the original investigator. ***Dependability*** according to Miles and Huberman (1994) addresses the issue of *"whether the process of the study is consistent, reasonably stable after time and across researchers and methods"* (Miles and Huberman 1994:278). The last construct is what is termed ***confirmability*** by Miles and Huberman (1994). The core of this construct is to inquire whether the findings of a particular study could be repeated by other researchers (Miles and Huberman 1994). Finally, ***validity*** of the qualitative inquiry means describing, explaining and finding out whether or not a given explanation indeed fits a given description about the piece of work under investigation (Janesick 1994; Tesch 1990).

In order to develop this discussion further, Henwood (1996) provides a sketch consisting of broad strands, epistemologies and methodological principles that may be used to determine the validity and reliability of qualitative inquiry (see Table 13). Strand 1 in this process *"appraises research by means of standardized analogues of the criteria of reliability and validity"* (ibid:31). This implies the development of criteria one could use to determine the reliability and validity of qualitative inquiry. Strand 2 involves the generation of new theory that is grounded in participants' own accounts. Strand 3 focuses on the discursive and reflective function of language. According to this approach, it is necessary in strand 3 to identify shifts in epistemological positions from empiricism, to what Henwood (1996) calls

'contexualism' and 'constructivism' which implies that any piece of research should be undertaken within a particular context taking into account participants' own accounts. Lastly, the methodological principles "*express the way that research questions and analytical principles are intertwined*" (Henwood 1996:31).

In the light of the above discussion, reliability and validity of the findings in this study were approached as follows:

- The researcher compared interview data on SEP with the data obtained from classroom observations. This step was taken in order to establish whether there were differences of opinion or agreements on the project's work and to provide explanations for any differences that may have occurred.

- The data from interviews, SEP documents, classroom observations and photographs were regularly contrasted in order to either corroborate or dispute the findings.

- Purposive sampling of the regions, SEP documents and records and SEP staff members and an interview guide in which informants were asked questions according to their experiences ensured the reliability and validity of the findings.

- Objectivity of the findings was ensured by providing a detailed description of how the data were collected, processed and displayed for drawing conclusions for each research question.

- Objectivity was also ensured by analysing competing views and rival explanations expressed by SEP staff members and stakeholders in the regions. This process was carried out during the data collection and during reporting conclusions. The reasonableness of the differing opinions on the project's work was determined by

considering the roles and responsibility of SEP stakeholders. This means that the reasonableness of conclusions was established by considering whether they were shared by the majority of stakeholders or not.

- The researcher solved personal biases in the data by going back to SEP staff who provided initial information in order to find out whether their views had been accurately reported by the researcher.

- The data on SEP was collected from the field using an empirical method of inquiry. This means that the researcher went to the four regions to collect the data needed from SEP personnel. A variety of methods, multiple-data sources, triangulation of various types and elite interviews were used in this regard. In addition, the researcher employed inductive methodological principles in order to discover valid and credible data about SEP in the regions.

- The researcher employed a grounded theory methodology in collecting data on SEP in the regions selected for this study. Consequently, the data were obtained through the researcher's prolonged involvement with the project on the various sites, using triangulation of the various types, describing and member checks. The aim in this regard was to derive meanings about SEP from the project's staff and personnel.

3.12 SUMMARY

This chapter examined and analysed the research design of the present research. First, procedures and strategies adopted in the pilot study were described. Three aspects of this part of the chapter discussed are: approaches and methods followed, reliability and validity of the data collected during the pilot study and the reporting of pilot results. Research questions developed from the literature survey and the pilot study were outlined and described.

Second, the characteristics of the constructivist paradigm and the theoretical framework that guided the present study were analysed and justified. It was pointed out that in view of the fact that the investigation is guided by the interpretive paradigm and the grounded theory approach, purposive sampling was chosen and justified to sample project documents, informants, schools and the regions.

Third, the data collection strategies, pilot study data sources and sampling procedures for the main study were discussed. The position of the investigator in this research was that of the participant-as-observer and the observer-as-participant. Informal, general guides and standardized open-ended interviews were employed to gather data from informants who had divergent experiences of SEP. Both the individual interviews and the focus group interviews were distinguished and used to gather data from informants. Content analysis as a systematic way of gathering data was outlined and it was shown how it was used in this research. Models of content analysis were identified, compared, analysed and their appropriateness for this investigation pointed out.

Fourth, methodologies employed in the study were analysed and their relevance to the present study were justified.

Fifth, approaches and sampling procedures and the samples chosen for the study were described in detail.

Finally, reliability and validity issues appropriate to the study were analysed and justified. The strengths and weaknesses of these procedures were identified and discussed. Furthermore, methods and approaches in research in general and how they were employed in this study were analysed.

CHAPTER FOUR

DATA REDUCTION AND ANALYSIS

4.1 INTRODUCTION

Chapter Three focused on the first part of the research design in which the methodology, approaches and paradigms followed in the study were explained. Chapter Four describes the analysis, reduction and interpretation of the data.

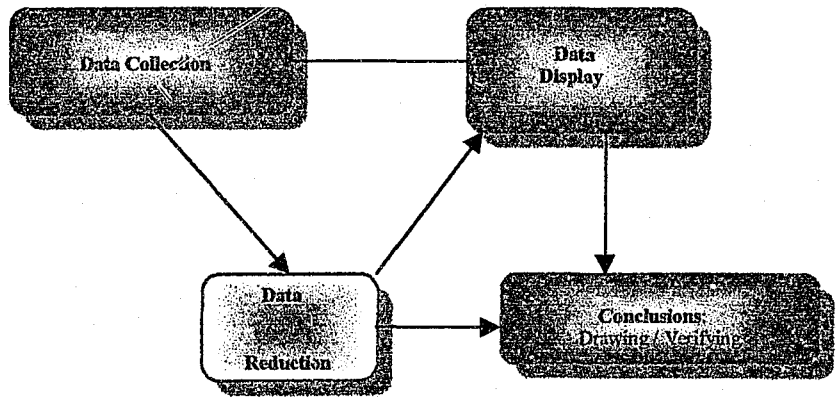
4.2 PROCEDURES EMPLOYED IN REDUCING AND ANALYSING THE DATA

The three key components of data reduction and analysis proposed by Miles and Huberman (1984; 1994) and Huberman and Miles (1994) and which guided the analysis in this investigation include: data collection, data reduction and examination and conclusion drawing as well as verification (see Figure 3). Huberman and Miles (1994) call these 'iterative procedures' where a given set of cases are examined and refined or modified on the basis of subsequent ones. These procedures correspond to the grounded theory approach which shares the features of generative and constructive analysis. The process of data reduction therefore followed what Tesch (1990) calls 'de-contextualization' and 're-contextualization' whereby data is coded and analysed in terms of smaller units and then regrouped in terms of patterns and trends.

The core of Miles and Huberman's (1994) model is the importance of linking four sub-processes in analysing the data. These sub-processes are: data, reduction of data, data display and conclusion drawing, and they "*occur before data collection, during study design and planning, during data collection as interim and early analyses are carried out, and after data collection as final products are approached*

and complemented" (Huberman and Miles 1994: 429). The strategy of analysing data suggested by Huberman and Miles (1994) has been followed by the researcher in this study.

Figure 3: Data reduction process and analysis model



Source: Denzin and Lincoln (1994:428)

In this regard Potter suggests the usage of what he calls the 'funnel' approach to reduce the data collected in the field (1991) (See Figure 4). The proposed 'funnel approach' resembles the approach suggested by Huberman and Miles (1994) and involves the description of steps to be followed in reducing large volumes of data into manageable units. Huberman and Miles' (1994) and Potter's (1991) models were employed to analyse the data in this study.

Figure 4: The "funnel" approach to reduce the data



Firstly, the large volume of data which was collected by the researcher from the various data sources, from a number of SEP personnel and from science educators outside the project was reduced as part of the analysis in this report (See Chapter Three for a detailed description of the samples of the data sources and informants). This was done by providing summaries of the data derived from SEP documents, interviews and classroom observations in the form of tables. Furthermore, the researcher devised a coding system, derived themes and patterns and clustered them into categories. Secondly, the researcher displayed the data on matrices in tables and figures. Lastly, conclusion drawing and verification of the data were performed by: comparing and contrasting the views of the different stakeholders in SEP, establishing confirmation or rejection of the findings, and by investigating the possible reasons for the varying perceptions held about SEP.

Data obtained from the project's documents and records were reduced by subjecting them to content analysis (Berelson 1952; Holsti 1968; Krippendorff 1980). This was done by clustering the data from the documents and records into themes, issues and patterns in the research questions, representation of the data in tables and figures as well as drawing conclusions by comparing and cross-checking the data collected from the different sources.

4.3 MODELS OF CONTENT ANALYSIS USED IN THE INVESTIGATION

Two models of content analysis were examined to establish their relevance to this study. These were the evaluative assertion or representational model and the instrumental model of communication.

The Representational Model

According to Osgood (1959), the representational model focuses on the analysis of evaluative assertions in data and assumes that messages in them can be analysed into units of assertions. Furthermore, it is assumed by Osgood (1959) that an analyst who adopts this model can judge whether the units are relevant or irrelevant, favourable, neutral, or unfavourable to the topic being studied. George (1959 (a)) points out that the representational model focuses on the analysis of frequency of occurrence of assertions in the data. According to this view, inferences are drawn by looking for the frequencies with which certain content occur.

The weakness of the representational model is that it is confined to the frequencies with which certain content occurs. Mahl (1959) in this regard argues that by focusing exclusively on the occurrence on frequencies, this model ignores the situations in which these utterances are made, as well as any additional information that may be available.

The Instrumental Model

The instrumental model is also referred to as the non-frequency, non-quantitative, non-statistical model (George 1959 (a); George 1959 (b)). This model relies less on the frequency with which a particular action or word occurs in the communication but rather focuses on the mere occurrence or non-occurrence of attributes for the purpose of making inferences. Consequently, a researcher adopting this model would rely less on the number of times particular assertions or themes recurred than on finding out whether assertions or themes occurred (George 1959 (a); 1959 (b)).

In view of the methods used to collect the data and the nature of data sources, the instrumental model of content analysis was considered appropriate in this research. This model was chosen because it provided the researcher with practical strategies of clustering the data collected from the field in the regions about SEP and also helped in drawing conclusions from the data. In accordance with the characteristics of the instrumental model chosen, the researcher recorded the issues, themes and patterns regardless of the number of times they occurred in the data collected.

4.4 DELINEATING AND DEFINING UNITS OF ANALYSIS

Three types of units that can be used to analyse data are: sampling, recording and context units (Krippendorff 1980; Berelson 1968; Holsti 1968; Kerlinger 1973).

Recording units are the smallest body of content in which a reference occurs or might occur. Recording units identified in content analysis include: word or symbol, theme, paragraph and item. Berelson (1968) further extends the meaning of 'theme' when he points out that it is also known as an 'assertion', a 'statement', a 'proposition', an 'idea' and an 'issue'. By proceeding descriptively as discussed above, themes, assertions, propositions, and issues served as recording units for defining units of meaning within SEP's documents written by different people in different contexts.

4.5 UNITS OF ANALYSIS AND CODING SYSTEMS

The units of analysis included individuals, clients of the project, a group of people, different components of the project, and the entire programme. However, these units were regarded as mutually inclusive except that each unit of analysis implied a different type of data collection and a different focus.

Units were therefore perceived holistically whereby, although certain information about the project could be extracted only from certain categories of stakeholders in the project, such data were analysed in terms of the broader analytical framework adopted in the study.

Two coding systems were considered for possible use in this study. One of these is the one proposed by Budd, Thorp and Donohew (1967) while the other is suggested by Potter (1987; 1991). Originally, the coding framework proposed by Budd, Thorp and Donohew (1967) was followed in the initial stages of coding and categorizing the data. This involved the establishment of agreements of trends and patterns that emerged from the analysis by the two investigators. However, the second and subsequent coding system followed by Potter (1987; 1991) was employed in the main study. Potter's coding system was preferred to the first one because it focuses less on frequency with which a particular action or theme occurred but rather on the analysis of occurrence or non-occurrence of attributes for the purpose of making inferences. This consideration was useful for this study because of the qualitative nature of data collected from the research sites.

4.6 DATA ANALYSIS

Maykut and Morehouse (1994) discuss three approaches to data analysis as proposed by Strauss and Corbin (1990). The first approach is commonly adopted by a researcher whose goal is to allow participants to speak for themselves as much as possible and to tell their stories. The second involves some selection and interpretation of speakers' words, field notes, quotations and the researcher's own

interpretation is described in a narrative form. The third relates to a situation where interpretations of descriptive research are enhanced in order to build a theory. This approach is an essential feature of the grounded theory which involves the "*highest level of interpretation and abstractions from the data in order to arrive at the organizing concepts ...of a theory to explain the phenomena of interest*" (Maykut and Morehouse 1994:122).

Their approach which is located within a grounded theory mode of research was adopted for this study. Accordingly, perspectives of multiple actors in the project as well as analytical interpretations of the investigator were two prominent features in this investigation. Following Strauss and Corbin (1994), Henwood (1996) and Pidgeon and Henwood (1996), the investigator adopted the view that although the multiple views of participants were given attention, these were further subjected to the investigator's own interpretations of what was happening regarding SEP's work.

In respect of the interpretation of findings, Marshall and Rossman (1989), Miles and Huberman (1984), Potter (1991), Marshall and Rossman (1989) argue that strategies one adopts to analyse and interpret the data should take into account the nature of the data themselves, how they were collected and the nature of the instruments. Huberman and Miles (1994) in this respect propose three sub-processes for analysing data that have been collected from the field. The core of their suggestion is that the analysis must begin by first reducing the data, followed by displaying the data then by drawing conclusions and verifying them .

4.6.1 Content analysis of interviews

As in the case of the analysis of documents and records, the interviews were subjected to content analysis in order to establish trends, patterns and issues that either recurred or did not in the data. Firstly, the reduction of interview data took the form of content analysis and was done against the background of the research

questions while in observations it established teacher-pupil interaction patterns.

The purpose of recording emerging themes and policy issues in the analysis was to establish and explain any agreements and disagreements that may have emerged from the data with regard to the implementation and institutionalization of SEP's policy and actions or practices. Lastly, the reduction process implied the coding of assertions to establish whether they were intentions or actions (Stenhouse 1975).

The content analysis took the form of identifying policy and practice enunciated by the various people and structures within SEP during its different phases. Subsequently, policies, intentions, aspirations and actions stated or implied in statements and assertions were identified. The purpose was to establish the extent to which SEP people agreed or disagreed on the various aspects of the project in the region. This system made it possible to distinguish between the intentions and aspirations as to what should happen, and what actually does happen in reality when innovation is implemented in different contexts. The coding system was first discussed between the two investigators, and trialed on a smaller scale before coding data for the main investigation.

4.6.2 Procedures adopted in the reduction and analysis of the data obtained from classroom observations and photographs

The project managers / implementers and the investigator used different observation schedules with the former using the visits as part of their routine teacher support. The investigator, on the other hand, used an observation schedule developed by Lewin (1990). This was elected because of the following advantages:

- It focuses on the processes in science teaching and learning such as observing, hypothesizing, interpreting data and making inferences;

- It captures, as far as possible, interactions of the whole class, of groups and individuals;

- It analyses interactions between the teacher and pupil in the learning and teaching situation.

The investigator elected to use Lewin's observation schedule because, even though its contents are not explicitly stated as SEP policy and intentions, they do reflect inherent features of meaningful learning and teaching of science. The schedule was marked as the lessons progressed and the emerging percentages and averages and other similar activities were finalised as soon as possible after the lesson.

A two-minute interval was adopted within which sub-categories were marked 1, 2 or 3, depending on the occurrence of the relevant activity appearing at that time. The numbers 1, 2 and three designate teacher-pupil interactions where 1 suggests that the lesson was dominated by the teacher, 2 signifies an intermediate level of pupil participation and 3 indicates that the lesson was dominated by pupils' initiated activities or participation (see description of teacher-pupil interactions in Lewin's schedule in Appendix 8).

A two-minute interval time span gave the researcher enough time to observe certain processes in the lesson as well. However, the nature of the schedule and the coding procedures adopted were such that more than one category and sub-category (processes) were coded if they appeared simultaneously during a two minute interval. Examples of categories and subcategories that appeared simultaneously were *inter alia*: 'general discussion' category and 'teacher writes' category, 'teacher explains' and 'teacher demonstrates', etc. The contents of the schedules are explained in Appendix 7 and indicate the processes in the lesson as well as the time spent on each.

4.6.3 Procedures followed to generate categories for the analysis of the data

A multi-method strategy was used to generate categories and patterns that could have emerged in the process as a result of the nature of the data. The original proposals by Marshall and Rossman (1989; 1994) were utilized in conjunction with Potter's (1991) analytical framework. The process involved establishing recurring regularities, convergence or divergence when placing data that seemed to belong together into patterns (Guba 1981).

Two strategies for generating categories of data were identified. The first concerned the usage of categories as articulated by the informants, while the second was the generation of categories for which the informants had no labels or terms (Guba 1981; Marshall and Rossman 1989; 1994).

In addition, strategies for developing concepts needed to classify and analyse data were examined. The first of these is the identification of indigenous concepts, generalizing concepts and indigenous typologies. Indigenous concepts and terms refer to those that may emerge or be created by participants as a means of communication within the programme. Sensitizing concepts and terms have their origin in social theory and research literature. The indigenous typologies on the other hand originate in anthropology and aim at preserving and reporting the indigenous categories of people studied.

Apart from the indigenous categories and typologies, the investigator constructed patterns, categories and themes since not all of them could be derived from the participants in the project. These were the analyst-constructed typologies and refer to typologies, themes and patterns constructed by the investigator through the process of induction (Marshall and Rossman 1989; 1994).

Following the strategies described, the various kinds of themes, trends and patterns emerged as a result of reduction of data from the project documents and records. They also emerged as a result of interactions between the different stakeholders with interests in the project, through lesson observations, by talking to the teachers as well as through analysis of photographs.

Indigenous and analyst-constructed concepts and typologies were used to develop themes, trends and patterns related to the various aspects of SEP. It was therefore possible to generate themes, trends and patterns with respect to the various aspects of SEP *inter alia*:

- Convergence or divergence on how the different stakeholders conceptualize implementation, evaluation and institutionalization of the project.
- How the effectiveness of SEP can be established.
- Themes, trends and patterns with respect to the teaching and learning of science through the SEP methodology.
- Themes, trends and patterns on the relationship between SEP and certain authorities in the four regions over a period of time.
- Themes, trends and patterns relating to lessons in science presented by the teachers in the regions.

4.6.4 Examination of the data

Miles and Huberman's (1984; 1994) and Huberman and Miles' (1994) ideas were employed to code themes, trends and patterns from the project's documents, observations, photographs and interviews. The display of the data involved clustering assertions according to whether they represented intentions and practice in SEP in the regions.

4.6.5 Drawing and verifying conclusions

According to Huberman and Miles (1994:432) *"tactics for generating meaning from the data are arranged from the descriptive to the explanatory, and from concrete to the more abstract"*. In other words, the meaning embedded within a particular phenomenon becomes clearer if one begins by providing a detailed description of empirical data and then moving on to the description and development of a theory from the field.

The strategies to verify, confirm and to conclude the findings of this study were also guided by Miles and Huberman (1984; 1994) and Huberman and Miles (1994). This process involved: counting, noting patterns and themes, clustering, using multiple methods, combining categories, finding mediating factors and building a logical chain of evidence. In addition, tactics to confirm data in this study were also developed. These include: checking the investigator for representativeness, checking for research effects, triangulation, weighing the evidence, making contrasts and comparisons, examination of earlier cases, using the exceptional case to account for regularity and for checking out rival explanations, working with negative evidence and getting feedback from respondents.

Tactics for confirming the data proposed by Miles and Huberman (1984; 1994) and Huberman and Miles (1994) were used in this section of the analysis. These tactics serve to ward off the most obvious biases in the findings.

- **Counting**

Counting was done to draw conclusions and verify data analysed in terms of frequencies, coding and assertions but was specially employed when dealing with frequencies and coding of data. This was used extensively when analysing the project's documents and records as well as observation schedules in science lessons.

- **The noting of themes, trends and patterns**

Noting of themes, patterns and issues formed the corner stone of the analysis of interpretive data collected through the naturalistic approach in this study. This tactic was helpful when dealing with data where a variety of methods were used. Patterns and themes were clustered and displayed in table form.

- **Triangulation**

Triangulation was extensively utilized to confirm findings in this investigation. The different types of triangulation used include the following: data triangulation by means of which a variety of data sources were used in each region, investigator triangulation where more than one investigator coded and analysed data from interviews and from documentation analysis. The multiple perspective and perceptions to interpret a single set of data and methodological triangulations were also used to analyse data on SEP in the regions and nationally.

- **Making contrasts and comparisons**

Comparing and contrasting findings from data obtained through triangulation and the usage of a variety of methods aided in the presentation of results. By making use of this tactic, the investigator could compare perceptions, views and perspectives of the different informants in individual regions and in the four regions selected for study.

- **Examining the outlier cases**

This was employed to confirm findings with respect to the recurrence or non-recurrence of certain themes, issues and patterns in the data. The examination of outlier cases proved very effective in dealing with evidence that seemed to oppose shared conclusions.

- **Checking rival explanations**

Rival explanations provided by the informants in the various regions about SEP were examined and used to confirm or discount findings. The areas around which the rival explanations emerged from the informants related to the project's intervention strategy, its management and its future role in promoting innovation and change in science education. Investigation into rival explanations was followed through until one of them became more compelling as a result of stronger and varied sources of evidence (Miles and Huberman 1994).

- **Looking for negative evidence**

This strategy was used in close collaboration with the checking of rival explanation tactics. Looking for negative evidence was initially employed to establish divergent or convergent evidence on a particular issue on the project from the same category of people in the project.

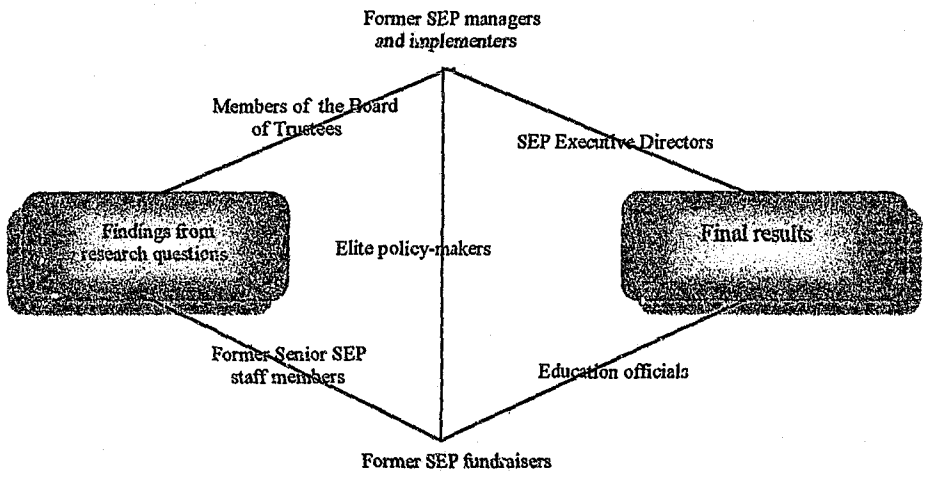
- **Getting feedback from informants**

This tactic was extensively utilized in confirming the findings of this investigation. It took the form of confronting informants with theoretical explanations that emerged from the data on the various aspects of SEP as an innovation project.

Verification of results from informants was carried out through member checks. Results from empirical data were taken back to the informants for confirmation and accuracy. It was hoped that informants would offer additional stories which would either confirm or reject results further. This strategy involved asking participants and informants to check whether their experiences on the project had been accurately described. Maykut and Morehouse (1994) point out that member checks can either take the form of listening to participants but not necessarily changing results, or to

agreeing not to publish anything that the participants do not find truthful. Following Maykut and Morehouse's (1994) observation, the investigator listened to the informants and modified results if his varied greatly from all informants. However, emphasis centred around rival explanations and negative evidence from a variety of informants. The debriefing stage to enhance the credibility, transferability, dependability and confirmability is illustrated in Figure 5.

Figure 5: A model for verification and confirmation of the findings



4.7 SUMMARY

This chapter examined and focussed on the methods adopted to analyse documentary (archival) data, as well as the interview and focus group data. The strategy adopted was to develop categories and to use these to analyse and interpret the data.

The representational and instrumental models of content analysis were described and their strengths and limitations pointed out. The adoption of the instrumental model for this study was justified.

The units of analysis and available coding systems that may be used in analysing the content were outlined and analysed and described.

The analytical framework developed by Miles and Huberman (1984;1994) and Huberman and Miles (1994) guided this section of the work. It involved the interaction of the four components of data analysis mentioned in the previous paragraph. Consequently, as the investigator proceeded through the various stages, the cyclical matrix of the interaction model was continuously borne in mind. However, Miles and Huberman's (1994) procedures in this study were complemented by procedures of grounded theory as proposed by Pidgeon and Henwood (1996). Consequently, the end-result of interactive analysis of the data and the research was an attempt to generate theories about the Science Education Project.

Procedures that may be adopted for generating categories as well as strategies of drawing and verifying conclusions were described and justified.

The investigator proceeded through the various steps which included: data reduction, displaying the data in tables and figures and examination and drawing of conclusions and verifying them.

CHAPTER FIVE

MODELS OF CURRICULUM DEVELOPMENT, INNOVATION AND CHANGE

5.1 INTRODUCTION

Chapters Three and Four outlined the research design guiding this investigation. They described how research questions were developed, the sampling procedures, data collection and data sources as well as research methodology and related issues.

The next four chapters analyse empirical findings relating to each of the four Research Questions in turn. The themes and trends examined in these empirical chapters came from the following sources:

- Interviews with elite policy makers and science educators within SEP and those outside it, senior SEP staff, the project implementers, its members of the Board of Trustees, education administrators in the four research regions, and teachers in schools that were provided with SEP science kits and worksheets;
- Observations of lessons taught according to SEP methodology;
- Photographs taken during classroom observations;
- Literature review on innovation and change in science education.

Informants who provided information on science education in general and on SEP in particular were assigned letters of the alphabet in order to ensure anonymity. Abbreviations were employed to indicate the sector or the organization informants either worked for or represented (see Appendix 9 for glossary and abbreviations). However,

the letters of the alphabet were assigned arbitrarily and not according to seniority of informants or the date on which an interview was conducted.

The themes and trends that came out of interviews, observations and literature review were identified by the researcher and then analysed in terms of an analytical framework proposed by Miles and Huberman (1984); Huberman and Miles (1994); Henwood (1996) described in detail in Chapter Three and Four of this research report. Following the suggested framework, themes, trends and issues as well as the sources from which the data obtained were represented in tables that are divided into columns. The first column indicates the themes, trends and issues in each of the areas reported on each of the four research questions and the second column indicates the sources of the data on specific themes, trends and issues.

The analysis of empirical evidence was carried out further by:

- Checking rival explanations provided by elite policy makers within SEP and those outside it, SEP staff, its Executive Directors, the project's members of the Board of Trustees, SEP donors and the teachers in schools provided with the project's science kits and materials;
- making contrasts and comparisons of the views on themes, issues and trends expressed by SEP staff, its members of the Board of Trustees, SEP Executive Directors, the project's donors and the teachers provided with SEP science kits and materials.

This chapter thus reports issues relating primarily to innovation and change in the context of SEP's work in the four selected research regions. The issues explored in it are represented in Table 14.

RESEARCH QUESTION ONE

How effective and enabling were SEP's models of curriculum development, and its approaches to innovation and change?

Table 14: Themes and trends explored in Chapter Five and sources of data

THEMES AND TRENDS	SOURCES OF DATA
SEP was readily accepted by other stakeholders because discursive approach was adopted to introduce it to the education departments	- interviews with the members of the Board of Trustees and with elite policy makers within SEP and outside the project - interviews with the education administrators in the four research regions - SEP documents and records
SEPs multiple aims and goals enabled it to be easily funded by sponsors and donors SEP's vision, policy, implementation and institutionalization changed from that of a small organization to a big bureaucratic one	- data from SEP documents and records - interviews with elite policy makers within SEP and outside the project - interviews with SEP's members of the Board of Trustees - interviews with senior SEP staff members who were involved with the project from 1980 to 1990
SEP innovation and change went through phases including needs, adoption and institutionalization phases	- data from the literature review - interviews with SEP staff, science educators within the project and SEP implementers
SEP adopted the package approach and the Research and Dissemination model because these were suitable for the prevailing conditions SEP model and approaches were effective and enabling in the 1980s and 1990s	- data from SEP documents and records - data from the literature review - interviews with elite policy makers within SEP and SEP staff in the regions - findings from evaluation report on SEP - interviews with SEP managers and implementers
The culture and ethos of SEP changed from the one characterized by cooperation among its staff to the one characterized by formal procedures	- interviews with former SEP staff who were involved with the project in the 1980s to 1990s - SEP documents and records
SEP's model of INSET was one of the project's strong points	- SEP documents and records - SEP's senior staff members - SEP implementers in the four regions

THEMES AND TRENDS	SOURCES OF DATA
SEP implementers played a major role in the implementation and institutionalization of SEP's work	- interviews with SEP's senior staff, its members of the Board of trustees and the project implementers - teachers supplied with the projet's kits and materials

5.2 MODELS ADOPTED TO INTRODUCE THE PROJECT TO EDUCATION DEPARTMENTS

The analysis of SEP documents and records and of interviews with elite policy-makers within the project suggest that informants with experience of the policy-making process agreed that the Science Education Project adopted a discursive approach to introduce its innovation and change in science education in the 1970s and 1980s. Accordingly, SEP was able to "*persuade industry, donors and some individuals in the erstwhile homelands and DET to support its innovation and change*" (Sci Ed (a); SEPB (b)). (See appendix 9 containing a glossary and an explanation of abbreviations used to report the data in empirical chapters). Further in view of the fact that policy on science was decided centrally in the 'old' education system in South Africa, SEP could "*only enter such a system by winning the hearts and minds of the users rather than prescribing its policy to the then departments of education*" (SEPB (f)). The various departments of education in the different regions in which the project was operating became aware of it from the teachers while the latter came to know about it from the project's Regional Directors. The consequence of adopting this bottom-up approach was that SEP, which was originally described by the former DET as revolutionary, was subsequently perceived positively because of the discursive approach to curriculum development adopted by SEP personnel to introduced the project to the education authorities.

The findings from interviews with elite policy-makers within SEP therefore support the argument that a discursive strategy to innovation and change is likely to result in meaningful change because it appeals to people's realities and practices (SEPB (d); Sci Ed (a); (c)).

The general conclusion from the results above is that past practice in policy-making within SEP where people were involved in the process was more acceptable than if they were to be provided with a blueprint or a document from which to work. It was further concluded that the project's policies were embraced by the majority of stakeholders in the project because the idea about it was first circulated among the broader community for discussion before it was considered an official policy. In this respect, one informant within SEP had this to say: *"the introduction of an innovation is perhaps a necessary step but even more important is the development of sets of concepts, words, stories and an environment in which the ideas can become acceptable"* (Sci Ed (b); (c)). According to the argument, this can only be achieved if people modify the language but not necessarily their original perceptions about a particular issue (SEPB (a)).

5.3 THE AIMS AND OBJECTIVES OF SEP'S INNOVATION AND CHANGE

Results of the analysis of the project's documents and of interviews eg. Sci Ed (a); NGO (d); (b); SEPN (d), indicate that the aim of the project was to involve pupils in the learning of science. However, the various documents and records also reflected the different aspects of this aim such as those relating either to pupils, teachers, the provision of science kits and material, the methodology and the general teaching and learning methods (See Rogan 1976 (a); (b)).

Naturally, most of the issues relating to the aim and the goals of the project appeared more prominently in the documents and records compiled and written in the Ciskei region where the project began its intervention mission in science education in the early

1980s for example *"the aim of SEP was to change the methods of instruction from rote-learning to a process approach"*. Also that , *"pupils should do science rather than just learn about it"* (See Rogan 1976 (a); (b); Macdonald 1980;1993). However, the unintended subsidiary, but positive goals the project wished to attain appear to have been a commitment to change teachers and to influence the Department of Education in respect of innovation and change in science education. It appeared from the results that subsidiary goals were intended to complement the explicit goal of giving pupils the opportunity to *do* science and not merely to learn about it (eg SEPB (b); SEPN (d); (e); (h)).

However, interview results with elite policy-makers suggest that in view of political changes since 1994, that there has been a general view that it is the current government's responsibility to provide basic material and apparatus in science (NGO (c); Para Org (d); SEPB (f); Sci Ed (k); (h)). Despite this shared view, the majority of informants representing the NGO sector argued that even if the government were to provide the basic apparatus and materials, South Africa has a cadre of teachers who, because of their inadequate training, cannot use science apparatus and materials properly and effectively. Thus, it was generally suggested that SEP should continue with its teacher professional development component inherent in its mission statement (Para Org (c); SEPN (d); DON (e); SEPB (e)).

Results from interviews with informants within SEP and outside who have an in-depth knowledge of the policy-making process pointed out the importance of ensuring that change agents understand how the local community interprets innovation. This involves understanding the local knowledge and cultural values of such a community. In this regard, it was suggested that innovation often fails because there is a mismatch between the understanding of the users of innovation and expert knowledge, especially in rural areas. This apparently occurs when experts or change agents *"intervene without trying to understand the values and knowledge of the local community about the intended innovation and change"* (SEPB (a); GSEP (a)).

The policy-makers therefore maintained that often the aims of innovation and change were not shared by the implementers and the users. According to this view, the implementers hold a particular view on why an innovation is introduced while the users hold their own totally different view. The research then concluded that a change agent's motive for introducing an innovation in education may be related to his/her desire to change traditional learning and teaching strategies, but the teachers may see such an innovation as a way of developing themselves personally and therefore moving to senior positions. Furthermore, schools may also join the project because of the material benefits they may derive from it e.g. provision of portable science kits such as the ones provided by SEP.

Consequently, the evidence indicates the need for change agents to explain the aims of innovation projects to the users and to ensure that the latter understand these aims. According to one informant, the project people must make the users aware of what it is that they are coming into so that they are able to change according to the intentions of the project (Sci Ed (a); SEPB (a); Berman and Mclaughlin 1975).

5.4 THE PHASES OF INNOVATION AND CHANGE IN THE PROJECT

The main purpose of investigating the phases and features of SEP's innovation and change in the context of this study was to trace the changes brought about by SEP in the four selected research regions. The findings from interviews with SEP Executive Directors, members of it Board of Trustees, elite policy-makers within the project and donors suggest that SEP, like all other innovation projects, went through stages including the orientation or needs phase, initiation or adoption, implementation or initial use phase, and incorporation or continued implementation or institutionalization.

Results of interviews and of the analysis of SEP's documents and records show that the majority of informants within the project agreed that the intended aim of the project developers and policy-makers was to institutionalize the project's philosophy and

methodology. Further, no significant discrepancies about the project's impact were apparent in 'older' regions, such as the Eastern Cape and the newer ones, such as the North West. Consequently, a conclusion drawn from these results is that the impact of the project in the Eastern Cape region was neither better nor worse than in the newer regions (GSEP (a); SEPN (a); SEP (a); Sci Ed (g); NGO (d)).

The most visible difference found by the researcher when comparing the phases of SEP in the four regions was that the majority of the project's implementers in older regions such as the former Transkei and Pietermaritzburg had been on the British Council Scholarship Programme to Leeds University. The indigenous term used to characterize these people is the 'been to'. Furthermore, results in this regard show that the project's implementers and teachers in these regions were comfortable with its philosophy and principles. In newer regions such as the North West and Gauteng a situation prevailed where teachers were still in the process of accepting the idea of what SEP was trying to introduce.

The researcher found from the results that it is usually difficult to decide at what stages or phases an innovation is operating; i.e. whether it is at an initiation, adoption, implementation or institutionalization stage. Results from the project's documents and records reliably support the argument put forward in the literature review that the introduction of one phase of innovation will not automatically lead to the next step or phase (See for example, Berman and McLaughlin 1975; Giacquinta 1973).

5.5 REASONS FOR ADOPTING THE PACKAGE APPROACH AND THE RESEARCH AND DEVELOPMENT MODEL

5.5.1 The package approach in curriculum development

Findings of the analysis of the project's documents, observations and interviews with SEP staff in the regions and at National Office as well as those from the recent external

evaluator indicate that the 'package' approach guided, and continued to guide SEP's curriculum development as well as its innovation and change while this study was investigated. The 'package' approach in the context of SEP's curriculum development, innovation and change model implied the following:

- the provision of science materials, science kits, worksheets and expendable resources such as chemicals
- the provision of a holistic view of curriculum development, innovation and change by means of a nucleus of implementers, methodology, content controls in science as well as INSET (Macdonald 1989; 1993; NGO (b); (d); SEPB (b); SEPN (d); (e); (g)).

Interview results suggest that the 'package' approach was considered suitable because of the deprived environment under which science was taught in schools for the blacks in the 1970s. One of these circumstances was that most teachers in South Africa were not adequately trained to teach science and needed some guidance in the field. The assertion in respect of SEP teachers, and probably teachers in general was that they had not been trained and had no idea of how sociology, history of education, cognitive psychology and other disciplines are interrelated with science. In the light of their inadequate training, some SEP teachers and some implementers could not be expected to *"develop, modify and implement curricula for their classes in their own situation"* (Bateson 1995:2). The assertion that some teachers within SEP and teachers in general were not as competent as they should be was reiterated by some informants. Sci Ed (a); (b); (g); SEPN (e) in this regard pointed out that:

> *"Teachers have very little knowledge about education. They get taught how to do things as opposed to why it should be done. I found that teachers knew how to do some things, not why it is important to do them like that. There is not enough theory behind why. If things did not work exactly they did not know what to do."* (SEPN (e)).

The reservation expressed above was further articulated in this way by one of SEP's staff "*SEP does not give its teachers and implementers adequate theoretical knowledge on constructivism and the process approaches to the extent that some of them do not recognize these approaches in the science lessons*" (GSEP (e)).

However, the researcher concluded from the results that the views about the teachers expressed by the interviewees only represented a certain percentage of the teachers who formed the sample. Moreover, even in this category, it was undoubtedly clear that some SEP teachers represented what could be regarded as some of the finest science teachers in developing countries. Furthermore, it became evident from the results that the majority of SEP implementers had a great insight into the epistemology underlying constructivism and the process approach and their effects on practice.

In addition, findings from interviews with elite policy-makers within SEP and outside it also suggest a general agreement from the majority of informants about the need for a curriculum that comprises the core or common aspects of science for all children while accommodating optional aspects that allow for regional and local needs. According to this view, the core should comprise certain aspects of science that every child needs to be exposed to in South Africa while the options would cater for the local or provincial needs (Par Org (a); NGO (d); Sci Ed (e)). An argument in support of the core and options in the science curriculum was that the latter should be based on the needs of the regions. Further that the interested stakeholders in education in the provinces and regions should be given a choice as to which of the options they would like to have included in their respective syllabi in response to their local needs (NGO (e)).

5.5.2 The Research Development and Dissemination model

Findings from interviews with SEP staff reveal some regional variations with respect to models and strategies adopted to disseminate the project's innovation and change. The dominant model in the Eastern Cape region according to the research results, was the

Research, Dissemination and Development model (RD and D) which exhibits the influence of centre-periphery approach. In this regard, research was undertaken by a few curriculum developers in science at the centre and the results thereof were disseminated to the other regions (Rogan 1976 (b); Macdonald 1989; SEPB (a); Sci Ed (j)).

Furthermore, the majority of science educators and elite policy-makers with in the project argued that the 'package' approach and the centre-periphery models were appropriate because SEP teachers were inadequately trained in South Africa. A concern raised in respect of this model was that SEP teachers often experienced a problem in implementing a project whose philosophy was developed without their input (SEPB (a); Sci Ed (b); NGO (e)).

The researcher concluded that the strategy of disseminating innovation and change through the RD and D and the centre-periphery model by the change agents was raised as an issue, by only two policy-makers. This thus represented an isolated case.

The main argument in this regard was that innovation and change in science curriculum development is likely to succeed if it is discursive in nature. The idea was captured in this way: *"there should be a shift from changing the structures to recognizing the power of discourse and language in shaping people's realities and practices"* (NGO (g)).

The relevance of the discursive nature of innovation was supported by evidence from interviews with elite policy-makers within SEP and outside it that change agents are likely to succeed in introducing innovation and change if *"they develop sets of concepts, words, stories and an environment in which ideas can become acceptable"*(NGO (g)). An analogy of ecological changes in the environment was used to describe this process of disseminating innovation and change into the system. The idea was succinctly summarized in this way by one of SEP's policy-makers who said that *"change agents*

must always be accompanied by an anthropologist who will help to reconstruct the users' perceptions of the envisaged innovation and change" (NGO (g)). Accordingly, SEP succeeded to disseminate its innovation successfully during its early years of development was that it applied this strategy, though unintentionally in some cases (NGO (a); (d); (e)). The researcher therefore found that SEP disseminated its innovation and change through the teachers, and not by producing a blueprint as was the case with the majority of departments of education.

5.6 THE CURRICULUM DEVELOPMENT AND RESEARCH AND DEVELOPMENT UNITS IN SEP

5.6.1 The role played by the Curriculum Development Unit

The roles and functions of the Curriculum Development Unit (CDU), Research and Development Unit (RDU) and the relationships of these units to the rest of the project emerged from interviews with SEP staff and the analysis of the project's documents as a concern.

Results show that some individuals within the project held a view that the CDU was in charge of developing the project's material and workbooks (SEPN (d); (e); (g)). However, the intention was according to senior staff members with SEP that the latter would be developed in conjunction with the representatives from the various regions to ensure that input from the regions would be incorporated into the revised versions if necessary.

According to people close to the policy-making process within the project, the intention was that the material would be trialed by the CDU on a smaller scale in the neighbouring schools while the trials on a larger scale would be undertaken by staff in the regions themselves (SEPN (e)).

In addition to the official position outlined above, varying perceptions emerged from interviews with SEP's managers and implementers in the four selected research regions in respect of the functions of the CDU. On the one hand, some informants close to the policy-making process in SEP insisted that the CDU did involve the regions because it drew its ideas from workshops and seminars organized for teachers as well as from the implementers and managers to revise the material (SEPN (a); (d); (e)). First, the policy and the official position of SEP was that the CDU was in charge of developing workbooks but did so in close collaboration with the project's implementers, managers and indirectly with the teachers. The SEP Equipment Committee (SEPEC) manager in charge of this process in 1996 revealed that all the regions have representatives who sit on the committee of the CDU, and also that any changes that were brought in were communicated by him to all the regions through their regional representatives. According to results from the analysis of the project's documents the terms of reference of this committee were inter alia to:

- ensure the manufacturing of good quality equipment
- effect the revision of science kit content and design in accordance with the revision of worksheets and development
- maintain a healthy, close and effective relationship with the company which manufactured the kits
- ensure that appropriate research related to design and maintenance of equipment was provided (IMPCO) (SEP 1992).

In view of contrasting perceptions about what SEP Equipment Committee claimed from results discussed above, the researcher concluded that there was a gap between the intentions/policy on the role of the CDU and what was happening in reality. Consequently, the views of SEP's Equipment Committee manager represented the policy while those of SEP managers and implementers in the selected four regions represented the reality. One of these was that the CDU developed the project's materials alone, without consulting the regions and allowing them to make any contributions in this respect. This concern was raised by the project's staff especially those at the implementation stage and the RDU staff eg. GSEP (a); PIETU (a); PIETU (cc).

5.6.2 The role played by the Research and Development Unit

In respect of the Research and Development Unit (RDU), evidence from interviews with SEP staff indicates that the official project's policy was that this unit should serve as a link between the National Office and the regions. An inference drawn from this suggests that one of the functions of the RDU was to support the entire project by *inter alia*, providing the project's managers of the different divisions, implementers and teachers with evaluation of various kinds in order to improve practice. (See IMPCO 1992 on the intended role of RDU) (SEP 1992).

However, results show that the views of some individual SEP managers and those of the RDU unit differed from the official position and, to some extent, represented what was happening in practice. In respect of who controlled the research priorities of the RDU, the perception of the RDU staff in this unit was that these were determined by the Executive Director of the project (SEPN (c); (f); (i)). One of the informants expressed the domination of the research by the Executive Director in this way *"one is unable to develop relevant research priorities because often the Executive Director provides us with a list of areas to research"* (SEPN (f)). However, the official stance negated the perceptions of the staff and held that the RDU staff were actually encouraged to present to the Executive Director research priorities that would have emanated from the staff's involvement with the teachers. Apparently, what the Executive Director did was to formulate the broad terms of reference to guide the activities of this particular unit and not to determine what they needed to do. The guidelines suggest that the RDU team should "*focus the attention of the project on the education system, the teachers and the learners*" (Triegaardt 1994 (b)).

Further that, *"the rationale behind the focus was to inform the project about its praxis in order for it to devise and implement strategies so as to impact on the practice of school science education"* (Triegaardt 1994 (b)).

In respect of the RDU providing the regional managers and teachers with information that would enhance implementation, a view was expressed that the RDU staff seemed to have decided which issues were to be discussed at the implementers' conference (IMPCO) by merely reading books and theories about what might be the teachers' needs and problems (GSEP (c); (e); Sci Ed (g)). One of the project managers was very explicit in asserting that some of the problems outlined above were the result of the lack of communication within the project.

A minority view in the interviews recommended that the RDU staff should interact more closely and regularly with implementers and teachers who are closer to the implementation stage of the project. Accordingly, this process would ensure that issues the RDU staff collects for the IMPCO are relevant to needs of the regions and teachers (Sci Ed (g)). What managers and implementers felt should happen was that the RDU staff should actually choose their areas of research by continuously interacting with the people who have direct contact with the teachers. Further, that the RDU staff should exchange ideas with people at the implementation stage and perhaps recommend some of the material and books that teachers can use (GSEP (c)).

The general perception from the research findings was, therefore, that the RDU was making very little contribution to supporting the managers, implementers and the teachers in tackling problems affecting the implementation of innovation and change (GSEP (a); (e)). Some individuals in the project were of a view that the RDU was ineffective because the unit lacked leadership to articulate priorities clearly and to make it responsive to the needs of stakeholders at the implementation stage of the innovation

(SEPN (e); Sci Ed (g); (h)). This fear was also expressed by another staff member viz. SEP (i) that *"the unit does not have any direction and as a result, it keeps on changing its staff"*.

The researcher concluded on the basis of results explained above that issues relating to the contribution of the RDU outlined so far confirmed the conclusions reached at one of the earlier Management Committee meetings of the project. Areas of common concern included the following: little or no involvement of the different stakeholders in the process of information collection and no attempt to comprehend the development of regions (implementers, teachers and wrong perceptions of RDU).

In respect of the support for the project teachers in the Gauteng region interview results with the teachers recommended that the seminars organized by the implementers should be conducted in schools rather than at SEP's regional office. The rationale was that equipment available in schools can be used for demonstrations rather than using equipment that was only available during demonstrations and not necessarily in schools. The teachers' concern was that often apparatus and the conditions recommended by SEP were different from those found in schools. Moreover, it was suggested by the informants that the project's methodology and other related strategies were likely to succeed if peer groups were used in a workshop but could be a dismal failure in a real situation (GSEPU (bb); (dd); (ee)).

Another reservation that arose from interview results and from SEP documents and which appeared to be a major concern for an individual SEP regional manager was that project workshops and seminars were conducted on an *ad hoc* basis because the level of training of some implementers was not considered. Consequently this created a problem because some of the new breed of implementers had completed only post-matric training in science and often did not possess the necessary skills and knowledge of science

teaching. It appeared problematic that the project did not have modules that could be used in workshops on content and methodology. One of the informants expressed misgivings about the nature of workshops organized for teachers (GSEP (e)).

Results especially from interviews with policy-makers familiar with the SEP project suggest that the lack of coordination among the various structures within SEP was the major impediment to successful implementation. In this regard, indications were that there were some uncertainties regarding policies between the researchers and the project implementers and that the CDU and the RDU seriously undermined genuine curriculum development and change processes in science.

In particular, one of the informants observed that there was confusion between the roles and functions of the CDU and the RDU. It was argued in this respect that such a confusion of roles impacted negatively on the implementation process. According to this view *"the CDU was actually not developing the curriculum as it was generally believed"*. Ideally, *"the CDU was to be more of a curriculum support for materials development"* (Sci Ed (a)). Accordingly, the task of developing the curriculum should have been given to the RDU and other structures closer to the implementation of innovation such as the regional managers, the project's implementers and the teachers.

In the light of such perceived undefined roles and functions, results suggested that the RDU should be responsible for developing the project's curriculum material provided by the CDU while the RDU was to enhance curriculum development by supporting the whole group by conducting internal evaluations which would then indicate the needs in SEP schools. Also that, by being closer to practice, the RDU unit would provide qualitative research and ensure that continuous formative evaluation was taking place in order to guide practice.

On the communication between RDU and the implementers, a view was expressed by the implementers that there was better communication at local level, including the implementers' conferences (IMPCO). However, a concern was raised by this group that many people at the implementation stage saw the RDU and the CDU as too far removed from the rest of the project people and that they considered themselves as superior to the rest (Sci Ed (g)). The position of elite policy makers who had knowledge of SEP in this respect was articulated in this way: *"It would be very helpful following the data to have an overall document, a policy document about what research and development would be doing for SEP and the determination of goals and priorities"* (Sci Ed (g)). Also *"as an organization, I think what would be very helpful would be an overall document, a policy document about what research and development is going to do for SEP"* (Driver 1993, part 5). The relationship and perceived lack of communication between the CDU, RDU and the SEPEC that existed when this investigation was written are better explained in the relationship building exercise organized by SEP (MANCO 1992).

5.6.3 Consultative Committees in the project

Results of the analysis of SEP documents and records and of interviews suggest that the Consultative Committees played a major role in the 1980s when the project was still working alongside the erstwhile education systems (NGO (b); Priv Sec (c); DON (f)).

However, it was suggested in the result that the success of these committees was largely determined by the quality of support they received from the various education authorities. This view was endorsed by some sentiments expressed by SEP policy-makers and donors to the effect that one could have as many committees as one liked, but that if the education authorities did not want to cooperate, there was nothing anyone could do (SEPN (j); (h)). It also appears that Consultative Committees were important strategies for getting input from local stakeholders provided the department was

agreeable to their activities (SEPIM (b)). Further, results of interviews with SEP staff indicate that one of the major problems that emerged was the general non-representation of stakeholders in the project in the region. The problems of the non-attendance of the ministries of education (old and new) was apparently more acute in the Gauteng regions (Sci Ed (i)) and the general attendance of stakeholders was so poor sometimes that nothing came out of these meetings (GSEP (e)).

However the emerging picture suggested some variations relating to the impact and contribution Consultative Committees were making in dissemination and implementation of innovation and change in the four regions. While in some regions the Consultative Committees apparently played a role in facilitating implementation, their impact in other regions was totally ineffectual. The lack of commitment of members of the Consultative Committees and especially absenteeism emerged as major factors that impacted negatively on the role of these committees.

The conclusion arrived at by the researcher in this regard was that, while the intention of the SEP National office was to create Consultative Committees give advice to the manager and implementer in implementing projects, the consensus reached by the minority of informants in the regions was that these committees were playing a minimal and sometimes insignificant role in this process.

5.7 SEP'S MODEL OF INSET

5.7.1 The nature of the model

Results from interviews and from the analysis of SEP documents and records reveal some variations in respect of interactions between the teachers and the project implementers in designing INSET programmes. The findings also indicate that in some cases, the variations were a result of misperceptions held by SEP staff about what was actually happening about the project's work. Some teachers in the four selected research

regions were of the opinion that the content of their INSET was top-down because it was decided by the implementers. However, some project managers and implementers expressed a contradicting view that decisions on the content and nature on INSET for teachers was bottom-up. According to this view, such programmes were finalized after implementers had visited schools and had asked the teachers about what they wish to be included in the INSET programmes. This view was endorsed as follows: *"we as teachers decide the content of the INSET in forums where we discuss issues which are then forwarded to the implementer"* (GSEPU (aa)). The latter position was reiterated by another teacher who pointed out that their INSET courses were decided by themselves after consultation on discussions of their common problems. Implementers had this to say on the matter: eg. SEPPIETU (bb) *"we require the teachers to tell us as implementers problems on either content or methodology that should be discussed at our INSET workshops"*(SEPNW (a); SEPEC (c)). The researcher in this regard found that the users' participation in the design of INSET workshops differed from region to region.

5.7.2 The role of the project's implementers and the teachers in SEP's INSET programme

The results from interviews indicate that the teachers were apparently encouraged to identify needs and problems in different schools in a cluster and these were then passed on to the implementer who organised INSET courses. However, it became apparent in some instances that the implementer did take the initiative with respect to the content of the INSET on the basis of his/her visits to schools and through observing lessons on the section of the syllabus. Furthermore, the implementer's initiative in respect of the content of the INSET was justified on grounds that some teachers were inadequately trained especially in the sciences.

Contrary to the perceptions of some teachers that they were not sufficiently involved in determining the nature of SEP INSET, the results of interviews show a general pattern from implementers in the selected four regions suggesting that this process was a joint effort between the teachers and the project implementers.

However, probes in the interviews with the teachers also warned of a tendency by implementers to assume that all the teachers were familiar with the content when this was not always the case. In such cases, it was pointed out that the implementers concentrated on methodology in their INSET programme and overlooked the content of science eg. GSE (gg) "*90% of the science content is sacrificed in favour of method. Furthermore, one teacher complained that they were teaching 'skeleton' content to describe that they were not themselves always sure of what they were teaching as a result of their pre-service training*" (SEPPIETU (dd)).

Results from interviews with SEP staff of the analysis of the project's documents and records suggest that one of the strengths of SEP's INSET intervention was the use of the project's implementers. Accordingly, SEP's INSET strategy included: workshops and seminars arranged by the implementer and regular visits to schools by the implementers. One of the influential informants within SEP captured the prevailing view about the prominent role INSET played in educational innovation when he asked that: " *the new education authorities should give proper recognition to the INSET needs of teachers*". The general feeling of the majority of informants in respect of this issue was summarized in this way: "*I think SEP is one of the brightest of the projects when it comes to models of INSET and I hope it will continue with its activities in the new dispensation*" (SEPB (b)).

Interviews with SEP staff, elite policy-makers, the project's documents and records endorse the opinion that the project teachers had developed such a good rapport with the implementers that there was little resentment on their part when the implementers advised them on the lessons presented. In this regard, results therefore suggest that the rapport seems to have been developed long ago when SEP was still servicing fragmented departments of education during the Apartheid era and was regarded as an alternative to the science curriculum provided by the then Department of Education. Interview results with the teachers themselves in the four regions in 1995 suggest that SEP implementers still enjoyed support when compared to the subject advisors. This claim was endorsed by comments from informants in the various regions eg. "*Implementers are very friendly and assist us with any problem we encounter in the classroom*" (SEPPIETU (dd)). Also: *"Our implementer is very concerned about our work and always ensures that we have the necessary science kits and material*" (SEPPIETU (bb)) and, *"Implementers do not visit schools to police us but to help us improve our performance in the teaching of science*" (SEPNW (cc)). Proponents of this viewpoint were of the opinion that teachers would benefit even more from INSET if they were provided with a manual or a guide containing topics to be discussed at workshops and seminars two to three weeks before the time.

There was also unanimity in the interview results and from the analysis of SEP documents and records indicating that factors such as teacher turnover, overcrowding, random change of science teachers etc. was clearly incompatible with the INSET model which involved the grouping of a small number of schools into what came to be known as a 'cluster' under the guidance of an implementer. The project's cluster model for INSET appeared to have serious limitations especially in rural areas where the majority of the teachers were poorly qualified and schools were sending a great number of their teachers to SEP's workshops. In addition to some reservations about the cluster model, some individual informants in the project argued that the impact of the model was never

evaluated eg *"the outcome or impact of our INSET programmes has not been evaluated to establish why the teachers would continue with SEP's intervention"* (GSEP (e)). Fears about continuation with the cluster model of INSET were expressed more prominently in the Gauteng region eg. GSEP (e) *"The ministry is worried that SEP has been serving Black schools and prefers that it should now service all schools and that the number of schools allocated to an implementer be increased substantially. So the cluster model of SEP INSET is under threat"*. Thus, the researcher concluded that SEP's INSET model was going to be affected by the general restructuring of the education in the provinces in South Africa.

The provision of adequate and effective INSET especially for science teachers emerged as one of the major themes in any effort to improve the teaching of science. One of the informants captured the prevailing belief about the continual need for INSET as a policy in science education when he said: *"proper recognition must be given to INSET needs of teachers, and if you want good science education, then you've got to support it— we need a more localised and in-school support from the department"* (NGO (d)). In this respect, the notion of INSET as part of all teachers' professional practice emerged clearly. The justification of INSET in the context of improvement of the teaching of science was based on the fact that the training of teachers in some colleges was totally ineffective.

The results of interviews also indicate some consensus that, despite the limitations of INSET in changing the situation relating to science teaching, these programmes were the only options left in many countries where the pre-service training of the teachers is inadequate (NGO (c)). However, results also reveal a concern that was raised by some informants that the tendency to neglect a pre-service component of teacher training with the hope that this could be compensated for by INSET is problematic. To counter this trend, a shift towards pre-service programmes was recommended as a strategy for

breaking the vicious cycle of producing ill-trained cohorts of science teachers hoping that INSET would remedy the problem. Moreover, a concern was raised by some informants that there still is much talk about implementing an INSET programme for science teachers but that there are some serious doubts about whether the present government South African government will ever achieve this goal. In view of the current state of science teachers, the extent to which the government was committed to upgrading of them arose as a major concern.

The researcher concluded on the basis of results from interviews and of the analysis of SEP documents that policy-makers who were familiar with SEP's idea of 'project implementers' as part of INSET and support structures felt that such an arrangement proved to be very effective in the past. In this respect reference was made to a model where a small number of teachers in some schools are placed under the guidance of qualified and experienced science teachers whose task it is to provide support for the teachers in the area rather than relying on the traditional subject advisors.

5.8 EVALUATION

5.8.1 SEP's policy on implementation of innovation and change

The conclusion arrived at by the investigator from the results is the need to rethink ways in which innovation and change is introduced into the education systems. This observation substantiates evidence from elite policy-makers in and outside SEP, from the analysis of the project documents and records and the literature, eg NEPI (1994).

The investigator concluded that SEP unintentionally made use of a discursive approach to curriculum development to introduce itself into the education systems in the 1970s and 1980s. It appears that the project introduced its innovation and change by appealing to the value system of the users and modified its strategies and language in such a way

that its innovation and change was understandable to the users and was within their own everyday experiences. By adopting a discursive approach to curriculum development, SEP managed to disseminate its innovation and change successfully even during the repressive years of the seventies and eighties by appealing to the stakeholders' realities and practices.

This case study further confirms an assumption that an approach to policy formulation that takes as its premise broad participation where issues are drawn from practice, is more likely to be supported than one handed down from the top and which has been decided *a priori*.

The discursive construction of realities from practice adopted by SEP is consistent with grounded theory, which guided the study. The conclusion drawn therefore is that the introduction of innovation and change should be based on an anthropological paradigm and its methodology and strategies.

5.8.2 SEP's innovation and change in science education

The investigator concluded from the analysis of SEP's documents/records, questionnaires and interviews with its staff, as well as from policy-makers, that the current democratically elected government is morally obliged to provide quality basic science education, which this research endorses. It also emerged from these analyses that policy on the provision and delivery of science education needs to be clarified. The research further revealed the need for users to understand the aims of innovation and change if the change agents hope to achieve their intended goals of such innovation.

The investigator also concluded that the features of innovation and change as outlined in the literature are problematic in practice. Results from the various sources and the literature reinforces the findings of research conducted elsewhere that sustained-

implementation of innovation and change should be analysed in terms of the level of use.

Consequently, the investigator is of the opinion that an evaluation of SEP innovation and change should be analysed in terms of the phases of innovation as proposed by Fullan and McLaughlin (1975); Giacquinta, (1973); Gross et al. (1971) and supported by evidence from interviews with informants. Moreover, the suggested framework enhances the evaluation of the implementation of the project. Consequently, results of this investigation regarding this issue support the theory that the initiation of SEP in older regions such as the Ciskei, Pietermaritzburg and Transkei, does not imply that the project became part of the education system (see Giacquinta 1973; Berman and McLaughlin 1975; 1978; Hall et al. 1975).

The conclusion drawn in this regard is that the current analysis raised doubts about beliefs that the existence of one stage of innovation will not automatically lead to the realization of the next.

5.8.3 The pre-package approach in curriculum development

The investigator reached the conclusion that the 'pre-package' model of curriculum development, similar to the one adopted by SEP in its early days of its development, was justified, and that it still has a place in conditions where the teachers are inadequately trained. This view supports the literature (Rogan 1976 (b); Macdonald 1980; Bateson 1995) and evidence from the project's documents/records and from informants in and outside the project.

However, it seems important, at least for the curriculum developers in science, to be aware of the philosophy underlying an innovation and especially its implications in practice. Moreover, it is important for the evaluators of an innovation to examine both the intended and unintended consequences of their findings for practice.

The sentiments expressed above had three policy implications for SEP. The first relates to the unintended negative outcomes of the 'package' approach. The second, relates to the apparent emphasis on the 'how' with very little regard to whether the teachers, and in some cases the implementers, understood epistemological assumptions underlying the 'package' approach. The investigator's view on the intended and unintended outcomes of the 'package' approach has implications for curriculum development and the implementation of innovation and change.

The policy implications of the centre-periphery model were *inter alia*: underplaying the importance of input from implementers and especially teachers who were concerned with practice; ignoring variations that were the result of factors in a particular context; and the lack of trialing of material in a real situation which sometimes led to unsupported generalizations.

5.8.4 Research Development and Dissemination of innovation and change

Results from interviews and analysis of SEP documents and records suggest that, like the 'package' approach, the Research Development and Dissemination (RD and D) approach to SEP's innovation and change had a special place during the early days of its development. The RD and D approach was apparently adopted because the teachers during that time did not possess the kind of training that would have enabled them to participate meaningfully in the process of curriculum development at least in the erstwhile Ciskeian environment, where science teaching was even worse than that in urban areas. However, the case study highlighted the limitations of RD and D in disseminating innovation and change. The negative impact RD and D may have on the implementation of innovation and change is supported by research findings and theories proposed by authors such as Stenhouse (1975); Schon (1971); Dalin (1978) as well as evidence from informants of SEP.

Results from the literature review and analysis of the project's documents and records indicate that some elite policy-makers who were instrumental in the development of the project's policy in the 1980s, point out that in fact SEP employed not only the RD and D approach, but also the discursive approach to disseminating its innovation and change. The findings suggest the appropriateness of discursive strategy in disseminating innovation and change. The latter view explains why the project managed to survive during the repressive education environment in South Africa. However, it appears that RD and D will continue to be a dominant model of disseminating innovation and change in the new dispensation in South Africa at least for some time to come.

5.8.5 The role of Curriculum Development and the Research and Development Units in the project

The researcher concluded on the basis of evidence from interviews and SEP documents and records that there was clearly a lack of clarity on the roles of the various structures within SEP and this indicates the problem of a common mismatch between policy and what was happening in practice. In this respect, perceptions/misperceptions of what ought to happen and what was happening regarding the roles and functions of the various structures emerged as important considerations in understanding the curriculum development process. A relationship-building workshop for the CDU and RDU held in 1995 is a classic example of the impact of perceptions/misperceptions on the implementation of innovation and change. Specific sources of these perceptions identified by the implementers at their various workshops and actions that were to be taken clearly demonstrated that very definite policies on CDU existed. The only problem according to the research findings was the lack of implementation of intended policies. The view expressed here is substantiated by the findings from the project's external evaluator in 1995 (Bateson 1995).

Further, it was concluded that it is important that the teachers become committed to a particular innovation, that they should identify themselves with it and should see the need to get involved with it. Secondly, it was also concluded that greater attention should have been given to formative evaluation conducted by the users and teachers, and that results should have been fed into the SEP National level so that policy could have been improved. The implication of the latter is a move towards action research aimed at supporting implementation of innovation and change in education.

5.8.6 SEP's INSET model

The conclusion reached by the researcher is that despite some criticisms about improving the teaching of science through INSET, this sector remains, and will remain, an important aspect of teacher development and teacher empowerment. However the demand emerged clearly from the results for a more school-focused INSET model as opposed to the traditional approach of organizing these programmes centrally. From the researcher's point of view, the conclusion that INSET remains an essential feature of teacher development and empowerment as was the case with SEP, is reinforced by the literature in general and in SEP's notion of an implementer who works and assists the teachers with their day-to-day problems is clearly one to be emulated. The model of allocating a few schools to an experienced implementer in science proved to be far superior to the one where the traditional subject advisor is given a large area in which to advise the teachers. However, even under this arrangement, it is crucial that the content of these INSET programmes be determined by the needs and aspirations of the teachers. The views of the implementers and of the teachers themselves confirm the value of SEP's INSET model.

Despite the insistence that INSET is part and parcel of empowering teacher development, it became clear that pre-service training needs urgent attention. Pre-service training is justified on grounds that it will lead to breaking the vicious cycle of poor teachers, and hoping that INSET will remedy this problem.

5.8.7 Implementation of policy in science and technology

The popular notion of developing an integrated science and technology curriculum surfaced in the 1990s as part of restructuring the entire education system. Consequently, the policy on the science and technology curriculum did not exist during the time when SEP was still very strong with its intervention strategy. Furthermore, the policy did not exist when this investigation was undertaken.

The majority of informants rightly observed that SEP could not begin to become involved in decisions when the policy in this regard did not exist, and when its overall motive was to fill in gaps relating to specific needs not fulfilled by the then departments of education. In other words, SEP was created for the specific purpose of introducing innovation which the then education departments could not provide.

Notwithstanding the fact that SEP could not develop the science and technology policy on its own initiative, such an integration is clearly viewed as an important ingredient of the process of refocusing science and technology which is crucial in the economic growth of a country eg. Priv sector (a); (b); NGO (h); Sci Ed (j).

5.9 SUMMARY

This chapter explored the following aspects relating to models of curriculum development, innovation and change in science education adopted by SEP:

- The models of curriculum development, innovation and change used to introduce SEP to the education departments were explored. It was concluded that SEP adopted a discursive approach to introduce itself to the education departments in the four selected research regions. The success of the project was therefore attributed mainly to the adoption of this approach.
- The aims and objectives of SEP's innovation and change were analysed. The aims and goals were examined and the various interpretation within this debate was discussed.
- The phases of innovation and change in the project were analysed. This section explored the phases of SEP and how these phases differed from one another.
- The package approach and the Research and Dissemination and Development strategy were discussed. This section explored SEP's package model and sought to justify these models and strategies.
- SEP's model of INSET was analysed and evaluated. Specific themes examined in this regard were the role of the project's implementers and the nature of the model. SEP's 'cluster' model of INSET was analysed and its strengths and weaknesses pointed out. The implications of the 'cluster' model in the new education dispensation were discussed.
- The last section of the chapter was devoted to the evaluation of the issues raised in the chapter.

CHAPTER SIX

THE LEARNING AND TEACHING OF SCIENCE IN SEP SCHOOLS

6.1 INTRODUCTION

The preceding chapter explored issues relating to innovation and change in the context of SEP's work in the four selected research regions. Chapter Six examines the learning and teaching of science primarily relating to SEP's work in the four selected regions. Since the study focuses on the development of SEP from its inception in the 1970s to 1995, some of the discussion in this chapter reflects the position during different times in the project's development.

See Chapter 5.1 on the procedures followed to analyse data in this chapter. Photographs taken during lesson observations were incorporated in the text order to exemplify the data on teacher-pupil activities. Themes, trends and data on lesson observations, as well as the sources of data are represented in table form (Table 15).

RESEARCH QUESTION TWO

How was the learning and teaching of science conceptualized in SEP?

Table 15: Themes and trends explored in Chapter Six and sources of data

THEMES AND TRENDS	SOURCES OF DATA
SEP's methodology was generally used in schools that were supplied with the project's kits and apparatus	- classroom observation and photographs - interviews with SEP implementers in general and in the four research regions, interviews with SEP teachers and evidence from SEP's external evaluator - SEP documents and records
The expansion of SEP into newer regions put strain on its resources	- interviews with senior SEP staff, members of the Board of Trustees and donors, science educators in SEP
Locus of control in SEP classroom revolved around the teacher	- classroom observations and photographs - interviews with SEP implementers, interviews with science educators in the project
Portable SEP science kits were, and still are suitable for disadvantaged conditions in South African schools	- interviews with elite policy-makers within SEP, interviews with SEP implementers, teachers - classroom observations
The process and constructivist approaches were followed by SEP	- interviews with past and the then current Executive Directors, SEP implementers, teachers in the four regions - SEP documents and records
Some informants felt that the process approach was followed while others felt that it was the constructivist approach	- interviews with past and the then Executive Directors, SEP mangers and implementers, elite policy-makers and science educators within SEP
Classroom observation affirmed results of interviews and analysis of SEP documents	- Classroom observations and photographs - interviews with teachers
Teacher-pupil interactions in SEP classrooms	- classroom observations - interviews with the teachers
Photographs in lesson observations exemplified data from other sources	- class observations - photographs
Teacher demonstrations dominated most of SEP classrooms	- classroom observations - interviews with the teachers - photographs
Practical component of science was associated with teacher demonstrations in SEP classrooms	- SEP documents and records - interviews with SEP Equipment manager, science educators within the project and teachers - classroom observations

6.2 IMPLEMENTATION IN THE CLASSROOM

6.2.1 SEP methodology

The purpose of this section of the research was:

- to establish whether project schools and teachers were doing what SEP intended them to do
- to explore and discuss any evidence or lack thereof that SEP teachers were using the material
- to examine how practical work within SEP's approach was actualized.

The results from interviews with elite policy-makers within SEP, Executive Directors, managers and implementers suggest that the intention of SEP developers was that the teacher should facilitate the learning process while the pupils take an active part in it. It was further indicated that the pupils themselves were actively involved in experimentation sometimes in pairs, but mostly in groups of about 6 or 7 learners.

Furthermore, individual SEP staff supported the view expressed in SEP documents and records that project teachers were performing experiments and that science was clearly linked to life experiences (SEPNWU (ff)). One pupil had this to say about the issue: "*Before the introduction of the project, it was difficult to understand what the teacher was saying, but now it is clear, because we are in a position to see and experiment what we are told*" (Macdonald and Rogan (1981:354); (GSEPU (ff)). The perception that SEP pupils had a better understanding of science and that the project teachers had developed innovative strategies to teach the subject were reiterated as follows in one of the interviews: "*I have seen pupils in SEP schools working on the material and understanding the content*". (Sci Ed (g)). Further, results from an external evaluator of SEP suggest that SEP teachers did teach science differently when compared with those

who were not exposed to SEP methodology (Sci Ed (g)). Non-SEP teachers were reported to have taught science theoretically. One informant who has had a great deal of experience with the project confirmed the sentiments in this way: "*I found plenty of evidence that teachers were doing practical work in classes— I used to visit schools unannounced and the teachers were happy to see me*" (SEPPIETU (gg)). These statements strengthen a generally held view that SEP teachers were committed to using the project's methodology and principles even when the project implementers were not present.

The view expressed in the interview results from SEP staff that teachers who were trained in SEP methodology were teaching differently from those who were not was supported by photograph No 5 showing the teacher conducting a demonstration while pupils observed.

The researcher came to the following conclusions relating to the issues raised above:

- Although there was frequent interaction between project teachers and the pupils, teacher demonstration tended to dominate most lessons.
- SEP's positive intended consequences regarding the training teachers in the SEP methodology were indeed evident.
- Teachers developed positive attitudes towards science and they taught the subject in a practical way when compared with non-SEP teachers. The perceived quality of SEP teachers and their apparatus was described in this way by informants whose view represented the majority within the project, "*SEP teachers use a unique science education package implemented through non threatening classroom intervention strategies as well as through the support from the implementers*" (SEPIM (b)).

However, the researcher also came to a conclusion during a cross-comparison of teachers' responses that although SEP teachers were aware that pupils themselves had to do experiments, it was not always possible to afford them this opportunity because of insufficient science equipment and kits. The implication of this was that teachers were often forced to rely exclusively on demonstrations. One informant (SEPPIETU (gg)) illustrated the extent of this frustration as follows: "*I ought to be involving the children with experiments, but I have to do them myself*" (Sci Ed (g)). Notwithstanding inherent limitations of teacher demonstrations, results suggest that the project teachers had developed a positive attitude towards science and were teaching it as practically as possible using special worksheets. On the basis of results provided above, the researcher came to a conclusion that the evaluation of the practical component of science was a major problem.

Lastly, the researcher drew a conclusion based on results that there were some consistencies between SEP's intention and what was happening in practice and that the teachers' roles should be limited to that of facilitators of learning while pupils should actively be involved in the *doing* of science. These observations were further supported by photographs 5 and 6 which demonstrate the types of skills the pupils were practising in SEP classrooms. The researcher also found out that for some project members, the *doing* of science meant demonstrations by the teacher with pupils observing while for others it meant *pupils doing* experiments, teachers asking higher order questions and teachers involving pupils in practical work (see Macdonald and Rogan (1981) on the issue of doing science as proposed by SEP).

6.2.2 Different views on the expansion of SEP

Two proposals relating to the expansion of SEP emerged from the interview results with the project's Executive Directors, donors, elite policy-makers in the project and its members of the Board of Trustees. One of these espoused by several informants closer to SEP National was that the project should concentrate on standards 6, 7 and 8 and should not expand its operations to standards 9 and 10 and into other new regions. This view was articulated in this way: SEPB (d) "*there is a great danger of the project becoming bigger as this might mean stretching its limited resources too thinly*". The view was supported by another informant who argued that SEP should not expand but that it should limit itself to standards 6, 7 and 8 and service them very well (Sci Ed (g)). The other reservation concerning the expansion of SEP related to the then system which controlled the matric science syllabus. Such an examination-driven education system was perceived as being in opposition to SEP's philosophy by many informants while it was also pointed out that expansion into standards 9 and 10 and into newer regions was going to lead to inefficiencies and ineffectiveness of the project (SEPB (c)). However, the researcher also found that a few of the project members were of the opinion that the project needed to expand to standards 9 and 10 as there was a great demand in these standards.

6.2.3 Locus of control in SEP classrooms

Two major arguments concerning the control of the rate of learning and the content to be learned arose from results. In this regard, the majority of informants within SEP were of the opinion that the rate of learning and the content to be learned in SEP's classrooms was theoretically controlled by the pupils themselves. According to this view, the role of the teacher was to be that of a facilitator of learning while the pupils were expected to be actively involved in learning. The minority argued that these processes were controlled by the SEP programme itself and the teachers.

Another view held by a few individuals suggests that the 'package' approach followed by the project indirectly controlled the rate of learning and the content to be learned. In this view, the 'package' comprising science kits, material and worksheets controlled these processes through its step by step approach to the learning and teaching of science.

The findings from interviews with SEP staff and classroom observations highlight the nature of interactions between teachers and learners in SEP's classrooms.

6.2.4 Portable science kits versus formal laboratories

The majority of SEP staff were of the opinion that the project's material and kits could not and should never be replaced by formal laboratories. However, the reasons why SEP kits should not be replaced varied. Some felt that the apparatus could not be replaced because it was, and still is suitable for the conditions in the majority of schools in South Africa and for the standard of training of science teachers eg. SEPIM (c) "*SEP kits can still be used alongside formal laboratories because they are user-friendly for individuals and especially for group work*". In support of the claim, some of the informants were of the opinion that the project's kit would continue to be used because the scarcity of existing laboratories meant that few learners could ever have access to such a facility (SEPIM (h)). The majority of the teachers further argued for the continued use of portable science kits because it is convenient to carry them from class to class (GSEPU (aa)). They also pointed out that portable kits were suitable in instances where a school has many science teachers who do not have the opportunity of using the laboratory. Accordingly, a laboratory in the latter case would be reserved for standards 9 and 10 while the junior classes used SEP kits (SEPPIETU (bb)). However, there was also a view held by a minority that the portable kit can be dispensed with as soon as formal laboratories are built (see Photograph 1 which confirms the view

expressed by the majority of SEP staff members that the project's kit could be used perfectly in the laboratory).

A related issue that emerged from interview results with SEP staff was the effects of learning science in groups or individually are whether there are any differences in learning science in laboratories or in SEP's classrooms. Results in this regard indicate varied responses relating to the issue of individual versus group work. One of the project teachers whose view represented the majority of the informants in SEP argued that it depends on the lesson and individual pupils because some pupils learn better individually while others learn better when they are in a group (GSEPU (cc)). Similarly, interview results show varied responses to the question of whether pupils learn more effectively in the laboratory of in the classroom. Some believed that pupils learn more effectively in the laboratory because of the atmosphere in a laboratory. The other teacher pointed out that he prefers to teach in the laboratory but using SEP kits because of the learning atmosphere created in it (SEPPIETU (hh)).

On the basis of results from interviews, the researcher concluded that:

- SEP's portable kits and materials are suitable to the conditions that characterize most schools in South Africa, e.g. in most schools, one of the classrooms has been converted into a science room for all the classes (see Photograph No 2).
- the project's portable kits and materials are ideal in situations where there are many science teachers who may want to use the laboratory at the same time.
- the limited number of SEP science kits provided by the project has an unintended benefit of promoting group work, thereby encouraging greater pupil involvement and participation (Photograph No 6).
- in view of the shrinking budget to education and expanding enrolment, it is cost-effective to continue to use portable science equipment in schools.

In addition, results of interviews indicate some misperceptions held by some teachers with respect to the science kit used by SEP, some of whom complained that the science kit made of plastic was unreliable when experiments were conducted. Individual informants therefore complained that because of the poor quality of equipment, they were not at all comfortable using it (SEPU (ee); SEPIM (f)). SEPU (ee) expressed his concern about the quality of these kits as follows: "*I really don't trust these new kits because they are made of plastic and are therefore unreliable*". Further one of the informants claimed that SEP materials used in 1995 was the same as that used in the 1980s. This perception was disproved by results from interviews with senior SEP staff showing that some worksheets were constantly revised and that some were in their fourth or fifth edition in 1995. The progress report by the SEP Equipment Committee Manager in this regard indicates that the committee had already taken up a number of issues with the manufacturing company in respect of:

- improving the quality of science kits in schools.
- addressing several complaints from the regions such as: 're-magnetising' weak magnets and compass needles, attending to test tube racks which were not aligned with the base board etc.

The researcher concluded that issues of the quality of SEP equipment raised above highlights the problem of a mismatch between the policy of SEP National and some individuals at the implementation stage of the project's innovation and change. The official position on the issue was that such a concern had been communicated to the manufacturer some time previously and he had subsequently requested that all unsatisfactory equipment be returned to Head Office and new correct ones be distributed to the regions. However, in view of the fact that intentions and official policy often take a long time to diffuse into the system, some regions and individual project members in 1994/95 were still in possession of the old equipment long after these had officially been withdrawn.

6.3 APPROACHES ADOPTED IN SEP CLASSROOMS

6.3.1 The process and constructivist approaches followed by SEP

According to interview results and SEP documents, the majority of the 'old' (first) generation SEP staff argued that the project was guided by the inquiry-based learning in the early stages of its development. However, the project's staff members interpreted inquiry-based learning differently and it was therefore known as the process or hands-on approach (Rogan 1976 (b)). In addition, results from SEP documents and records compiled by what could be called the 'first' generation in the project suggest that the process approach guided SEP during its earlier years (Rogan 1976 (b)). Further, interviews with the 'second' and the 'third' generation of SEP in the 1990s especially those at the implementation stage pointed out that the project was still guided by the process approach. Some informants closer to the project argued that SEP had its roots on the process approach to science education prevalent in the late 1960s, 70s and 80s (Thorne 1993). In this regard, it was pointed out that SEP followed this approach because its worksheets encouraged hands-on achievements. However, results of interviews with senior SEP staff suggest a gradual shift away from the process approach to constructivism as the guiding principle of SEP's activities in the 1990s. A move towards constructivism was initiated at the implementers' Conference (IMPCO) in 1993 and the training of SEP personnel on the process and constructivist approaches were funded by the British government. During this period, some 150 teachers, implementers, RDU and National office staff and Regional managers undertook training, some to Masters level on science education a Leeds University (see Driver 1993; Driver, Towse and Wood-Robinson 1993; Khumalo 1992; Thorne 1993).

However, results from classroom observations and from interviews with some of SEP managers and implementers indicate that the project was still following the process approach in 1994/1995 during the writing up of this investigation. Some project managers pointed out that they had been using constructivism all along and that the only change was that this approach was subsequently given a new name (GSEP (e); SEPN (e)). The majority of the informants subscribed to a view that there is no difference between the two (GSEP (ee); SEPN (a); SEPN (g)).

Regarding the differences between the process and constructivist approaches, the researcher found that, SEP's methodology continued to be guided by the process approach. This view contrasts with the one expressed by SEP staff closer to policy-making that the project was guided by a constructivist approach. Further, the researcher concluded from the literature review that the differences between the process and the constructivist approaches relate to assumptions underlying each as described below.

6.3.2 Educational implications of the process and constructivist approaches

Results of interviews and analysis of literature indicate that the process and constructivist approaches have important implications. It was suggested in this regard that both approaches are essential for meaningful teaching and learning of science (Driver 1993; Driver and Bell 1986; Novak 1988; Scott et al. 1987).

The results of interviews with elite policy-makers within the project indicate that it is
useful that the teachers should have a deeper understanding of these approaches because they have to adjust their methodologies accordingly. The belief that knowledge of epistemological differences between the process and the constructivist approaches could help the teachers to review their methodology was articulated by one of policy-makers within SEP as follows: "*Both the teachers and curriculum developers in science must have an understanding of the constructivist approach and how it might affect teaching and learning*" (Sci Ed (g)). The constructivist approach was defended on grounds that in addition to suggesting maximum pupil involvement in the learning process, the approach also takes cognisance of the content to be learnt and the notion of students' prior knowledge inherent in it.

Regarding the question of whether the project was guided by the process or the constructivist approaches, the researcher found out that even though there was a gradual shift towards a constructivist approach by senior SEP staff, this shift was never apparent in practice. It appeared that this shift was never recognized because the two approaches share certain fundamental features such as 'hands on' work even though this means different things in the two approaches.

In addition, interview results further reveal some concerns about the notion of prior knowledge inherent in the constructivist approach. As far as this issue is concerned, it was argued that the so-called prior knowledge may in fact reinforce conceptions (misconceptions) in the learning and teaching of science (GSEPU (ee)).

The researcher concluded from the results that despite an appeal to involve pupils maximally in the learning of science, most teachers still dominate lessons. Consequently, the idea of following the process or constructivist approaches in order to allow the pupils to understand science better failed because teachers never stood back and reflected on their own practice.

6.4 TEACHER-PUPIL INTERACTIONS IN SEP CLASSROOMS

6.4.1 Variations of teacher-pupil interaction in SEP classrooms

The lessons were observed and analysed in terms of two indicators. The first indicator was the frequency of occurrence of a particular activity. The second was percentage time spent on each subsidiary category.

The data derived from these observations have been presented in tabular form (Tables 16 to 23). Two sets of tables are presented. In the first set of tables the first column of each table designates the percentage of time spent on a category (process skill) and its subsidiary categories in a lesson. The second column contains percentage of time spent on 'within' as suggested in the observation schedule. See Lewin's original observation schedule in Appendix 7.

The second set of tables reflects the distribution of observations on a teacher/pupil centred scale. A summary of lessons reflecting the distribution of observations on teacher/pupil centred scale has also been presented in tabular form (Tables 20 to 23).

Results of classroom observations suggest some variations of the time spent on each lesson on the 'overall' and 'within' activities in the observation schedule. 'Overall' activities in the context of Lewin's schedule which was used in this study refers to the time spent on each of the main process skills in a lesson, for example 'general discussion' or 'individual-teacher discussion'. The 'within' category, on the other hand, refers to the time spent on each subsidiary process skill, namely hypothesize, observe, interpret data etc (see appendix 7 for a detailed description of the usage of these terms). The lessons showing how these categories were coded are presented in a tabular form (Tables 16 to 19).

Regarding the difference in teacher-pupil interaction, results of classroom observation show that such teacher-pupil interactions varied greatly when comparing the lessons in the four selected research regions. These were also presented in tabular form (Tables 20 to 23).

The researcher makes the following conclusions from the observation results on teacher-pupil interactions in SEP classrooms:

- teachers who were better qualified in science and had a better understanding of SEP's methodology spent more time in the 'Individual-teacher discussion' category while the least qualified spent more time on 'General discussion' category process skill.

- Better qualified teachers spent more time in 'hypothesize', 'interpret data.' and 'infer from data' subsidiary process skills of the 'Group discussion', 'Group-teacher discussion' and 'Individual-teacher discussion'.
- The 'Pupil-use worksheets' process skill was applied only in two lessons. In this regard, the researcher concluded that SEP worksheets were not used either because these were not available or teachers preferred to use textbooks.

In respect of whether lessons were teacher-dominated or pupil-centred, the researcher found the following:

- As in the case of the 'Overall' and 'Within' activities described above, the researcher found that better qualified science teachers who had a better understanding of SEP's methodology tended to involve pupils more frequently in the lessons compared to those who were poorly qualified. In particular, pupil involvement in the lessons conducted by qualified teachers were more prominent in the 'Individual-teacher discussion' process skill.
- Better qualified science teachers maximized pupil activity especially in the 'hypothesize', interpret data' and 'infer from data' process skills.
- Poorly qualified teachers spent most time in the 'observe' skill. This implies that teachers were the ones who were doing science while the pupils were observing the process. In these situations, the teachers spent a lot of time on 'Teacher explains' and 'teacher demonstration' process skills.
- Teachers who understood SEP methodology required pupils to summarise their own findings in their books after an experiment had been conducted in the classroom.

In short, the tables have been included to provide support in quantitative form for the discussions in Section 6.4.1. relating to teacher-pupil interactions.

Table 16: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the Eastern Cape region

	OBSERVATION 1		OBSERVATION 2		OBSERVATION 3	
	a	b	a	b	a	b
	Overall %	Within category %	Overall %	Within category %	Overall %	Within category %
1. Settling class preparation/administration						
2. General Discussion	18.7		17.1		10.6	
i. Introduce facts/principles		11.5		12.2		25.9
ii. Recall facts/principles		9.6		4.9		7.5
iii. Apply facts/principles		17.3		12.2		14.8
iv. Hypothesize		3.8		9.8		7.4
v. Observe		21.2		34.1		18.5
vi. Interpret data		17.3		12.1		18.5
vii. Infer from data		19.2		14.6		7.4
3. Group-Teacher Discussion	47..5		33.8		31.9	
i. Introduce facts/principles		12.9		11.1		8.6
ii. Recall facts/principles		12.1		1.2		7.5
iii. Apply facts/principles		6.9		16.0		16.0
iv. Hypothesize		15.9		17.2		11.1
v. Observe		25.8		25.9		29.7
vi. Interpret data		11.3		11.1		8.6
vii. Infer from data		15.1		17.3		18.5
4. Individual-Teacher Discussion	8.6		13.8		13.4	
i. Introduce facts/principles				3.0		5.9
ii. Recall facts/principles		12.5		3.0		14.7
iii. Apply facts/principles		4.2				8.8
iv. Hypothesize		8.3		27.3		8.8
v. Observe		62.5		45.5		29.4
vi. Interpret data		4.1		9.1		11.8
vii. Infer from data		8.3		12.1		20.6
5. Teacher draws/writes/reads		54.6		33.3		42.2
6. Pupil draw/write	11.8	45.4	11.2	22.2		15 6
7. Pupils use text/reference books				44.4	17.7	42.2
8. Pupils use worksheets						
i. Reading				22.2		22.3
ii. Writing			7.5	77.8		29.9
9. Teacher explains experimental procedure		46.0		50.0		23.9
10. Teacher demos experiments		32.4		37.5	26.4	23.9

Notes: Types of interactions
- 1 = Teacher dominated interactions
- 2 = A balance between teacher and pupil dominated interactions
- 3 = Pupil dominated interactions

Calculation of the overall categories in the lessons (Tables 16-19) = $\frac{\text{Teacher-pupil interactions per category X 100}}{\text{Teacher-pupil interactions in the lesson}}$

Calculation of "within categories" in the lessons (Tables16-19) = $\frac{\text{Teacher-pupil interactions per subsidiary category X 100}}{\text{Teacher-pupil interactions per category}}$

Table 17: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the North West region

	OBSERVATION 1		OBSERVATION 2		OBSERVATION 3		OBSERVATION 4	
	a	b	a	b	a	b	a	b
	Overall %	Within category %	Overall %	Within category %	Overall %	Within category %	Overall %	Within category %
1. Settling class preparation/administration								
2. General Discussion	24.8		21.3		23.6		24.3	
i. Introduce facts/principles		50.0		14.0		31.1		7.5
ii. Recall facts/principles		50.0		14.0		21.3		11.3
iii. Apply facts/principles				14.0		9.8		
iv. Hypothesize				5.3		22.9		20.2
v. Observe				21.0		14.7		30.3
vi. Interpret data				21.0		18.0		10.1
vii. Infer from data				10.5				20.2
3. Group-Teacher Discussion	47.6		21.3		28.3		24	
i. Introduce facts/principles		14.0		14.0		10.9		7.7
ii. Recall facts/principles		8.0		14.0		10.9		11.5
iii. Apply facts/principles		6.0				8.2		7.7
iv. Hypothesize		28.0				15.0		37.1
v. Observe		44.0		28.0		23.3		25.6
vi. Interpret data				26.3		23.3		16.2
vii. Infer from data				17.5		8.2		
4. Individual-Teacher Discussion					9.3		10.1	
i. Introduce facts/principles								
ii. Recall facts/principles								
iii. Apply facts/principles								
iv. Hypothesize						41.7		
v. Observe						58.3		42.8
vi. Interpret data								28.5
vii. Infer from data					9.3			28.5
5. Teacher draws/writes/reads	17.1	62.0	11.2	44.9	10.9	50.0	9.6	44.9
6. Pupil draw/write	10.5	37.9	23.1	55.3	8.9	41.0	3.8	14.4
7. Pupils use text/reference books					1.9	8.0	3.8	40.5
8. Pupils use worksheets								
i. Reading								
ii. Writing								
9. Teacher explains experimental procedure			12.3	44.7	11.2	63.0	6.8	28.0
10. Teacher demos experiments			10.8	55.3	6.6	36.9	8.3	35.5

Two lessons were observed in the Gauteng region.

Table 18: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the Gauteng region

	OBSERVATION 1		OBSERVATION 2	
	a	b	a	b
	Overall %	Within Category %	Overall %	Within Category %
1. Settling class preparation/administration				
2. General Discussion	16.4		17.6	
i. Introduce facts/principles				3.7
ii. Recall facts/principles		17.9		3.7
iii. Apply facts/principles		15.4		3.7
iv. Hypothesize		8.3		20.7
v. Observe		48.3		20.7
vi. Interpret data		5.5		26.4
vii. Infer from data		4.5		18.8
3. Group-Teacher Discussion	20.9		22.6	
i. Introduce facts/principles		19.0		8.8
ii. Recall facts/principles				17.6
iii. Apply facts/principles				26.4
iv. Hypothesize		49.9		38.2
v. Observe		25.6		5.8
vi. Interpret data		6.1		2.4
vii. Infer from data		6.1		
4. Individual-Teacher Discussion	17		13	
i. Introduce facts/principles				
ii. Recall facts/principles		9.1		
iii. Apply facts/principles		15.2		15.3
iv. Hypothesize		26.7		15.3
v. Observe		40.1		46.1
vi. Interpret data		9.1		23.0
vii. Infer from data				
5. Teacher draws/writes/reads	7.7	35.2	5.6	34
6. Pupil draw/write	12.1	43.5	4.6	28.8
7. Pupils use text/reference books	11.3	21.3	6.3	38
8. Pupils use worksheets				
i. Reading				
ii. Writing				
9. Teacher explains experimental procedure	14.5	48.7	14.6	48.8
10. Teacher demos experiments	51.6	51.3	15.3	51.1

Table 19: Observation schedule - percentage frequency of occurrence of observations in SEP schools in the Pietermaritzburg region

	OBSERVATION 1		OBSERVATION 2		OBSERVATION 3		OBSERVATION 4	
	a	b	a	b	a	b	a	b
	Overall %	Within category %	Overall %	Within category %	Overall %	Within category %	Overall %	Within category %
1. Settling class preparation/administration								
2. General Discussion	15.7							
i. Introduce facts/principles		15.7		11.6		13.9		17.2
ii. Recall facts/principles		8.2		16.3				17.2
iii. Apply facts/principles				20.9				17.2
iv. Hypothesize				13.9		19.4		27.6
v. Observe		35		57.4		38.9		10.3
vi. Interpret data		41.1		8.3		19.4		
vii. Infer from data	15.7							
3. Group-Teacher Discussion	16.8		20		17.2		23.4	
i. Introduce facts/principles								
ii. Recall facts/principles								
iii. Apply facts/principles				19.1		19.0		61.5
iv. Hypothesize		19.1		31.9		47.6		38.5
v. Observe		31.9		17.0		28.6		
vi. Interpret data		17.0		31.9		9.5		
vii. Infer from data		31.5						
4. Individual-Teacher Discussion	15.5		28.9		20.2		10.5	
i. Introduce facts/principles								
ii. Recall facts/principles								
iii. Apply facts/principles						21.1		
iv. Hypothesize		40.1		36.8		32.4		69.2
v. Observe		40.8						30.8
vi. Interpret data		18.4		63.1		10.1		
vii. Infer from data		34.3						
5. Teacher draws/writes/reads	5.9	28.1	8.9	40.4	9.0	45.2	18.5	54.8
6. Pupil draw/write					4.3	21.4	3.8	14.4
7. Pupils use text/reference books					1.9	8.0	3.8	40.5
8. Pupils use worksheets								
i. Reading	7.8	37.5						
ii. Writing								
9. Teacher explains experimental procedure	11.2	36.6	11.2	55.18	12.9	51.9	12.9	59.2
10. Teacher demos experiments	11.2	36.6	8.8	44.2	8.8	40.7	8.3	35.5

Table 20: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Gauteng region

	PUPIL INVOLVEMENT OBSERVATION 1			PUPIL INVOLVEMENT OBSERVATION 2		
1. Settling class preparation/administration	1	2	3	1	2	3
2. General Discussion						
i. Introduce	100		-	100		-
ii. Recall facts/principles	100			-	100	-
iii. Apply facts/principles	20	80		-		-
iv. Hypothesize		100			18.2	81.5
v. Observe		100		9.1	90.9	-
vi. Interpret data	60	40		14		85
vii. Infer from data	40	40	20	0	80	
3. Group-Teacher Discussion						
i. Introduce	100		-	-	-	-
ii. Recall facts/principles	100		-	-	100	-
iii. Apply facts/principles	-	-	-		50	50
iv. Hypothesize	-	100	-	33		66
v. Observe	-	100	-	-	54	46
vi. Interpret data		100			100	-
vii. Infer from data	60	40		-	100	-
4. Individual-Teacher						
i. Introduce	-	-	-	-	-	-
ii. Recall facts/principles	-	-	-	-	-	-
iii. Apply facts/principles	-	-	-	-	100	-
iv. Hypothesize	100	-	-	-	100	-
v. Observe	20	60	20	-	-	-
vi. Interpret data	30	40	30	-	-	-
vii. Infer from data	100	-	-	-	-	-
5. Teacher draws/writes/reads	-	-	-	35	47	18
6. Pupil dra /write	100	-	-	35	42	21.5
7. Pupils use text/reference	-	100	-	-	52	47
8. Pupils use worksheets	-	-	-	-	-	-
i. Reading	-	-	-	-	-	-
ii. Writing	6.6	93	-	-	-	-
9. Teacher explains procedure	25	50 80	25 20	-	59.0 21	41 78.6
10. Teacher demos experiments	-	-	-	-	68.9	31.1

Notes: Types of interactions

1 = Teacher dominated interactions
2 = A balance between teacher and pupil dominated interactions
3 = Pupil dominated interactions

Calculation of percentage times spent on each category (Tables 20-23)

= Time spent on individual type of interaction X 100
Total time spent on an interaction per individual category

Table 21: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the North West region

	PUPIL INVOLVEMENT OBSERVATION 1			PUPIL INVOLVEMENT OBSERVATION 2			PUPIL INVOLVEMENT OBSERVATION 3			PUPIL INVOLVEMENT OBSERVATION 4		
1. Settling class preparation/administration	1	2	3	1	2	3	1	2	3	1	2	3
2. General Discussion												
i. Introduce	100		-	100		-	100				100	
ii. Recall facts/principles	100			-		-	42	57	-	-		
iii. Apply facts/principles	100			-		-	30.67	-	69.33		-	
iv. Hypothesize	100			14.3	85.7	-	-		-	7.11	28.59	64..3
v. Observe	100			-	100	-	-	100	-	-	28.8	71.2
vi. Interpret data	100			-	57	42	18.3	25	56		57.1	42.9
vii. Infer from data				100		-		-			100	-
3. Group-Teacher Discussion												
i. Introduce			-	-		-	-					-
ii. Recall facts/principles	-		-	-		-	100			25	75	
iii. Apply facts/principles		-	-				-		-	-		-
iv. Hypothesize	25	75	-						-	-	66.	33.3
v. Observe	100		-	-	100	-	-	40	60	-	60	40
vi. Interpret data				10	90	-		66		25	75	-
vii. Infer from data				-	100	-	8.3	84.2	7.5		80	20
4. Individual-Teacher												
i. Introduce											10	90
ii. Recall facts/principles												
iii. Apply facts/principles				37.5	25	37		57.1	42.9			
iv. Hypothesize					50	50	-		-			
v. Observe	33.4	66.					8.3	66.7	25	-	10	90
vi. Interpret data	100			100			7.1	50	42.9	-	10	90
vii. Infer from data					57.1	42	68.4	31.6		-		100
5. Teacher draws/writes/reads	47.7	52	-	100				-		4.6	54.5	40.9
6. Pupil draw/write		23	76	100			-			16.7	66.6	16.6
7. Pupils use text/reference							100	-	-	-		
8. Pupils use worksheets												
i. Reading											100	
ii. Writing												
9. Teacher explains procedure	37.5	62		32.5	55.5	12.5	75	25		-	29.4	70.5
10. Teacher demos	81.8	18		40	60		52.6	47.4	-	-	11.8	88.2

Table 22: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Pietermaritzburg region

	PUPIL INVOLVEMENT OBSERVATION 1			PUPIL INVOLVEMENT OBSERVATION 2			PUPIL INVOLVEMENT OBSERVATION 3			PUPIL INVOLVEMENT OBSERVATION 4		
1. Settling class preparation/administration	1	2	3	1	2	3	1	2	3	1	2	3
2. General Discussion												
i. Introduce facts/principles	71.4	28.6	-	-	100	-				100		
ii. Recall facts/principles	71.4	28.6		-	100	-	-	100	-	10	60.0	30.0
iii. Apply facts/principles				-	100	-	30.7	-	69.3		-	100
iv. Hypothesize				100	-	-	-	100	-	-	100	-
v. Observe				-	100	-	-	100	-	-	-	100
vi. Interpret data				-	100	-	11.1	-	88.9	-	100	-
vii. Infer from data				-	100	-	45.5	-	54.5	-	100	-
3. Group-Teacher Discussion												
i. Introduce facts/principles	42.9	57.1	-	-	100	-	-	25.0	75.0	-	100	-
ii. Recall facts/principles	-	100	-	-	100	-	-	25.0	75.0	-	-	100
iii. Apply facts/principles	100	-	-				-	100	-	-	100	-
iv. Hypothesize	-	100	-				9.1	90.9	-	-	6.8	93.1
v. Observe	-	100	-	-	100	-	-	-	-	-	60.8	39.1
vi. Interpret data				20	80	-	11.8	35.2	52.0	-	100	-
vii. Infer from data				-	100	-	100	-	-			
4. Individual-Teacher Discussion												
i. Introduce facts/principles												
ii. Recall facts/principles												
iii. Apply facts/principles												
iv. Hypothesize							-	100	-			
v. Observe							-	14.3	85.7	-	-	100
vi. Interpret data										-	100	-
vii. Infer from data										-	100	-
5. Teacher draws/writes/reads	51.7	48.3	-	-	57.1	42	14.2	-	85.8	-	32.3	67.7
6. Pupils draw/write	100	-	-	-	7.7	92.3	-	34.9	65.2	-	100	-
7. Pupils use text/reference books							100	-	-	-	35.7	64.2
8. Pupils use worksheets												
i. Reading												
ii. Writing												
9. Teacher explains experimental procedure				-	36.4	63	10.3	27.6	62.0	-	45.4	54.5
10. Teacher demos experiments				-	68.9	31.1	52.9	47.1	-	-	-	100

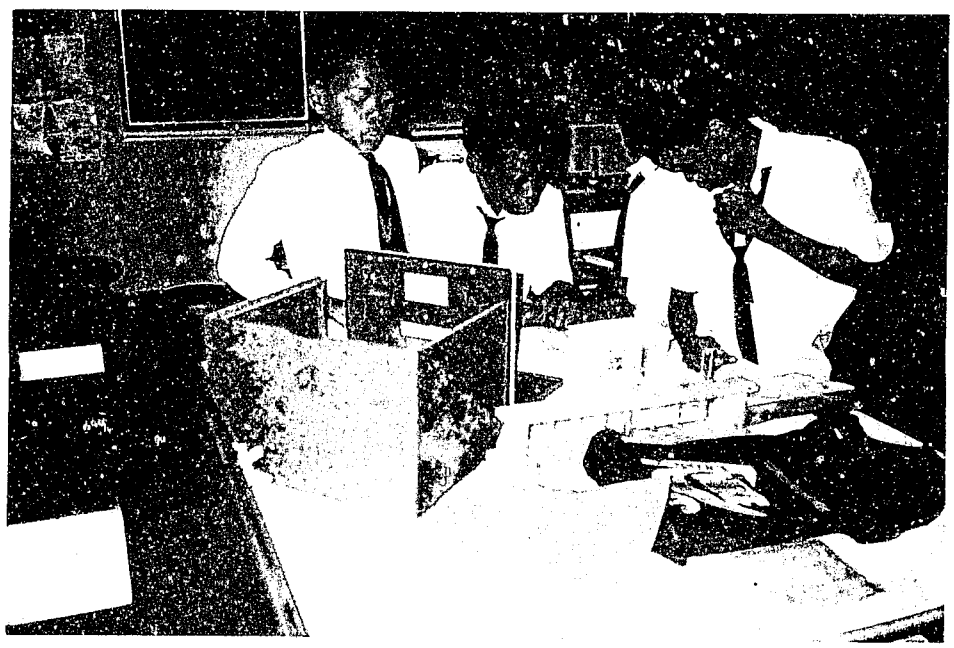
Table 23: Observation schedule - distribution of observations on teacher/pupil centred scale in SEP lessons in the Eastern Cape region

	PUPIL INVOLVEMENT OBSERVATION 1			PUPIL INVOLVEMENT OBSERVATION 2			PUPIL INVOLVEMENT OBSERVATION 3		
1. Settling class preparation/administration	1	2	3	1	2	3	1	2	3
2. General Discussion									
i. Introduce facts/principles		100	-	100			100		
ii. Recall facts/principles		100		100		-	100		-
iii. Apply facts/principles		100		-	100	-	100	-	
iv. Hypothesize					100	-	16	83	-
v. Observe		100		-	100	-	50	50	-
vi. Interpret data			100	-	100	-	100	-	
vii. Infer from data			100	30	40	30	100	-	-
3. Group-Teacher Discussion									
i. Introduce facts/principles			-	100		-	-		
ii. Recall facts/principles	-	100	-	100		-	-		
iii. Apply facts/principles		100	-				-		-
iv. Hypothesize	-		-						-
v. Observe	-		100	-		-	-	-	-
vi. Interpret data		100			100	-		100	52.00
vii. Infer from data		100		-	100	-	100	-	-
4. Individual-Teacher Discussion									
i. Introduce facts/principles									
ii. Recall facts/principles									
iii. Apply facts/principles									
iv. Hypothesize							-		-
v. Observe		18.1	81.		100		-	14.23	8.6
vi. Interpret data		100		80	20				
vii. Infer from data		100		80	20			100	
5. Teacher draws/writes/reads		36.4	63.6	-	100		53	38.4	8.2
6. Pupils draw/write		100	-	-	67	33	27	9	63.62
7. Pupils use text/reference books								100-	-
8. Pupils use worksheets									
i. Reading		21.5	78.5		91.6	8.4			
ii. Writing									
9. Teacher explains experimental procedure		20	80	-	69.2	30		38	62,00
10. Teacher demos experiments		50	50	-	30.3	69	23.1	76.9	-

6.4.2 Photographs in lesson observations

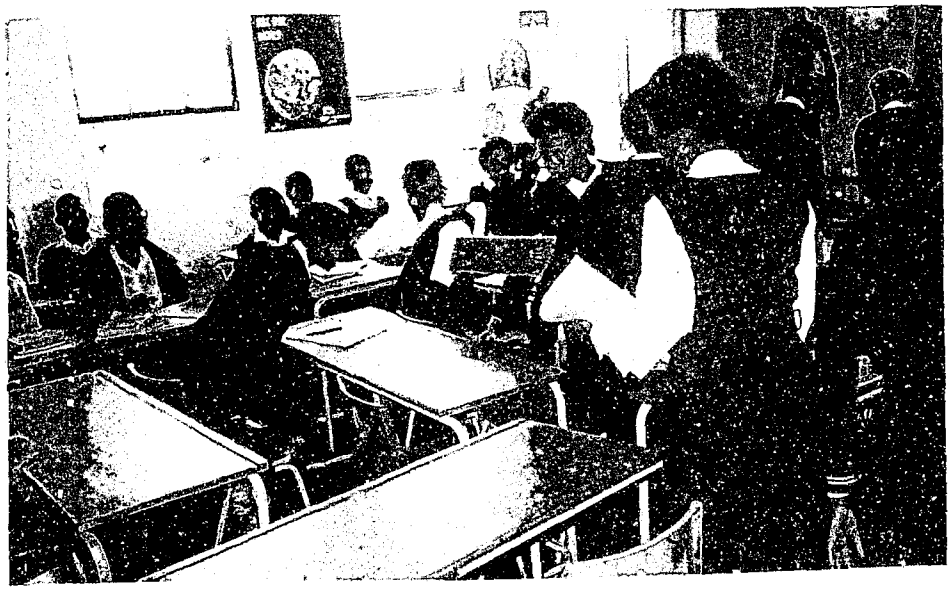
Photographs of SEP science lessons were taken during classroom observation and are reflected below. These photographs serve to reinforce some assertions made by the researcher during observation.

Photograph No. 1 taken at a school with fully equipped laboratory but also supplied with a SEP science kit.



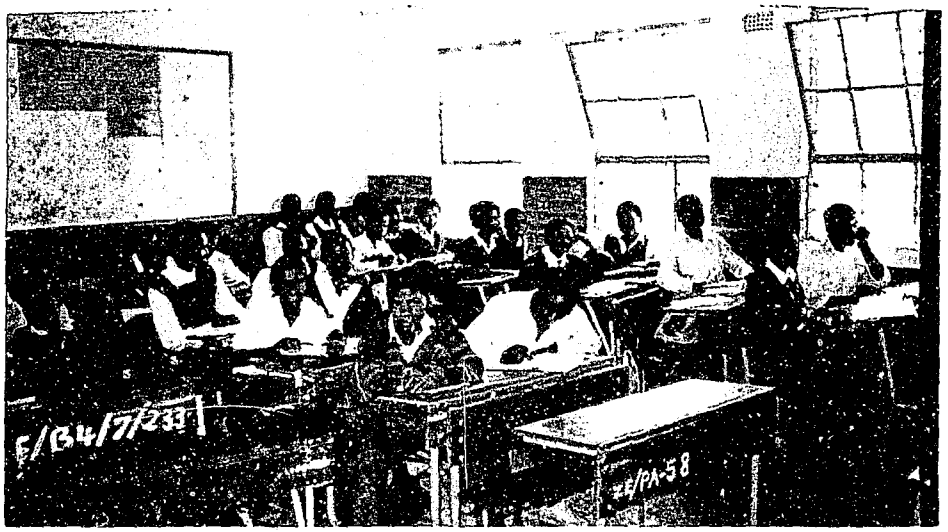
The photograph supports the argument that SEP equipment can be used successfully in the formal laboratory. It also exemplifies a claim that the project pupils are actively involved in the learning process, that the equipment can easily be moved around and that they are allowed to work in a group.

Photograph No. 2 shows pupils using SEP kits in groups in a classroom converted into a laboratory.



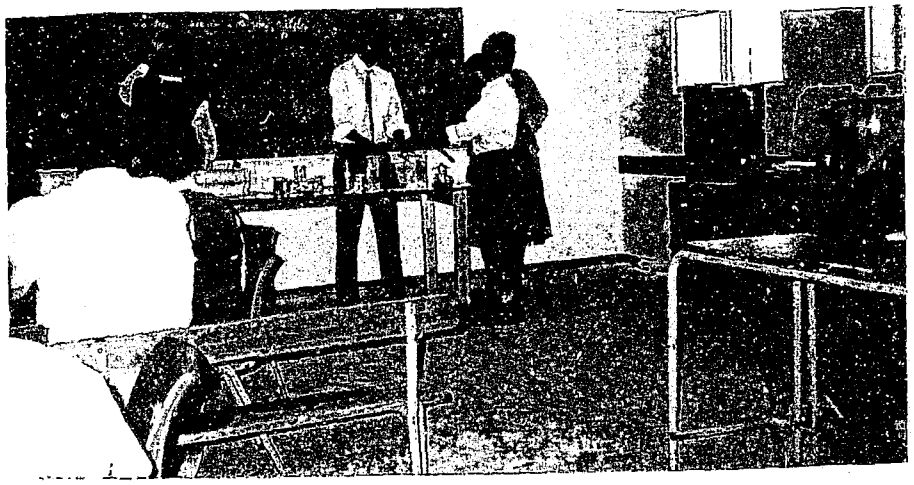
The photo shows a type of teacher-demonstration lesson which has become a common phenomenon in SEP schools. In this regard, evidence that the incidence of teacher demonstrations was one of the prominent features of the project is strengthened. It also supports the notion that pupils are sometimes given an opportunity to do experiments even though this involves only a few of them.

Photograph No. 3. taken at one of the schools where apparatus was destroyed and sometimes stolen.



This photo shows some typical conditions under which SEP's philosophy was implemented. It supports claims that there are often gaps between intentions and policy on the one hand, and what actually happens in practice. It also reinforces an assertion that although in some instances the school was classified as a project school, traditional seating arrangements where the teacher is active and the pupils passive was not an unusual phenomenon in some SEP schools. Furthermore, the photo also endorses the assertion that overcrowding was one of the major impediments in the learning of science.

Photograph No.4 taken at a school in a village/farm



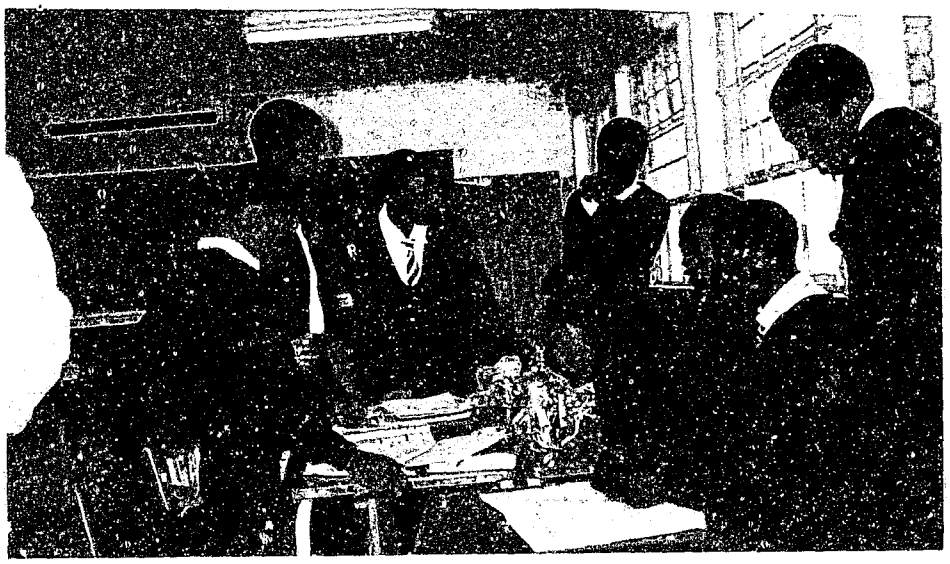
This photo supports an assertion espoused by informants that individual SEP pupils were allowed the opportunity to handle the science apparatus. This photo confirms a view that the portable science kits can be used even in disadvantaged areas where there is no water and electricity. In this particular instance, the photo reinforces a claim that SEP teachers and pupils had positive attitudes towards science and that the kit could be used successfully even in the classroom.

Photograph No. 5 showing teacher demonstration.



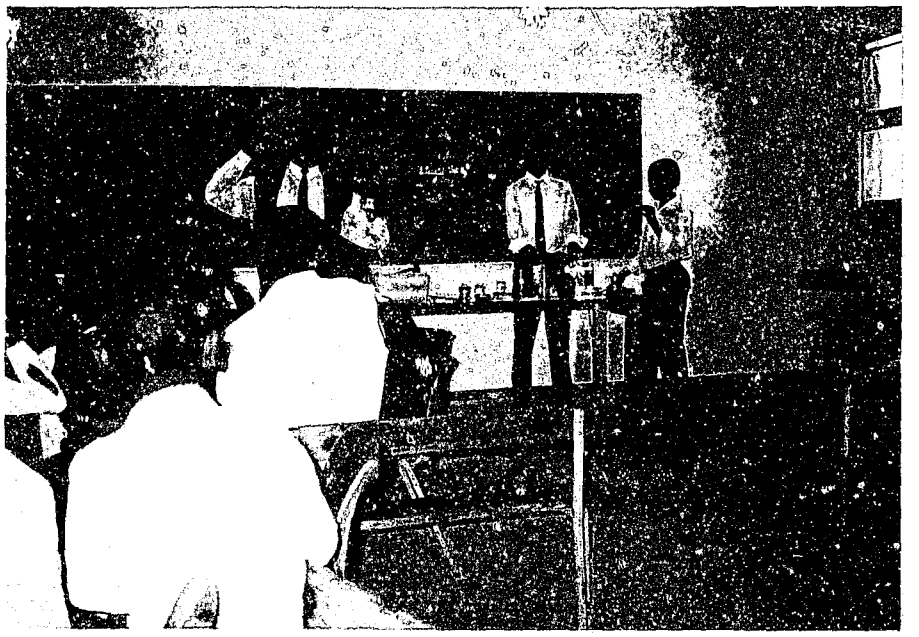
The photo supports the claim made by the majority of SEP respondents that pupils were afforded the opportunity to do science. In this photo, the teacher first gave the pupils an opportunity to do experiments in groups and then summarized conclusions drawn from the pupils' responses on the chalk board. It also supports the observation that SEP kits were used in the laboratory.

Photograph No. 6 was taken at a farm school where SEP kits were most welcome and were used effectively and regularly by the pupils.



The photo supports the view that SEP pupils are motivated, understand what they are doing and can indeed handle science equipment confidently. In this instance, the experiment was conducted in a small laboratory using SEP kits. The photo also clearly shows the dedication of pupils and the positive consequences of group work.

Photograph No.7 showing both teacher and pupils demonstrations.



It reinforces the argument that demonstration forms a significant part of the reality of doing science in a SEP classroom. In it, the pupils observed the demonstration by the teacher in a classroom specifically arranged for this particular lesson. Furthermore, this photo confirms the view repeatedly expressed by most SEP staff that project pupils were given the opportunity to handle apparatus. The notion of encouraging group work is also supported.

6.4.2 Explanation of the differences between teacher-pupil interactions in SEP classrooms

The researcher concluded from the results that the differences of teacher-pupil interactions could be attributed to the following factors:

- The aim and type of the lesson. This occurred where the teacher's aim was to revise the previous experiment.
- The availability and non availability of apparatus.
- The limited supply of SEP kits and apparatus.
- The nature of the topic.
- The physical conditions in the school.
- The teachers' competency and experience.
- The intrusive nature of the observation could also have influenced the teacher's behaviour on that day.

It was further found that although the project's intention was that teachers should use worksheets with portable kits, this was not the case in some schools. The result of interviews with teachers after lessons support the result of classroom observation that the project worksheets were not always used. The teachers explained that they made use of SEP worksheets only in cases where the experiments they were dealing with did not appear in the textbook (SEPPIEU (bb)). The use of books instead of worksheets was further confirmed by another teacher who argued that he often did experiments in the book rather than using the worksheets (SEPNW (cc)). These responses suggest that SEP teachers used the science kit but supplemented them with textbooks provided by the department instead of the project worksheets. In some cases, it was obvious that it was not always possible to use the worksheets because either there were not enough of them or they were not available in some schools (SEPECU (ee)).

The researcher derived the following implications on this aspect of the analysis:

- The positive and negative unintended consequences of limited apparatus and kits as well as teacher demonstrations have implications for SEP's policy and practice.
- The negative unintended outcome was that by limiting demonstration to the teacher, pupils could easily have memorized what was happening without understanding.
- The positive unintended outcome of limited SEP apparatus and science kits is that some teachers were compelled to organise pupils into groups thereby affording pupils the opportunity to participate more actively in the learning process.
- The grouping of pupils had an advantage because the majority of teachers believed that pupils learn science better in a group than if each was left to do experiments alone.
- Group work and teacher demonstrations are useful strategies where one is working with a large number of pupils as was the case in many SEP schools.

6.5 ASSESSMENT OF PRACTICAL WORK IN SCIENCE TEACHING AND LEARNING

6.5.1 Practical work in SEP's methodology

Results from interviews and analysis of literature on SEP show that practical component of science teaching and learning was interpreted differently by the various project's staff. The findings in this regard suggest that for the majority of the staff, the nature of SEP's approach meant doing science practically eg. "*SEP has accepted the challenge of using practically-based approaches to science teaching and has tried to meet the needs of providing science kits*" (Manana 1993). This view was supported by the following statement: "*SEP's approach encourages practical work*" (SEPIM (e)). Further, one of the teachers using SEP methodology asserted that they had been teaching science theoretically but that they had changed and were conducting more experiments since they were introduced to SEP (SEPECU (dd)).

The results further suggest that the majority of informants associated the practical component of science with teacher demonstration (See the section on teacher-pupils interaction (Tables 20 to 23 and Photograph No. 2)). As far as this matter is concerned, no distinction was made between experiments conducted by the teachers and those where the pupils took an active part. Consequently, informants who clearly equated practicals with teacher demonstrations argued that these two activities could be used to test the effects of the project in improving science (SEPN (a)). However a minority view expressed by individuals within the project (SEPN(a); (b); (c); Manana 1993) proposed the differences between the traditional and alternative ways of interpreting practical work within SEP.

Results of interviews in respect of practical work in SEP's methodology were also supported by the literature on the project. Accordingly, Manana (1993:4) argues that "*teacher demonstration by itself in the 'old' SEP approach was equated with practical work while in 'new' SEP regions, attempts were made to reintroduce hands-on-practical work*" This concern was further reiterated in the results of a survey conducted on this issue in schools in the North West region thus:

> "*much of the practical work advanced by our school science syllabi is done through demonstrations. We do not underrate the importance of such work ---but we would argue that such work does not guarantee procedural understanding. Also by carrying out demonstrations--- we should not assume that children will learn the concepts easier*" (Diyane 1991:14).

The expressed view above is also supported by a similar study undertaken in the Eastern Cape (see Khumalo (1992) for detailed examination of practical work and teacher demonstration).

However, despite some expressed concern about equating teacher demonstration with the practical component in science, one informant defended teacher demonstration within the context of SEP. The reason for supporting teacher demonstration was that apparently, the project had been successful over many years because:

- it was able to change the teachers' and pupils' attitudes towards science.
- it encouraged group work and peer advice.
- it afforded pupils the opportunity to handle apparatus even if only two or three were actually involved in conducting experiments.
- it managed to reach a great number of pupils even where only one science kit was available.

6.5.2 Differing interpretations of practical work

Results of interviews indicate that assessment of the practical work component in science often meant different things to different people. Some informants, especially those at the implementation stage of the project, acknowledged that they had a problem with the evaluation of the practical component. One informant, whose view represented the general concern of teachers, pointed out that because they concentrated on demonstrations, pupils could not do practicals and that this made it difficult to evaluate this component (GSEPU (cc)). The majority of the teachers indicated that because of limited science apparatus it was difficult to evaluate practical work of individual pupils (SEPPIETU (ff)).

The majority of informants argued that there was a need for a policy that makes assessment of practicals in science mandatory. Informants reflected on their experiences and advised that unless the practicals were examined, neither the teacher nor the students would take them seriously. Following this argument, the examination-driven system has enormous implications for teacher change because the slow rate of change in the system tends to retard the impact of innovation such as SEP.

Results of interviews suggest that the issue of what to assess in science was one of the factors that distinguished SEP's philosophy from the philosophy held by the education system which is bureaucratic by nature. These findings suggest that for SEP, qualitative assessment of what was going on in teaching from the individual's point of view has always been a priority. In support of qualitative assessment, people within the project argued that it was not easy to quantify SEP's success in terms of student performance because the project has been involved with junior secondary schools (standards 6, 7 and 8) which were not externally examined. They were also of the opinion that examination results have not been a major concern of the project. One of the reasons for this was apparently that "*SEP operated in the junior phase of schooling where examination was conducted internally*" (Thorne 1993:6). One of the senior SEP staff members argued that the project has been greatly successful when judged against its objectives of bringing about qualitative improvements in science teaching and learning. This contrasted with a view that SEP's should be judged in terms of pupil performance.

Further, the findings of interviews indicate that the majority of informants regarded assessing practical work a cumbersome process in the average South African school with insufficient apparatus. It was also suggested that the education system was in some cases a major impediment against the assessment of practical work because of the system tends to be bureaucratic and takes time to change. Consequently, the majority of informants argued that practical work is unlikely to be taken seriously if it is not formally assessed and properly monitored. This view was captured as follows: "*Although the syllabus states that practical work should be done, this will never be taken seriously because is it not part of the examination and even the pupils themselves would not want to do anything that is not examined*" (Sci Ed (g)).

The researcher concluded from interview results that the major challenge facing science curriculum planners is to evaluate innovation projects not only in terms of pupil performance but also to focus on qualitative improvement of science as well. In addition, policy on assessment of practical work should not be equated with summative evaluation at junior secondary and matric levels. On the contrary, it was suggested in interview results that assessment should be done continuously to ensure that marks accumulated from the practical component in science during the year should count towards a passing mark.

The researcher also concluded from interview findings that it is important to determine the types of skills one wishes to develop in a particular lesson. In this regard, reference was made to criterion and norm-referenced assessments. Accordingly, it was concluded that if skills development is a primary aim, criterion-referenced assessment will be the appropriate approach. An assertion emanating from this argument that has relevance for SEP's practice is that a curriculum which favours the process approach would favour criterion-referenced assessment.

6.5.3 Different views on assessment

The general agreement amongst respondents was that practical work was never accorded its rightful place in the South African education system. Practical work was part of the science curriculum in the then Indian schools but not in the curriculum which was intended for Africans (for a detailed examination of this assertion see Naik 1994; O'Neil 1994).

Part of the problem of practicals is that they put enormous pressure on teachers especially if they attempt to teach according to the process or constructivist approaches. Results also suggest that factors in the education and in schools tend to hinder the usage of modern methodologies in the teaching of science and that these factors may emanate from the system and include overcrowding and the lack of general support for science teachers. The identification of the factors would apparently enable planners to plan more sensibly. The other problem relates to the very nature of the science curriculum which according to the informants, does not spell out how practical work should be done under the conditions outlined above. The general concern about the absence of the practical component in science was articulated as follows *"the teachers often resort to doing 'textbook practicals' or doing practicals theoretically"* (Sci Ed (b)).

6.6 EVALUATION AND INTERPRETATION

6.6.1 The process and constructivist approaches in SEP

The conclusion reached is that although the process and constructivist approaches are not mutually exclusive in practice, there are fundamental epistemological differences between them but that these differences were treated as side issues by most SEP staff and science educators in and outside the project. The investigator's view supports the literature (Scott et al. 1987; Scaife 1994; Gott and Mashier 1991; Driver and Bell 1986; Novak 1988) and the views of informants regarding the epistemological differences between the process and the constructivist approaches. This is so because in constructivism one takes pupils' prior beliefs, questions them and then builds a lesson on the basis of that while in the process approach, the pupils are given things to do. However, the conclusion arrived at in this study is that epistemological differences on the learning and teaching of science were never clearly articulated by informants.

It was found that while some informants closer to policy-making argued that SEP had abandoned the process approach in favour of constructivism, some felt that constructivism was merely a label given to what the project teachers had been using all along.

Another area of difference between the process approach and constructivism according to interview results relates to misconceptions that emerge during the teaching and learning of science. Furthermore, the conclusion reached supports the warning sounded in the literature that constructivism may easily create misconceptions in the learning of science. Teachers interviewed made interesting comments on their experiences of the problem of utilizing pupils' prior knowledge inherent in constructivism.

6.6.2 SEP's approaches to the teaching and learning of science

The investigator's findings support the view derived from the project's documents, informants and the literature (Macdonald and Rogan 1981; Bateson 1995) that SEP pupils were actively involved in the learning of science as envisaged in its mission statement, and that they could do a number of things that non-project pupils could not. The researcher found from interview results that pupils in the project:

(i) were able to arrange science kits in a manner that showed that they understood the processes involved;
(ii) showed an interest in the material; and,
(iii) demonstrated that they understood the concepts (Bateson 1995).

Bateson's evaluation of the project comparing SEP and non-SEP schools further confirmed that the project pupils understood the process in learning better than the non-project ones. Accordingly, the project's pupils were able to do experiments on their own and were able to answer questions based on practical work. This view reinforces the findings of the evaluation (Bateson 1995) as well as previous literature (Rogan and Macdonald 1985).

In addition to the impact the project had on the pupils, results also suggest that SEP teachers:

(i) taught science topics with better understanding;
(ii) that they used the apparatus with some understanding and,
(iii) demonstrated they were trained in the project's methodology.

Photograph No. 3 exemplifies the extent of overcrowding and the traditional seating arrangement of the pupils. It became clear that although teachers should ideally facilitate the learning process, there were cases where they completely dominated the lesson (see Tables 20-23 on the lessons observed). Closely connected with the role of the teacher and the pupils, was the issue of demonstrations by teachers as opposed to experimentation by pupils themselves. Results of classroom observations suggest that most lessons were dominated by teacher demonstrations (see Tables 20-23). Although some teachers and implementers did not have any problem with teacher demonstrations in SEP classes, some expressed a concern about this practice. Consequently, some informants were explicit during the interviews that although, ideally, it was the pupils who were supposed to do experiments, in practice there were not enough science equipment and kits to expect pupils to perform experiments. The conclusion arrived at in this regard supports the general views expressed in the literature (Ross and Lewin 1992; Torrance 1985; O'Neil 1994) and by informants.

6.6.3 Locus of control in SEP's classrooms

The researcher concluded that the unintended negative consequence of who controlled the rate of learning and the learning content was that the SEP's 'package' approach was viewed to be educationally prescriptive and restrictive. This approach was prescriptive because the teacher and pupils were implicitly expected to follow certain steps clearly laid down in the project's worksheets. Classroom observations and informants supported the researcher's conclusion that the 'package' approach tended to prescribe what was to be learned and how that was to be learned.

However, the unintended positive consequences of the 'package' approach to learning and teaching was that the majority of teachers in disadvantaged communities (who had inadequate training) were enabled to deal with innovative ways of teaching science. Consequently, such teachers needed to be provided with such a 'package' as well as a guide in order to help them to cope with the demands of innovative methodology and content. The positive and negative consequences of who controlled the rate of learning that emerged reinforce Stenhouse's (1975) view about the importance of making a distinction between curriculum as intention and curriculum in action when implementing a curriculum. A possible negative aspect of following the step by step approach is that some textbooks or even the worksheets themselves might contain errors which are often repeated by some teachers who may not be able to identify and challenge these errors.

Lastly, this investigation sheds light on the mismatch between policy and practice in curriculum development. It is evident that while the intention of the project developers was to maximize pupil participation, the rate of learning and the content itself was determined by the project's materials and worksheets.

6.6.4 Portable science kit versus formal laboratories

SEP's introduction of portable science kits which can be used in the absence of running water and electricity, is perhaps one of the major innovations in science education suitable for conditions in many rural areas.

Despite the intention of the current government's education policy to provide science education for all, the economic conditions are such that many schools especially in rural areas will still continue to operate without laboratories. In so far as the usage of the portable SEP kit is concerned, this was justified on grounds that it is cheaper than laboratories which clearly take the bulk of the budget allocated to science. Furthermore, research conducted in developing countries indicates that the pupils do not necessarily learn science more effectively in the formal laboratories.

In the light of research on the usage of portable kit and formal laboratories, this study challenges assumptions suggesting that more money needs to be spent on building laboratories in order to improve science in countries with limited resources such as South Africa.

Lastly, this discussion sheds light on the theories and assumptions on learning. It questions a commonly held belief that children learn science more effectively and understand better by performing experiments in a laboratory.

6.7 SUMMARY

This chapter examined learning and teaching of science primarily relating to SEP work in the four selected research regions. The following were explored in more detail in the chapter:

- An analysis of SEP methodology and the extent to which the project schools and teachers were using SEP's methodology. The components of the project's methodology discussed included: the differing views on the expansion of SEP, the locus of control in SEP classrooms and the merits of portable science kits compared to formal laboratories.
- Approaches to the teaching and learning of science adopted in SEP classrooms were analysed and critically evaluated.
- In this regard, the implications of the process and constructivist approaches followed by SEP during the different times of its development were analysed.
- The chapter also analysed teacher-pupil interactions in SEP classrooms. Issues that were explored in this regard were variations of teacher-pupil interactions in SEP classrooms and the explanation of the difference between these interactions.
- Assessment of practical work in SEP's methodology were analysed. Differing interpretations of practical work and different views on assessment were examined.
- Lastly, the chapter provided the researcher's interpretations of issues relating to teaching and learning in SEP classrooms.

CHAPTER SEVEN

SEP AND ITS CONTEXT

7.1 INTRODUCTION

The preceding chapter focused on the discussion of results relating to the use of SEP kits and how they influenced the teaching and learning of science in project schools in the four selected research regions. Chapter Seven describes the findings in respect of the relationship of SEP with stakeholders in so far as the delivery of innovation and change in science education is concerned. See Chapter Five for procedures followed to analyse data in this chapter. Themes and trends explored in the chapter, as well as the sources of data are presented in Table 24.

RESEARCH QUESTION THREE

How did the nature of the relationship between SEP and other stakeholders affect the implementation of the project's work during the period under review?

7.2 ISSUES OF ADVOCACY AND IMPLEMENTATION

The nature and quality of relationships between the different stakeholders in the delivery of educational services are major determinants of whether innovation and change introduced into the education system is effective or not. This is more so because stakeholders often have varying interests and motives for supporting a particular innovation. Such interests are themselves the result of intricate interactions that arise out of particular socio-economic circumstances.

Table 24: Themes and trends explored in Chapter Seven and sources of data

THEMES AND TRENDS	SOURCES OF DATA
Donors and sponsors played a major role in the development of SEP in the 1980s to 1990	-analysis of SEP documents -interviews with elite policy-makers in SEP, members of the Board of Trustees and SEP staff
Education departments had the potential of either facilitating or discouraging the implementation of SEP's methodology	-Analysis of SEP documents and records - interviews with elite policy-makers in SEP, members of the Board of Trustees and SEP staff
Structural changes in education affected SEP's work in the 1990s	- interviews with elite policy-makers in SEP, members of the Board of Trustees
The funding of SEP after the democratic election as from 1994 affected the project's work	- analysis of SEP documents - interviews with elite policy-makers and members of the Board of Trustees
The changing relationship between SEP and donors affected the implementation in the regions	- interviews with senior SEP staff members - interviews with members of the Board of Trustees, SEP donors/sponsors
It was easier for SEP to obtain funding from donors in the 1970s and 1980s than it is in 1990	- interviews with former SEP staff members - analysis of the project's documents and records
Relationship between SEP and the education departments was more cordial in the former homelands than it was in the former central government schools	- interviews with former SEP staff, members of the Board of Trustees - analysis of the project's documents and records
The channelling of funds to the government led to bottlenecks in the system which disrupted a smooth flow of funds to the provinces	- interviews with former donors, members of the Board of Trustees, former Executive Directors
Evaluation and acceptability did not emerge as primary concerns in the 1970s and 1980s	- interviews with SEP elite policy-makers and interviews with senior SEP staff - analysis of SEP documents

7.3 SEP, THE DONORS AND EDUCATION DEPARTMENTS

Results of interviews indicate varying views with respect to the project's intention and policy of working with stakeholders (comprising the sponsors, the community, education authorities, teachers, pupils, research and academic institutions) in implementing innovation and change. Each of these will be examined in turn.

7.3.1 SEP and the donors

According to results of interviews with the project's sponsors and the education departments in the selected four research regions there were two important stakeholders in the implementation of SEP's innovation and change. In respect of support from the donors, the research findings suggest that SEP could not have begun with its intervention initiatives if it were not for the private sector which was prepared to provide capital in order to enable the project to pursue its reformist goals alongside science curricula provided by the state (SEPB(b); (f)). Results from the analysis of SEP documents and records support the view that the donors made it possible for the project to begin with its work in science education. Consequently, sponsors from the private sector and industry have formed the backbone of the project since its inception in the early 1970s. The term coined and used within the project to describe the importance of sponsors is that the latter were the 'life blood' of SEP.

Further, results of interviews suggest that the majority of SEP staff were of the opinion that a healthy relationship existed between the project and the sponsors especially during the early years of its development (Priv Sec. (c); SEPN (f); (i); SEPB (b)). This latter view is supported by individual comments made by one of SEP's policy-makers during the period of investigation on the issue eg. "*the relationship is healthy because the education authorities were responding well to requests from SEP Head Office*" (SEPN (d)). Also "*we have enormous support and*

as a result, ninety-five of our SEP teachers are seconded to the project" (SEPB (b)). Thus, informants closer to policy-making in SEP pointed out that sponsors were satisfied with the projects performance and were therefore prepared to fund it from its inception in the 1970s through to the 1990s (DON (e)). According to this view, the project's sponsors relied entirely on internal and external evaluations of the project conducted over the years to continue giving it financial support.

However, results from the analysis of the project's documents, records and interviews also suggest that the perceived cordial relationship between SEP and the sponsors should be seen within the socio-political context of education in the divided society of the 1970s and 1980s. First, results indicate that the private sector/sponsors funded SEP because the education system was perceived as generally illegitimate in the 1970s and 1980s. This view was articulated succinctly by senior SEP member of the Board of Directors and a policy-maker who observed that the dramatic question in 1984 was the state as an illegitimate stakeholder and therefore that it held the power but certainly not the authority (SEPB (f)). Accordingly, the private sector apparently pledged itself to support not only SEP, but other NGO projects perceived to be offering alternative science education to the disadvantaged communities.

Second, interview results with representatives of sponsors and donors of SEP confirmed the argument that their companies and organizations indeed supported the project because they did not want to give their financial support to a system founded on untenable education policies (DON (b); (c); (f)). Interview results suggest further that donors continued to give the project financial support because they believed that it was making qualitative differences in improving science and paid little attention to the impact the project was making on examination results (NGO (a); SEPB (b); (d)). In this regard, results of interviews indicate that in view of the inequalities in science education that characterised the education system in South Africa at the time, pupils' performance in the project was never viewed as the sole indication of the project's success.

Results from interviews indicate that the majority of informants within the project were of the view that some donors were still willing to fund SEP even as late as 1995. At the same time, however, there were indications of a decline in financial support from both the overseas and local donors.

7.3.2 SEP and the education departments

As far as cooperation with the education departments is concerned, analysis of interviews and project documents and records yielded similar indications, namely, the project put resources, equipment and people into the education system gave rise to a number of expectations. These were that the education departments would allow freedom to get into schools and would also continue to second teachers to the project (SEPB (b)). The level of willingness of the education departments to allow SEP to operate, was an important factor in the successful implementation of SEP's methodology. Access to schools was found to be a pre-condition to SEP being able to utilise the support it received from the various stakeholders which varied, and included financial, professional, logistical, administrative and moral support. Available funds would have been useless if the departments of education had not cooperated in the process of implementing SEP's innovation and change. Consequently, successful implementation of the project's methodology would have been almost impossible if SEP implementers, teachers, researchers and others were not cooperative in this matter.

7.3.3 Structural changes in the education departments

Interview results with elite policy-makers within the project and outside it suggest that relations between SEP and the education authorities revolved around the issue of governance and the scope of the operations of NGOs within the new political dispensation.

According to one senior SEP staff member whose view undoubtedly represented the majority of stakeholders in SEP, the main problem in 1984 was the absence of the state as a legitimate stakeholder in the provision and delivery of innovation in education. It was however revealed in this regard that the legitimacy of the state post-1994 a non issue since we are in a newly democratically elected system under totally different conditions (NGO (a)).

Results of interviews with senior SEP staff indicate that the overwhelming majority of informants both within and outside SEP acknowledged that the NGO and CBO sector are experiencing identity crises during this post-election period in South Africa. However, it was indicated in this regard that some informants closer to policy-making in SEP were still confident in 1994/95 that NGOs such as SEP would continue with their intervention programmes but conceded that they would have to cooperate more with the education departments (DON (b)). In this regard, results of interviews suggest that the prevailing view inside SEP was that the project needed to review its intervention strategy. This was necessary because the role of NGOs such as SEP was going to change quite sharply where it would have to relinquish the role of provision, and assume a role in training (Priv Sec (e)). This belief was supported further by another informant whose perspective represented the view of the majority namely that SEP needed to work in close collaboration with the government and not in opposition to it.

The changing role of the project was described as follows: "*Since 1990, the emphasis has had to be on delivery and not only legitimacy*" (SEPN (c)). Interview results with senior SEP staff members show a concern within the project that the majority of NGO projects that have been only about legitimacy prior 1995 have had to scale down their operations or close down in the post-apartheid South Africa. However, interviews with senior SEP staff members indicate that "*SEP had been fortunate to have been involved in the delivery of innovation but that the project needed to revert back to training and curriculum development*" (SEPN (c)). In addition, results show

some fears that SEP would lose its effectiveness if it continued to expand as a delivery system and that the project would not be able to maintain implementers in schools because of financial constraints.

However, the general trend that arose from interview results was that regardless of the kind of government we would have, there will still be a special place for independent research and curriculum development and innovation projects like SEP. In addition to the need to change the intervention strategy, the findings suggest variations in respect of the relationships between SEP and the education departments over times and across the regions and even among individuals within the education departments. Despite perceived variations, the majority of informants pointed out that there have generally been harmonious relations between SEP and the Education Departments. According to interview results such relationships were healthier in the erstwhile self-governing and 'independent' homelands, than they were in regions that were under the control of the former Department of Education and Training (formally for black schools).

Results of the analysis of the project's documents records and interviews suggest that these variations could be attributed to the fact that schools in the former self-governing and 'independent' homelands were relatively more deprived compared to those under the jurisdiction of the erstwhile Department of Education and Training. Accordingly, SEP was accepted by the education authorities who were of the opinion that the project was augmenting the limited resources provided by the education departments in those areas. The research revealed two key factors which help to explain some of the variations described above. According some informants, the first was that "*Most of the senior authorities in these regions were blacks and some of them were trained in SEP philosophy and practice*" (GSEP (a)); and second that, "*regions where most of the senior authorities were whites and where it was felt that the Department had the necessary expertise, the relationship between SEP and the Education Department varied from less than cordial to very cold*" (GSEP (a)). In

the latter case SEP was apparently seen to be competing unnecessarily with the education department in the areas of curriculum development in science education and INSET.

In addition to interregional and interdepartmental variations, results also suggest that the relationship between SEP and the Education Department, also "*depended largely on individual authorities in education*" (Sci Ed. (j)). In this regard results of interviews show that relations between the project and the education departments depended on individual officials in the various education departments. The consequences of this phenomenon meant that the relationship between SEP and the education authorities changed whenever individual officials were changed and this had a bearing on issues relating to accountability.

7.3.4 Changing relationship with the education departments

Results of interviews suggest two factors which clearly represent a gap between intentions and aspirations and what was actually happening in practice. The first concerns the uncertainties that exist regarding where the project wanted to go. The second was evident in a rejection of the implementers' perceptions and fears by the official position of SEP which claimed that, "*further discussions between SEP National and the Ministries of education in the different regions were indicating that the project will still be supported by the authorities*"(Triegaardt 1994).

Interview results also suggest a general decline in the relationship between SEP and the education authorities especially after the installation of a democratically elected government in 1994. The deterioration of relationships led to a situation where contracts entered into between SEP and the education department were seldom honoured by the education officials. In some cases, education authorities apparently organized INSET workshops during the same time SEP science teachers were expected to attend theirs. This resulted in the teachers having to abandon SEP

workshops in favour of those organized by the authorities even if they were benefiting very little from INSET programmes organized by the then department of education in the regions. In this regard, interview results show that in some instances, SEP teachers were openly intimidated and even victimised by the chief education officers in the North West region although evidence from documents and records compiled recently suggest a great improvement in this regard. Further, results of interviews indicate that the widespread turnover of teachers who had been trained through SEP by the school or the department, the failure to recognize the burden facing science teachers, and the lack of incentives for these teachers tended to affect the project's work in the selected four research regions.

7.3.5 Changing relationship with the donors

The diminishing financial support reported earlier was clearly influenced by the recommendation of a commission set up by the European Community to investigate the financing of the NGO sector in a democratic and legitimate system in South Africa. Interview results with the majority of SEP's staff show general agreement that the project's work was affected by financial constraints brought about by the newly proposed procedures of funding NGOs. Accordingly, informants generally agreed that through the legitimization process, most donors are now inclined to contribute their money into the system through the government's Reconstruction and Development Programmes (RDP) (ANC 1994 (b)) rather than to give it to the NGOs as was previously the case. The British government remained one of the few donors that continued to fund SEP directly and its contribution towards the project increased in 1994/95. This funding was routed through the ODA and the British Council. The shift in the funding procedures was, and still is, of grave concern to the project's staff who argued that the autonomy of the project would be seriously undermined. One of the senior informants within SEP had this to say about the new funding procedures for the project: "*we have already seen foreign donors channelling funds through the government and that is something we must oppose very strongly*" (SEPB (c)). A concern was expressed in the results of interviews with SEP staff that by giving money to the government to distribute among the NGO projects such as SEP, overseas donors were adopting a very short-sighted approach.

It was argued that, as opposed to this system, large amounts of money were made available to fund alternative curriculum projects in the donor countries (SEPB (d)).

The concerns about the new funding formula and a fear for the survival of the project were raised specifically by SEP staff members at the implementation stage. Fears in respect of the nature of relationships were articulated by informants close to the policy-making level within the project as follows: "*Money is drying up and donors now contribute money to the RDP. So it might be that the donors themselves are creating problems for the NGOs such as SEP because they rush to the government hoping that the latter in turn would recognize the contributions NGOs have made and are making*" (GSEP (e)). The other reservation, capturing the majority view of informants on this issue especially those closer to policy making, was articulated as follows: "*We must oppose any attempt by overseas donors to channel money through the government since this is in contrast with development in donor countries where NGOs are financed directly*" (SEPB (f)). However, the new conditions were justified on the grounds that whereas NGOs previously obtained private funding only and tried to upgrade teachers outside the system, this sector would now be using public funds and would therefore have to be accountable to the government by entering into contracts with the government institutions (NGO (g)). This view was further expressed as follows: "*I think that there are going to be a lot of NGOs such as SEP who would be contracted to the department*" (DON (b). However, results of interviews suggest that contrary to the fears raised about the funding of SEP, some informants also close to policy-making argued that at least up to 1995 SEP was still an exception because the project was still enjoying financial support from its donors eg. SFPN (b).

The researcher found, despite displeasure from the majority of the project staff, that funds would be challenged through the government's RDP. The Bill confirming this position had already been accepted by parliament during the time this research was undertaken and was to become law in the near future. One of the major features of

the Bill which clearly was a temporary measure with regard to the funding of NGOs including SEP, was the creation of Transitional National Development Trust (TNDT) as a structure through which the money intended to be accessible to NGOs would be received and distributed. The Bill became the Not-for-Profit-Making Organizations Act of 1997 (Republic of South Africa 1997). It was found that the funding of SEP became regulated by the Not-for-Profit-Making Organizations Act of 1997 (Republic of South Africa 1997). The new conditions contained in the Act are first, that applications for such funds would be done by a group of projects and not individuals representing individual projects; and second, that the government would need to support the existence of such a project. In addition, these procedures require that SEP and other NGOs should be evaluated more rigorously and that they should become more accountable for the money they receive from the government.

7.4 EVALUATION AND ACCOUNTABILITY IN SEP

7.4.1 Differing views on accountability

The research suggests that the issue of the relationship between SEP and the education authorities was in fact a problem of accountability and to some extent, the evaluation of the project's activities or lack thereof. One of the representatives of donors who had a long association with SEP argued that as long as SEP had to fund-raise, the project would remain accountable to the funders and that the latter would be entitled to withdraw their funds if they were mismanaged. Further, the research indicates that evaluation and accountability did not emerge as primary concerns in the 1970s and 1980s. It appears from the results that while SEP was accountable to its clients in the 1980s, the project became accountable to funders as from 1989 through to 1990. The nature of the problem was articulated by one of the senior informants representing SEP's major funders who indicated that it was difficult for them in the 1980s to prove that SEP was effective.

He reiterated the view of the majority that they were convinced that the project was making some improvements in science but that this could not be demonstrated. This

perception appeared throughout the analysis of interview results that perceived qualitative changes brought about by the project in science were almost the only available criteria to the donors on which they could base their decisions about financial support.

The researcher found from the results of interviews with the majority of informants and of the analysis of the project's documents and records that SEP became accountable to the donors for the money they were providing. This position was defended on grounds that fortunately "*SEP had a competent and vigilant Board of Directors who enforced strict accountability procedures in relation to the use of funds*" (SEPB (a)). One of the prominent policy-makers and a science educator of long standing with SEP proposed two strands of accountability. In the first place, it was recommended that there should be financial accountability where it can be established whether the money will be spent properly and legally thereby ensuring that there will be no fraud or corruption. The second strand comprises professional accountability to the pupils through the education department (SEPB (d)). The results further suggest that although the two types of accountability outlined were never clearly articulated as SEP policy, the practice within the project indicates that this was how accountability was perceived.

It was further found that the majority of informants shared a view that accountability of SEP should be understood within the historical and political changes in the country (SEPB (h)). Some with a long experience with the project and the development of the NGO sector expressed an opinion that NGOs including SEP had an unusual degree of autonomy and that, because they have been able to claim enormous accountability to mass democratic movements, little attention was paid to their accountability (SEPB (f)). However the general feeling was that, in the light of the political changes, this position according to the informants had changed dramatically and the issue of accountability needed to be redefined as well.

Furthermore, the researcher found that the majority of policy-makers associated with SEP linked the accountability of the project with its effectiveness in terms of improving examination results. This condition was problematic on two grounds. In the first instance, informants close to policy-making argued that it was never the project's intention to evaluate its effectiveness in terms of examination results because the examination-driven system in South Africa conflicted with SEP's philosophy and methodology (Sci Ed (a)). Second, SEP has up to 1995 been operating in standards 6, 7 and 8 and therefore standard 10 results in science were perceived to be an inappropriate indicator of the project's effects on the system.

7.4.2 Governance and funding of SEP over time

The findings confirm that some gaps existed between policies on the one hand, and implementation realities relating to SEP's relations with the education authorities on the other. The perception held by SEP implementers in general, and those in the Gauteng region in particular was that, "*the new Ministry of education was never satisfied with the cluster system of serving schools as proposed by SEP*" (GSEP (c)). According to this view, "*the Ministry preferred that the implementers should service larger numbers of schools*"(GSEP (c); (d); (e)) and should not concentrate on only a few schools in the cluster. As far as this issue is concerned, there was also some kind of despondency among SEP implementers that their positions were adversely affected by what they perceived to be "*undefined policies between SEP and the education authorities*" (GSEP (d)). Most of them expressed fears that their contracts might be terminated at any time.

In addition, interview results support fears expressed by the implementers earlier that there was no longer receiving enough money to continue with its operation in 1995. Accordingly, contrary to the intentions and statements from the education authorities and SEP, the fears expressed by the implementers earlier seem to have been correct because the project in 1995 has ceased to operate by means of implementers and had changed its intervention strategy significantly.

The findings further support the project's managers and implementers that, like many other NGOs, SEP was negatively affected by the new funding procedures. Accordingly, the decision to curtail the project's operations in the regions was taken by the Board because the latter feared that continued expansion was going to compromise the quality of the project's operation. However, it is clear that the role and functions of the project changed significantly from that of an NGO, to that of a consultancy. This was necessary because SEP was no longer receiving generous support from the donors and sponsors. Consequently, SEP has had to reposition itself and begin to compete with other projects providing innovation and change. Lastly, the researcher found that some informants pointed out that there seemed to have been a general complacency among SEP people that because the project had such a good track record in its intervention and that it had both human expertise and organized structure that it would automatically be given the opportunity to continue its work within the new dispensation.

The researcher made the following conclusions based on the results:

- that the past government's policy towards the NGOs and the private sector was unfriendly and hostile because these were perceived to be undermining the state ideology of separatism in education.
- that despite the perceived hostility at the time, NGOs such as SEP and the private sector continued to provide and deliver an alternative science curriculum.
- that because SEP was operating with pupils from the then illegitimate system, it was sometimes accused of being too reformist compared to those that operated without having to interact with pupils from the former education systems.
- that innovation projects in science needed to reassess their intervention strategies in the new dispensation.
- that the nature of relationships with the various stakeholders with an interest in a particular innovation is a major determinant of whether the latter will succeed or not.

- that accountability did not emerge as a primary concern in the 1970s and 1980s.
- that education authorities may implicitly discourage innovation, and further that whether innovation and change will be sustained in a particular context is largely influenced by the relationships between the project's staff and individual education officials more than the official policies.
- that sponsors and donors are likely to fund projects with more than one aspect such as improving learning and teacher development.
- that there were shifts in SEP's culture and ethos from the one of brotherhood, cooperation and support to one governed by formal procedures.
- that the investigation into this aspect of SEP contributes to the debate surrounding the future role of the NGO/CBO sector in the provision and delivery of education in South Africa during the close of the twentieth century and beyond. The results from this part of the work reinforce the perceptions that the very idea of foreign donors preferring to channel funds through any government institution posed a serious threat to SEP as an example of an NGO. The case study also sheds light on the assertion that funds are often directly or subtly used as a controlling device in education.

7.4.3 Implications

The following are the implications relating to the evaluation and accountability in SEP:

- in view of the general belief that the government is now legitimate, interview results suggest that SEP needed to review its policy and convince the donors that the project could still contribute as a delivery agent of innovation and change in science education.
- that while in the past it was accepted that projects such as SEP were bringing qualitative changes in the system it became necessary that SEP should demonstrate its effects on student performance in the new dispensation.

- that SEP needed to prove to the donors that it was operating effectively and efficiently by remaining outside the bureaucratic education system. The view that SEP should limit itself to Standards 6, 7 and 8 and do justice to improving science in these standards may be just one way of ensuring its effectiveness and efficiency in the system.
- that accountability is central to the understanding of the relationships between the education system and the project in the provision / delivery of education.
- that the debate around accountability in this study has shed light on the need for some kind of accountability of projects such as SEP in the new education dispensation.
- that while formative evaluation was, according to the informants, carried out consistently, summative evaluation conducted by external evaluators was rare within SEP.

7.5 SUMMARY

This chapter focused on a discussion of issues relating to the relationship of SEP with stakeholders insofar as the delivery of innovation is concerned. It was pointed out that the nature of the relationship between SEP and stakeholders in the implementation stage of the project varied during the period under review. Themes and trends explored in this chapter and the sources of data were identified. Issues explored in it include:

- The relationship between SEP, the donors and education departments from 1980 to 1995.
- Evaluation and accountability in SEP during the period under review in this thesis.
- Implications of the nature of the relationship between SEP and stakeholders for the implementation of the project's philosophy.

The chapter described ways in which the relationship between SEP on the one hand, and the donors, education departments and stakeholders on the other changed during the period under review in this thesis.

CHAPTER EIGHT

INSTITUTIONALIZATION OF INNOVATION AND CHANGE

8.1 INTRODUCTION

Chapter Seven analysed the relationships between SEP and its stakeholders as far as innovation and change in science education are concerned. This chapter analyses empirical findings relating to the institutionalization of the project's innovation and change. See Chapter Five for the procedures followed to analyse data in this chapter.

Institutionalization in the context of this thesis refers to a process where innovation and change or the project's philosophy, principles and practice become part of the education system. The term is therefore seen a part of a continuous process comprising the different phases of innovation and change. The extent of institutionalization is thus a way of assessing the effects and effectiveness of an innovation. However, results further indicate that the institutionalization process was to be understood in the context of varying conditions within which SEP was operating. Themes and trends explored in this chapter as well as sources of data are represented in Table 25.

RESEARCH QUESTION FOUR

How did SEP deal with the issue of institutionalizing its innovation and change?

Table 25: Themes and trends explored in Chapter Eight and sources of data

THEMES AND TRENDS	SOURCES OF DATA
Specific strategies were developed to institutionalize SEP's methodology	- interviews with senior SEP staff, members of the Board of Trustees, Executive Directors - analysis of the project's documents and records
Specific strategies were adopted to institutionalize SEP's methodology in the post-election era	- interviews with SEP members of Board of Trustees, senior SEP staff, elite policy-makers inside SEP
i) SEP's policy of keeping contact with teachers aided the institutionalization of its methodology ii) The policy of recycling teachers aided the institutionalization of SEP's work	- interviews with policy-makers within the project, SEP implementers SEP Executive Directors and analysis of the project's documents and records - interviews with SEP Directors, elite policy-makers, SEP implementers and the analysis of the project's documents and records
SEP's methodology was sometimes used with little or no support from the education authorities	- interviews with former SEP managers, implementers
Teacher commitment and administrative support are necessary for sustained-implementation of SEP's innovation and change	- interviews with former SEP managers, implementers and Executive Directors
SEP was accountable to its clients in the 1980s but became accountable to funders in the 1990s	- interviews with former SEP staff who were involved with the project in the 1980s and 1990s
Factors in the environment affected SEP's innovation and change	- analysis of SEP documents and records - interviews with SEPs staff, elite policy-makers and its members of the Board of Trustees
i) Meaning of institutionalization in SEP ii) Institutionalization of innovation and change depends on commitment and enthusiasm of the teachers	- analysis of SEP documents - interviews with SEP staff, elite policy-makers and members of Board of Trustees - interviews with SEP senior staff, elite policy-makers

8.2 INDICATORS OF INSTITUTIONALIZATION IN EDUCATION SYSTEMS

Results of interviews and analysis of SEP documents suggest that practical steps taken to enhance sustained-implementation included: school-based INSET, teacher secondment models including a partnership between the traditional pre-service INSET and the utilization of an implementer (an experienced science teacher) to support the teachers in small groups, and the recycling of both the teachers and implementers. 'Recycling process' in the context of SEP meant a system where people were given the opportunity in and outside the project to work in the education departments. The recycling of the project implementers and teachers was employed to promote institutionalization of the project's innovation. "*The recycling involved a policy of sending teachers to Leeds University and then to negotiate their secondment when they returned*" (GSEP (a)). Further, recycling meant sending these well trained and experienced teachers back to the departments. The intention was to ensure that the seconded teachers and implementers spend some time in the project but also that they be reabsorbed into the system.

Interview results with the majority of SEP staff and users show that the project's philosophy, methodology and practice had indeed become part of the teachers' daily routine as was envisaged in SEP policy.

Results of interviews and the analysis of SEP's documents and records reveal the following indications of institutionalization of the project's work:

- Teachers and pupils made use of SEP's material and kits even when the implementer was not present. However, some implementers observed that in some cases, teachers made use of SEP kits and material only when they were visited by implementers who usually prearranged their visits (GSEP (a). "*When I visit*

schools, I don't just go into the classroom, I make prior arrangement and when you do so, teachers normally use SEP kits but you cannot be sure of what happens when an implementer is not present" (GSEPIM). Some implementers dismissed the suggestion that the kits and material were used only when the implementer was visiting because evidence demonstrated that pupils were familiar with the apparatus. An evaluator confirmed the view that students were familiar with the project when he said: "*I found plenty of evidence that teachers were using the project's worksheets and apparatus even in cases where my visits were unannounced*" (Sci Ed (g)).

- In some cases in the regions, even schools and teachers who were not supplied with the kit and material attended SEP-organised workshops and seminars and made use of its methodology. Consequently, the teachers involved the pupils in the learning of science processes making use of SEP's recommended methodology even if they were not officially listed as SEP schools. However, the level of use of the project's philosophy, methodology and practice varied from region to region and from school to school.

8.3 THE INSTITUTIONALIZATION OF SEP'S INNOVATION AND CHANGE DURING THE APARTHEID ERA

Results of interviews with senior SEP staff and the analysis of the project's documents and records suggest differing opinions on whether SEP's philosophy and practice on innovation and change were to become part of the apartheid education (old) system and the post-apartheid (new)one. The uncertainty surrounding institutionalization of the project's innovation and change related to the extent to which the project was to remain and to whom it was to be accountable.

Furthermore, these results indicate that attempts to institutionalize the project's philosophy and practice were clearly located within the context of the historical, ideological and political situations within which SEP developed and operated. Consequently, institutionalization in the context of SEP's work was generally discussed in terms of whether innovation and change were conceptualized as part of the 'old' system of education (during apartheid), or within the context of the new democratic dispensation which began in the 1990s. In this regard, the researcher found that opinions on institutionalization also varied according to perceptions, needs, aspirations and interests of the different stakeholders in the project.

Results suggest overwhelming agreement between both the former and current SEP staff that it was crucial that the project should maintain its autonomy during the 1970s and 1980s. The need to work towards making the project autonomous was apparently prompted by the donors who were asking questions about how long they were going to continue funding SEP, and when the project was going to institutionalize its practice and embed itself in the national education structures (SEPB (f)). Results from senior SEP staff suggest that the term 'lodging' had become part of the discourse which describes a situation where the project was allowed to remain autonomous and therefore think creatively, but work within the system in the 1980s (SEPN (h); (i); SEPB (b)).i.e, lodging its practice and philosophy, but not its organizational structure and autonomy.

Interview findings of the analysis of the project's donors reveal uncertainties as to whether the project should remain autonomous or not, this was also discussed in relation to the context of the project working within the system at different times in history. A senior staff member who had extensive dealings with the project pointed out that SEP could not become embedded in the system for ideological reasons (SEPN (d)). The major concern expressed by the majority of the project staff was apparently that

"autonomy of the project would ensure that it did not become contaminated by association with the then discredited education system of the eighties" (SEPB (b); (d)). According to one experienced user (GSEPU (hh)) SEP *"had to remain autonomous and not be 'magnetized' to any education department"*. The argument went on that *"the organization itself could not institutionalize, but rather that it should be the principles, philosophies and the action practice that must be institutionalized"* (GSEP (a); SEPN (d); (h); SEPB (g); SEPIM (h): SEPB (d)). Consequently, the issue of whether the project was going to institutionalize its innovation featured more prominently in the former Ciskei and Pietermaritzburg regions, where SEP started with its intervention strategy, than in newer regions.

As far as this issue is concerned, results from the project's documents and records as well as those from interviews with senior SEP informants concurred that the project could not change the conditions in schools while remaining outside the system as some intervention projects did. *"I don't think most community organizations had ever thought of intervening in the system in the way SEP did"* (SEPB (d)). Senior staff members in this regard pointed out that SEP expected certain conditions such as secondment contracts and freedom to visit schools to be satisfied because it was making available resources, equipment and its staff available to the departments of education in the 1970s and 1980s (SEB (f)).

Furthermore, the majority of the senior staff who had extensive experience with the project argued that SEP worked like a social movement by exploring various strategies of institutionalizing its philosophy and practice such as entering into private relationships with education departments, and through contracts. Consequently, the project had the capacity and responsibility to engage constructively with the system and was not to be seen as a 'social welfare service'.

In addition to autonomy as an overarching policy of SEP, results of interviews with the project implementers suggest that the Pietermaritzburg region could have been afforded greater autonomy from the Centre for Adult Education which accommodated it, as well as from SEP National because it was more advanced than other regions. Concerning this issue, a concern was raised that there was a gradual shift from that region having a degree of autonomy towards greater control being exerted by SEP National between 1989 and 1990 (Moodie 1980; MacKie 1991).

8.4 INSTITUTIONALIZATION OF INNOVATION AND CHANGE IN POST-ELECTION ERA

Results of interviews with SEP staff and members of the Board of Trustees show some divergent interpretations on whether SEP's philosophy and practice in the 1990s should be institutionalized or not. In this regard, the majority of senior staff members in the project as well as members of the Board of Trustees supported a policy that SEP should remain autonomous and it should institutionalize its philosophy and practice even in the new system of education (SEPB (g); SEPN (h); SEPB (d)). Institutionalization of SEP's practice was generally associated with the project's autonomy and there was a fear that it might become part of the bureaucracy that characterizes education systems (SEPN (d)). However, for some, institutionalization of the project's practice was an inevitable and desirable stage of successful innovation and change.

Despite the varying perceptions about institutionalization, strong indications from available results were that the project's philosophy had in fact become part of the teaching and learning of science in standards 6, 7 and 8 in the Transkei and in some schools in the Pietermaritzburg and Eastern Cape regions. A view that the project's philosophy was indeed institutionalized in some schools and regions was supported by empirical evidence

that even schools and teachers who did not have the project's kits and material because of limited supply, were still using SEP's philosophy in the learning and teaching of science (Bateson 1995). Consequently, the funders were apparently satisfied that there had been evidence of the institutionalization of the project's work in the various regions (see Fullan and McLaughlin 1978 in Chapter Two of this thesis for the explanation of patterns of institutionalization process).

The researcher found the following on the institutionalization of the project in the post-apartheid era:

- Even though some schools were not provided with the project's apparatus and material, the principals encouraged the teachers to attend SEP's workshops because they believed in its intervention strategy and approach to improving science. Transkei is an excellent example of a situation where the project's philosophy and practice became part of the teachers' daily routine.
- Individual schools and teachers used the SEP approach despite the inadequate support they received from the education authorities. Consequently, there had been cases of what could be termed isolated institutionalization of innovation and change of SEP's work with the following implications:

First, the notion of complete or total failure of institutionalization of innovation and change is problematic because this thinking ignores the fact that different levels of use exist in this process. Second, the levels of use of SEP's innovation and change varied from whether the teachers were trained in the SEP approach, to situations where they could actually use the innovation in the classroom. In addition, the levels of use served as a guideline when evaluating the extent to which the SEP innovation was sustained (see also the detailed examination of these 'levels of use' in Chapter 2 of the thesis).

However, the researcher further found that there was a concern around the wholesale institutionalization even within the democratically elected education system. This was articulated in this way by one of the senior SEP staff whose views represented the majority (SEPB (b)): "*I think as soon as SEP becomes wholly institutionalized, its innovation and change will fall away. What we want to do is to influence the education department to accept SEP's methodology*". Also *"you can institutionalize the practice, the way of teaching and this is what SEP has been trying to do whether departments supported them or not*" (SEPB (a)).

8.5 STRATEGIES ADOPTED TO INSTITUTIONALIZE INNOVATION AND CHANGE

8.5.1 Contact with teachers

Results of interviews with policy-makers within the project indicate that the intention of the project developers was to promote the institutionalization of the project's practice by exposing trained teachers to its methodology and philosophy at the pre-service phase of their training. It was believed that by introducing the teachers to innovation and change they would be familiar with the project's philosophy and practice eg "*I think SEP must begin to focus on the pre-service and not concentrate on INSET only*" (GSEPU (cc)). However, the findings revealed:

- That the intention of introducing the teachers to SEP's philosophy and practice during their pre-service training in the 1980s was not implemented in the 1990s.
- That SEP adopted a policy of recycling to Leeds University and to negotiate their secondment back to the education departments as a strategy of institutionalizing the project's principles and practice effectively (GSEP (a)).
- That informants concurred that SEP's innovation and change would not be easily institutionalized unless the system was 'open' to the extent that it would allow and

explicitly support the project in various ways. As far as support from the education departments was concerned, the findings suggest that innovations were given the blessing of the education authorities at a higher level. This means that SEP's innovation stood a better chance of success if it was supported by the education officials openly rather than remaining lukewarm about it: *"Every change agent hopes to influence the system and it is equally SEP's intention to influence the system by negotiating that its philosophy should become part of the system"*(SEPB (b)). Consequently, evidence exists to show that the implementation of new ideas such as those proposed by SEP survive even if they are supported only by individuals in the education system.

8.5.2 Contact with education administrators

The findings from interviews with SEP staff indicate that SEP's intention was to institutionalize its practice on how science should be taught even if there was minimal support from the departments of education in the regions where the project was operating. Results of interviews in this regard show that the project was to operate through regional managers and especially the project implementers whose main tasks were to support schools and teachers within a 'cluster' (SEPB (b)). The term 'cluster' is an indigenous word coined and used within the project's community, and involved the grouping of schools according to certain criteria set out by the project itself. Results indicate that the 'cluster' model contributed significantly to institutionalizing SEP's model of innovation and change in science education in the regions.

Interview results and the analysis of SEP's documents and records further suggest that the strategies adopted by the project to strengthen the institutionalization of its philosophy and practice were only partially implemented while others were never implemented at all. For example, the recycling of the project implementers and the teachers depended largely on the attitudes of individual education officials towards the project.

8.6 FACTORS WHICH INFLUENCED INSTITUTIONALIZATION OF SEP'S INNOVATION AND CHANGE IN SCIENCE

Results of the analysis of the project's documents/records and interviews indicate that the innovations and changes introduced by the project were not sustained in some regions because of factors inherent in the educational environment in these regions. However, results imply that while some inhibiting factors could be attributed to the attitudes of the education departments, some were purely the result of the structural features of education in general in South Africa. It further became clear from the results that some of these factors were not limited to SEP, but affected all science teachers and most innovation and change initiatives in the country. Specific factors that militated against the institutionalization of the project's philosophy and practice were:

- overcrowding in science classes in many black schools.
- the non-recognition by the department of the burden facing science teachers in general and SEP teaches particular.
- the large turnover of science teachers
- unsympathetic attitudes of education authorities and principals towards the needs of science teachers, eg allocation of single science periods
- the type of examinations required by the education system

The researcher found from interview results and from the literature that certain factors tended to militate against the institutionalization of SEP's innovation and change. The attitude of the education authorities towards SEP as a change agent and their perceptions the innovation and change it had facilitated emerged as a major concern from these results. As far as this is concerned, it was pointed out, using SEP as an example that innovation in education often fails or is discontinued because such innovations are either explicitly or subtly discouraged by the officials in education. The policy-makers further endorsed perceptions that emerged that certain mechanisms needed to be employed to strengthen

institutionalization of implementation of innovation and change. As far as the importance of institutionalization is concerned, the data suggests that this process should be pursued and that it can succeed even if it is not explicitly supported by the education authorities.

Further the researcher found from the results that the kind of institutionalization envisaged relates to a situation where the project's work became the daily routine only in certain schools and circumstances. This means a situation "*when the officials do not actively or explicitly curtail the project but give it inadequate support*" (see Berman and McLaughlin 1978 in Chapter 2 on the detailed examination of patterns of institutionalization). As far as this issue is concerned, results of interviews show that often innovation fails to be institutionalized because of the examination-oriented system which emphasises a product orientation to learning rather than a process orientation. Consequently, the examination system was found to be one of the major impediments in promoting institutionalization of innovation and change. The majority of informants were of the view that small innovation projects such as SEP stood a better chance of ensuring quality of science teaching because they are relatively small when compared to large bureaucratic education systems of a country.

8.7. EVALUATION

8.7.1 The meaning of institutionalization

The researcher concluded from the results that there is a need to analyse the meaning, policy and theories underlying institutionalization of innovation and change and making it part of the education system into which it is introduced.

First, it was found that although institutionalization is often regarded as the last phase of innovation and change, the process is not as linear in practice. The findings confirm the

views expressed in the literature that initiation, adoption, implementation and institutionalization did not follow a neat pattern in the regions in which SEP was investigated. The various phases constitute a 'seamless garment' in practice to the extent that it is misleading to conceptualize initiation as the first phase and institutionalization as the last in the four regions.

Second, it was concluded that institutionalization should not be perceived as a product because it is difficult to set up time-frames to judge whether innovation and change have been institutionalized or not. This view was endorsed by the fact that no significant patterns emerged in the regions where the project was introduced first, and where it was introduced last. In other words, institutionalization depends on a range of complex factors, not time elapsed. The results of interviews and of SEP documents confirm a view in the literature that institutionalization of innovation and change occurred at various levels in the system and that it often follows different patterns. Accordingly, institutionalization of innovation and change usually varies according to the levels of use and the contexts within which it is implemented. It emerged from the study that the process of institutionalization varied at national, regional and at classroom levels. The results further suggest that institutionalization is more likely to be sustained if it is endorsed and adopted by the schools than if it is imposed. The case study suggests that divergent opinions as to whether SEP innovation should be institutionalized or not often resulted from confusion about the intention of those who participated in this process. For NGOs like SEP that clearly wished to operate outside the system for political reasons, institutionalization for the majority of staff meant becoming part of the system. The results of this investigation shed light on the problem of assuming that sustained-implementation necessarily meant the entire organization institutionalizing, as many people tend to think is the case.

Thirdly, the results of interviews confirm the views in the literature and from informants that it was not only feasible, but also desirable that the project should institutionalize its principles and practice without itself becoming part of the education establishment even in the new dispensation in South Africa.

Fourthly, the researcher found out that this study supports the findings of previous research conducted elsewhere that institutionalization of innovation and change is often not obvious. Consequences of subtle and implicit sustained-implementation of innovation and change were confirmed through the following instances:

- The project continued to be used by the teachers despite the negative responses from the top education officials in the regions towards SEP.
- Some individual schools encouraged the teachers to attend SEP courses even in instances where the education department in a region was not supportive of the usage of the project's methodology.

8.7.2 Institutionalization of innovation and change by SEP

The results shed light on the inherent conflict of policies in institutionalizing innovation and change on the one hand, and maintaining the autonomy or independence of NGO innovation projects such as SEP on the other. As far as this issue is concerned, the results highlight that some SEP staff were reluctant to support the institutionalization of innovation and change because they felt that SEP would thereby become redundant.

However, fears relating to institutionalization seem to be founded on a conceptual framework that conflates institutionalization of the philosophy and practice with institutionalization of the organization. While some people within SEP could make this important distinction, some could not and remained suspicious of the term.

8.8 SUMMARY

This chapter focused on the analysis of empirical findings relating to the institutionalization of SEP's innovation and change. The mode of analysis undertaken in this chapter was evaluative, based on the data obtained from the project's documents/records, the literature on innovation and change, SEP personnel and other stakeholders. Themes explored in this chapter include:

- Indicators that SEP's philosophy was institutionalized during the period under review;
- The institutionalization of SEP's innovation and change during the apartheid and post-apartheid eras, and strategies adopted to institutionalize the project's philosophy during the period under review;
- Factors in the environment which influenced the institutionalization of SEP's innovation and change in science; and,
- Evaluation and implication of the institutionalization of SEP's work during the period under review.

It was also shown in this chapter that the institutionalization process is not linear in practice, that institutionalization varied according to the levels of use and the contexts within which it was implemented. Further, it was suggested in this chapter that the project's philosophy became part of the teaching and learning of science especially in the former Transkei region.

CHAPTER NINE

IMPLICATIONS, LIMITATIONS AND THE NEED FOR FURTHER STUDY

9.1 INTRODUCTION

Chapters Five, Six, Seven and Eight focussed on the analysis of results of the investigation in the four regions under review.

This chapter examines the implications derived from the investigation, the limitations and the need for further study.

9.2 THE FRAMEWORK OF THE INVESTIGATION

The analysis has highlighted four major implications of the evaluation framework used in this research: First, a framework that conceptualizes curriculum as a dynamic interaction between the vision and policy of those involved in curriculum development on the one hand, and the implementation thereof on the other has proved useful in the current study. The implication is that the evaluation framework and models used in this study could be of value in other situations. For example, the framework and models could serve as guides to other change agents and researchers. They could also be used to demonstrate that the presence of any of the so-called stages of innovation and change will not automatically lead to subsequent ones and that vision and policy are not necessarily translated into practice as intended.

Second, the evaluation approach adopted in this study has provided useful guidelines for analysing stated aims and goals of innovation and change. The implication is that similar approaches could be used by other researchers to evaluate the implementation and institutionalization of innovation and change.

Third, Chen's theory-driven perspective which distinguishes between intentions and their implementation has been found to be useful in analysing the intended and unintended outcomes of SEP's innovation and change. The implication is that the theory-driven approach to evaluation, which assumes that there is a theory underpinning each project's work, could be useful to researchers undertaking evaluations of the work of other innovatory projects in the future.

Fourth, the revised grounded theory methodology adopted to investigate SEP has enabled the investigator to collect data from a field setting and to analyse stakeholders' perspectives and perceptions on the project. The implication is that grounded theory may provide other researchers with a methodology for conducting action research or evaluation research, providing a way of distilling theory from the work of projects in applied settings.

9.3 FINDINGS

Other implications of and insights drawn from the study are described below. These implications and insights relate to the conceptual and analytical framework adopted in the research and are discussed under the four research questions.

9.3.1 Conceptual and analytical frameworks adopted

It was indicated in Chapter Three that the research data were collected and analysed within the constructivist paradigm relevant to a non experimental research situation. Grounded theory methodology provided the overall framework to investigate multiple-perspectives and perceptions of SEP. Insights gained by following this approach were inter alia:

- the research revealed convergence or divergence evident in the data relating to vision, intention, policy on the one hand and what was happening at the implementation on the other.
- the research highlighted variations regarding the implementation of the project's innovation and change in the various regions under review over the time period covered.
- the framework aided in examining perceptions of the different participants

about SEP.

- triangulations employed throughout the investigation highlighted the importance of reconciling divergences that emerged when analysing data from different data sources.

The constructivist paradigm and the grounded theory methodology adopted in this report provided useful analytical frameworks to analyse the extent to which the users' advocacy and perceptions influenced the implementation of innovation.

Furthermore, the study suggested ways of reducing data collected in a non experimental situation. Insights and implications on the four research questions relating to vision, intention, policy and implementation are discussed in turn.

9.3.2 Vision, intention and policy relating to models of curriculum development, innovation and change

RESEARCH QUESTION ONE

How effective and enabling were SEP's models of curriculum development and its approaches to innovation and change?

- The vision, intention and policy of SEP were reasonable and attainable in the context of South African education in the 1980s and 1990s.
- Models of curriculum development and approaches to innovation and change adopted during the different times of the project's development were enabling and appropriate for the conditions that existed at that time.
- There was a shift of vision and policy relating to the culture and ethos of SEP, from one where individual staff members were regarded as change agents in the 1980s to one where SEP was positioned as an INSET project in the 1990s and beyond.
- There was a shift in SEP's culture and ethos from one of cooperation and support in the 1980s to the one governed by formal procedures as from 1989 and beyond.

- There was a shift in SEP's culture and ethos from one of cooperation and support in the 1980s to the one governed by formal procedures as from 1989 and beyond.
- SEP's vision and policy relating to the project's culture and ethos were characterized by efficiency, cost-effectiveness and a sense of accountability from the staff.
- In a number of cases gaps existed between the vision, intention and policy on the one hand and the practical implementation of SEP work on the other.
- SEP's model of INSET was very effective but the usage of implementers and the project's rapid expansion proved too costly during the 1990s. Accordingly, the project stopped operating through implementers in the regions because of financial constraints.

9.3.3 The teaching and learning of science

RESEARCH QUESTION TWO

How was the teaching and learning of science conceptualized in SEP?

- There existed a number of contradictions with regard to the adoption of the 'process' and the constructivist approaches in examining SEP's intended and unintended outcomes in the current study.
- The shift of policy from the process to constructivist approaches was never clarified and made explicit to the staff at the implementation level of innovation and change. Consequently, no differences were found between the teaching of science by the project teachers according to the process approach or the constructivist approach.
- SEP's portable science kits were used by the majority of the project teachers while its methodology was used even by some of the schools which were not provided with the apparatus but whose teachers attended SEP's workshops.

- Teacher demonstration as opposed to pupil experimentation dominated the teaching and learning of science in SEP classrooms.
- Practical work was conceptualized differently by project staff at national and regional levels. Thus, the distinction between teacher demonstration and practical work involving the pupils highlighted the problem of assessing practical work in SEP classrooms.

9.3.4 Relationship between SEP and the education departments

RESEARCH QUESTION THREE

How did the nature of the relationship between SEP and other stakeholders affect the implementation of the project's work?

- SEP was funded in the 1970s and 1980s because it was considered a long term investment by the donors. SEP was multifaceted and the donors were convinced that the project was making qualitative changes in science.
- NGOs such as SEP played a major role in providing innovation and change in science in the 1970s and 1980s.
- Shifts in the culture and ethos of SEP 1980s. The organization changed from one characterized by cooperation to the one governed by formalized procedures. This had implications for implementation in the financial flow from 1991 onwards.
- SEP needed to change its policy in response to the changing material conditions of the 1990s. However, it was found that the project was unable to respond quickly enough to these changing conditions.
- The channelling of money intended for NGOs through the government affected funding procedures, the autonomy and accountability of SEP and other NGOs. The channelling of money for NGOs through the government resulted in the usage of funds to control the NGO sector in post-apartheid era.

- Only NGOs that belong to the newly created NGO coalition were likely to benefit from the funds administered by the government in post-apartheid South Africa.
- SEP had the potential to carry out innovation because of its size and location when compared to the huge bureaucratic education system. However, this possible in the 1980s but not in the 1990s due to rapid changes in education authority, government policy and funding of NGOs.
- Accountability was not a major concern in the 1980s but became a major preoccupation in the organization in the 1990s.
- SEP was acceptable to its clients in the 1980s but became accountable to funders in the 1990s. The project moved from operating in a relatively autonomous way in the 1980s to being more influenced by bureaucratic control.
- The envisaged relationship between the government and the NGO/CBO sector as proposed in the Not for Profit Making Organizations Act of 1997 highlighted the need to review the criteria through which accountability is measured.
- It appeared from the analysis that there is a need to rethink and review the relationship of the NGO/CBO sector with the government, something that never arose in the 1970s and 1980s.
- NGOs in South Africa are faced with a challenge of redefining their roles and intervention strategies during the post-apartheid period.
- In the context of SEP stakeholders expressed a view that changes in government and in education policy would affect the autonomy of SEP and its survival.
- As a general rule however, the need for a cordial relationship among the stakeholders appears to be an important condition for the success of innovation and change.

- Stakeholders hold and will continue to espouse divergent views on accountability and autonomy of the NGO/CBO sector in the new dispensation in South Africa.

9.3.5 Institutionalization of innovation and change

RESEARCH QUESTION FOUR

How did SEP deal with the issues of institutionalizing its innovation and change?

The study has highlighted a number of insights into institutionalization of innovation indicating that this should be seen within the particular social, political, historical and ideological context of a country. Insights that emerged are as follows:

- Institutionalization meant different things to different SEP stakeholders. To some it meant that the project was to become part of the education system and lose its innovation while to some it meant only lodging SEP's methodology in the education system.
- Institutionalization and accountability during 1980 to 1989 were matters of internal concern to SEP while these became external concerns as from 1991 to 1995. The differences between the two periods are that SEP was accountable to its clients during developmental phase but became accountable to the funders and education departments during the expansion and consolidation phases.
- Autonomy of SEP was paramount during the apartheid era because the project did not want to be associated with the discredited education system of the 1970s and 1980s. However, the project continued to work with pupils in the discredited education system while it remained autonomous.
- Institutionalization of SEP's work varied from school to school and depended largely on teacher mastery, commitment and other factors in the education system and in the environment.

- The support of the education administrators is necessary for the institutionalization of innovation.
- SEP's methodology was used even in cases where the project was not explicitly supported by the education administrators at higher levels because the teachers identified themselves with the project.
- Sustained implementation at classroom level depends primarily on the interest and commitment of teachers often regardless of support from role-players at other levels in the education system.
- The findings revealed that many SEP schools and teachers did assimilate parts of the project with or without formal sanction from the various education authorities. This is a useful consideration to be borne in mind in the evaluation of the impact of a particular innovation on the education system.
- Introduction of innovation and change in one area does not necessarily mean that such an innovation will become part of the teachers' daily routine. This research has contributed to knowledge on theories, models and approaches relating to the institutionalization process of innovation and change.

9.4. THE PRESENT POSITION OF THE SCIENCE EDUCATION PROJECT

This investigation into the Science Education Project has been guided by four research questions. These research questions emerged as a result of the investigator's interaction with the data on the project over a number of years.

However, the context and conditions within which SEP has been operating have been changing constantly. Issues that emerged as a result of the changing conditions of SEP are:

- the government's perception and attitude towards NGO/CBOs in a post-apartheid South Africa.
- the role of the governments and the NGO/CBO sector in the provision of science education and innovation and change in South Africa.

- the changing policy on the regulation and administration of funds from foreign donors and the business sector.
- advocacy by stakeholders on behalf of an NGO or lack of it.

The issues outlined in the paragraph above were not part of the original research questions but developed during the process of data analysis and during the writing-up process. The investigator's conclusions on the issues above are summarized in the following way: First, it is evident that perceptions of the government and those of the public in general towards the NGO/CBO sector changed dramatically after the first democratic elections in South Africa. Expectations had been that this sector should work in partnership with the democratically elected government.

Second, findings clearly suggest a shift of emphasis from the role of NGOs as providers of alternative curricula to that of being service providers working in close cooperation with education departments.

Third, the creation of a body through which the funds from donors are currently channelled has had an impact on the autonomy and accountability of NGOs. The expressed and subtle ways in which the activities of NGOs have been controlled have been received differently by people of different political persuasions. One of the reservations expressed about the current arrangements is that the system has become bureaucratic and that this tends to hinder the flow of funds to their intended destination.

Fourth, it should be noted that SEP changed its intervention strategies in response to the present conditions. This implies that SEP had to develop alternative intervention strategies if were to continue with its work. Accordingly, SEP began to operate as consultancy for organizations and schools interested in its work. In view of the financial crises facing NGOs, SEP discontinued the use of implementers and this was followed by the resignation of the Executive Director and appointment of two co-directors one of whom resigned at the end of 1997.

However, SEP is still doing some work on limited funds from some donors but is currently working as a consultancy.

9.5 LIMITATIONS OF THIS INVESTIGATION

9.5.1 Research paradigms, research methods approaches and perspectives

According to the chosen paradigms adopted in this research, the investigator ought to be able to penetrate the perspectives and meanings of the participants (Cohen and Manion 1994; Denzin 1970). The weakness of this study lies in the fact that the perspectives and meanings of such participants were influenced by the political and social contexts within which SEP operated over time. Perspectives and perceptions therefore varied according to whether participants belonged to what came to be known as 'old' or 'new' generation in the project. The conditions therefore reflected more the individual's positions and the contexts than those of the project itself.

9.5.2 Case study

Yin (1994) points out that a case study explores a single unit which could be an activity, a programme, event or a process bound by time. Generalization of the findings was never the intention in the current investigation and the conclusions arrived at may be regarded as limited as they cannot necessarily be generalized to other similar projects. As far as the generalization of the results is concerned, it can also be argued that generalization would also be unrealistic for the entire project because of the varying contexts. The realization of the limits of generalizing results serves as a caution to other researchers who may adopt a case study approach in future. Furthermore, the results of the case study revealed widespread diversity on the various issues to the extent that generalization to other regions could be misleading.

9.5.3 Sampling

According to the multi method, multi perception and triangulation methods that formed the basis of this study, analytical inductive or purposive sampling procedures were found to be most appropriate for collecting the data (Denzin 1990). Although these procedures were useful in this investigation, they might constitute a weakness in as far as they decrease the generalization of the findings.

The grounded methodology approach and purposive sampling influenced the choice of the project's documents and records. The choice of purposive sampling led the investigator to sample from a variety of project documents and records that were written for diverse purposes and compiled by different people in varying contexts. Consequently, what were considered real issues in the 1970s and 1980s are no longer considered as such in the 1990s. nother limitation of the study relates to the debriefing sessions in order to verify and confirm the findings. In the first place, some informants, especially the teachers who provided initial data on the project, could not be traced in order for them to comment on the findings because the project had ceased to operate through implementers in those regions. Secondly, some of the former SEP staff could also not be contacted because they too have moved to other employment following the collapse of the project. Thirdly, some individuals of the remaining SEP were reluctant to comment further on the findings.

9.5.4 Instruments

The data from the observation of science lessons were analysed by utilizing Lewin's (1990) original work. Lewin's schedule as explained in Chapter Three of this investigation comprised a three level scale to indicate the degree of pupil participation in a lesson. However, limitations of Lewin's schedule were revealed in this investigation.

One such limitation is that the schedule forced the researcher to compartmentalize the teaching and learning process into time intervals within which observations could be recorded. Consequently, the schedule has the limitations of slotting observations into quantifiable behaviour. However, the schedule proved useful if used with detailed note-taking during the observation and by means of follow-up interviews with the pupils and teachers. The schedule is, therefore, particularly appropriate for observing science lessons.

9.5.5 The project in the socio-political context of post-election South Africa

SEP's intervention strategies as far as innovation and change in science is concerned were located within the socio-political context of the time. On the one hand, the period of the 1980s was characterized by political instability that culminated in an education crisis in South Africa (Hartshorne 1989; Kallaway 1984; Schaffer and Morphet 1983 (a); (b); Morphet et al. 1986; Buckland 1984; Chisholm 1984). On the other hand, this study covered a period when reforms in education were articulated almost exclusively within the context of the de Lange Commission (1981) which clearly represented the government's view. Subsequently, the project found itself having to operate within totally new conditions following the first democratic election in South Africa.

The shortcoming of the investigation is that these important developments could not be discussed in more detail. An in-depth analysis of these historical developments would clearly have highlighted the power relationship that would explain the envisaged relationship between the present government and the NGO/CBO sector. For these reasons, further study is clearly needed to examine the historical developments of the NGO/CBO sector during apartheid education and in the post-election era.

9.5.6 The role of the NGO/CBO sector in the provision and delivery of innovation and change in education

The Reconstruction and Development Programme (ANC 1994 (b)) and the White Paper on Education and Training (Republic of South Africa 1995) raised issues relating to the provision and delivery of educational services. Paragraph 5 of the White Paper clearly states that the state has the responsibility of providing education. In addition to the provision, the policy on the delivery of educational services also became a matter of intense debate in the 1990s. Central to this debate therefore, have been notions of the accountability and autonomy of NGOs and CBOs within the democratically elected government in South Africa (Kahn 1993). Consequently, since the election of a new government in 1994 in South Africa, there have been major shifts in the relationship between the state and the NGO/CBO sector.

During this time, financial support of NGO/CBO from the donors was diminished rapidly in favour of the government's RDP.

However, this changing relationship between the state and NGO/CBO sector is beyond the scope of this study. Further investigation of the envisaged relationship needs to address the distinction between the provision and delivery of educational services in the post-election era in South Africa. Such a study would also cover issues of cost-effectiveness of the NGO/CBO vis-a-vis the efficiency of the bureaucratic education system.

Furthermore, there is a need to examine the policy and implications of the Bill in relation to the autonomy, accountability and the funding of NGO/CBO sector in the future education dispensation in South Africa. A detailed investigation of this Bill fell outside the ambit of this study partly because the Bill was introduced during the writing up stage. An investigation into the Bill needs to be undertaken in terms of two divergent views, one being that of the government and the other of the

NGO/CBO sector. These views may clarify claims that the Bill was nothing but a controlling mechanism to regulate the NGO/CBO sector (Douglas 1995 (a); The Citizen 1996). However, the government's policy and justification for redefining its relationship with the NGO and CBO sector will hopefully be clarified.

9.6 SUMMARY

The first part of this chapter focussed on the conceptual analytical frameworks employed to examine the various aspects of the Science Education Project investigated in this study. The frameworks adopted made it possible to evaluate the project's outcomes in relation to its original stated aims and objectives. By adopting these frameworks, it has become possible to establish the impact and effects of the Science Education Project in the four regions chosen for investigation. The current investigation therefore showed the relevance of the analytical models and frameworks while examining the preordinate aims of innovation and change and its outcomes.

The second part of the chapter focussed on the review of the paradigm employed in this study. The justification and pertinence of a post positivist paradigm in investigating a case study was presented. The conclusions arrived at in the chapter suggest that the grounded theory approach including its multi method and triangulation procedures, could be usefully employed in similar studies and research. However, problems relating to reduction of the data to manageable propositions were also pointed out

Other researchers working with a combination of documentary, interviews and observation data may find the analytical framework, suggested by Miles and Huberman (1994) and used in this study, useful.

The chapter also focused on models of curriculum development and approaches to innovation and change as well as the multi method approaches adopted in this study. The conclusion arrived at was that no single model can be said to be appropriate because of differing contexts and conditions in South African education in the 1989s. For example the role of NGOs in the 1980s differed from their roles in 1990 in respect to delivery of innovation.

The evaluation model adopted in this study enabled the investigator to examine both the intended and unintended outcomes of innovation and change under discussion. By adopting this model, it became possible to highlight policy issues and the intentions of the developers of innovation on the one hand, and what actually happened in practice on the other. The focus of the distinction between intention and practice, provide a useful framework to make informed judgments on curriculum development process as well as effectiveness of innovation. The model therefore provides important framework to investigate the aims and goals of the planners of innovation and the extent to which these goals were realized in practice.

The chapter concluded by outlining the limitations of the study. The limitations included those relating to research methods, approaches, perspectives and observation schedules used. Furthermore, the limitations in terms of what the study has covered and the need to undertake further study relating to some aspects have been acknowledged.

CHAPTER TEN

VALIDATION, VERIFICATION AND CONFIRMATION OF THE FINDINGS

10.1 INTRODUCTION

The investigator came to a number of conclusions when analysing and interpreting the findings in the previous chapters. The purpose of this chapter is to pull together the findings and to provide a general picture of what has been discussed in the previous chapters. The findings were subjected to further interpretation through the process of debriefing in order to provide a balanced picture of what was earlier reported about SEP. Miles and Huberman's (1994) procedures used are: weighing the evidence, checking the meaning of outliers, checking existence of extreme cases, following surprises, looking for negative evidence, checking out rival explanations and getting feedback from informants. Themes and trends subjected to debriefing were obtained from the analysis of data in empirical chapters.

A total of twelve informants participated in the debriefing process. They included Representative of the Department of Education in Gauteng province, SEP's former Executive Director, current Acting Directors, members of the Board of Trustees, sponsors, former senior SEP staff who was involved with the project in the 1970s through to the 1990s, former senior SEP managers and implementers as well as from the analysis of SEP documents and records. A copy of the thesis was presented to both former and current project staff in the Gauteng region while those in the other three regions completed a questionnaire based on a summary of the findings. The themes and trends explored in the debriefing are presented in tabular forms (Tables 26-29).

10.2 RESEARCH QUESTION ONE

How effective and enabling were SEP's models of curriculum development, and its approaches to innovation and change?

Table 26: Themes and trends explored in Research Question One and sources of data

THEMES AND TRENDS	SOURCES OF DATA
SEP used a discursive approach to introduce itself to the education departments SEP appealed to the value system of its users and clientele	- interviews with members of the Board of Trustees and policy-makers within SEP - interviews with member of the Board of trustees and elite policy-makers
SEP developers and its clientele became involved with the project for different motives and interests The culture and ethos of SEP differed during the various phases of its development The culture and ethos of the project were characterized by the spirit of brotherhood, cooperation and support	- interviews with policy-makers within SEP and members of the Board of Trustees - interviews with former SEP who were involved with the project during the 1980s and early 1990s. - interviews with former SEP staff who were involved with the project in the 1970s and 1980s through to the 1990s
The process of innovation and change is not linear in practice The levels of 'use of the innovation and change does not reflect the time when it was first introduced The use if the project's work varied	- analysis of SEP documents and records and literature - analysis of literature - interviews with SEP Executive Directors, former managers and implementers
SEP's model of curriculum development was accepted because it comprised many dimensions The models and approaches adopted were enabling and effective during the early days of the project's development	- interviews with SEP staff and teachers - analysis of SEP's documents and records - interviews with elite policy-makers within SEP - analysis of SEP's documents and records
SEP adopted a bottom-up model to disseminate its innovation	- interviews with elite policy-makers with SEP and former and current Executive Directors

THEMES AND TRENDS	SOURCES OF DATA
The CDU and RDU played and important role in implementing SEP's work	- analysis of SEP documents and records - interviews with former and current Executive Directors
There was insufficient consultation and cooperation between the regions and the Units	- analysis of SEP documents and records - interviews with SEP staff
SEP's model of INSET was suitable for the conditions in disadvantaged communities but turn out to be costly	- analysis of SEP documents and records - interviews within SEP staff at National and Regional levels

10.2.1 Models adopted to introduce the project to the education departments

The findings in the empirical chapters suggested that SEP was not introduced by means of a blueprint to the departments of education within which it was working. In contrast, the project operated like a social movement using a discursive approach where SEP was first introduced to the teachers, while the education departments learnt about it from these teachers. In terms of this approach, SEP developed concepts, words and stories which made it easier for the project to be accepted by the education departments even those which originally rejected it.

The conclusion that the project adopted a discursive approach in which the change agents oriented themselves to the needs of the teachers' value system through direct contact was confirmed in the debriefing process. It was confirmed that the most effective ways of introducing innovation require a change of attitudes and an appeal to the value systems of users or the clientele system.

Three former SEP's staff who were involved during in the 1970s and early 1990s confirm that the vision and policy relating to the culture and ethos of the organization differed during the development, expansion and consolidation phases of the project.

10.2.2 The aims and goals of SEP's innovation and change

The findings in the empirical chapters suggested that participants who were associated with SEP held differing views about its aims and goals. Consequently, the change agents (SEP developers) and its clientele (the teachers) became involved with the project for different motives and interests.

In the debriefing, conclusions were confirmed by former SEP managers and implementers (i.e. those people who designed the project's original policies) as well as the former Executive Director. Furthermore, these informants endorsed the fact that the users should fully understand the aims and goals of an innovation if they are expected to implement it. Results of debriefing also emphasised the need to analyse the differences in the value systems of the change agents and those of the users.

10.2.3 The phases of innovation and change in the project

The results supported the literature (Berman and McLaughlin 1975; Berman and McLaughlin 1976; Berman 1981; Bishop 1986; Fullan 1982; March 1975) that the phases of innovation and change exist in theory only. The findings which also suggested that no rigid distinction can be made between the different phases of innovation and change in SEP were endorsed by informants in the debriefing phase. Further results corroborated evidence that although institutionalization is presumed to be the final phase of planned change process in theory, the process is not linear in practice.

It was further suggested in the empirical chapters that the introduction of SEP in the older regions did not mean that its innovation and change was better implemented in these regions than it was in new ones. Results of debriefing affirmed the view that the 'level of use' of the innovation does not reflect the time when the innovation was

first introduced and that the introduction of one phase of innovation will not automatically lead to the next one.

Results of debriefing also affirmed the view that the use of the project's innovation and change varied from persuading the users to accept the idea to its actual use in the classroom. Results of debriefing also affirmed observations (Hall et al. 1975; Leithwood 1981) that adoption of innovation and change is not accomplished because the decision maker has decided to introduce it on the contrary teachers demonstrate a wide variation in the type and degree of their use of innovation and change.

Results further endorsed the conclusion that although SEP was introduced at different times in the regions, it could be misleading to suggest that the project was either at an adoption, implementation or institutionalization stage in any particular region.

10.2.4 Models and approaches of curriculum development, innovation and change

The findings revealed that SEP's model of curriculum development comprised many dimensions (worksheets, science kit and teacher development). It was also suggested that the multidimensional nature of the project enabled it to attract funds easily from donors and made it attractive to most education departments. This view was confirmed in the debriefing by SEP's fund-raisers and donors during the 1980s, the current members of the Board of Trustees and its former and current sponsors.

The interpretation of the findings demonstrated that the model and the package approach (comprising teacher development, material and worksheets and portable kits) were enabling and effective during the early days of the project because of deprived conditions in the disadvantaged schools and the inadequate teacher training.

Informants who were the project's former and current members and participated in the debriefing reaffirmed the belief that, despite the limitations of the centre-periphery or 'package' models of curriculum development, the conditions under which SEP operated during its early days of development justified the use of these models. However, these informants echoed concerns about the relevance of the package approach where the teachers are adequately trained (Stenhouse 1975; Cornbleth 1990). Further, results of debriefing affirmed the view that SEP staff was characterized by cooperation, brotherhood/sisterhood and support during the development phases of the project. In this regard, results affirmed that there was a shift in SEP's culture and ethos from one of cooperation and support in the 1980s to one governed by formal procedures as from 1989 onwards.

10.2.5 Research development and dissemination of innovation

Conclusions reached in the empirical chapters on which models of disseminating innovation were followed in the project were suggested. Results of debriefing confirmed the differing interpretations of the models followed in SEP. One such view was that the RD and D approach was used, while the other one asserted that the bottom-up strategy whereby SEP's innovation was advocated by the teachers was employed. These contradictions were confirmed by informants within the project in the debriefing stage of interpretation.

Further, results of debriefing affirmed the suggestion that SEP adopted a bottom-up strategy which ensured its success was endorsed in the debriefing. One of the informants argued in support of the view that change agents should always be accompanied by an anthropologist if they wish to convince the clientele to adopt the innovation.

10.2.6 The roles of the Curriculum Development and the Research and Development Units

The findings in the empirical chapters indicated a gap between the CDU and other structures which were in charge of implementing the project's innovation. SEP's staff in the implementation phase in particular insisted that such a gap did exist. Their position and experience in this issue strengthen the argument that there was often a mismatch between intentions and practice in the project. Results of debriefing confirm that there was a mismatch between the CDU and the regions in terms of participation in the process of curriculum development.

Informants in the debriefing process also supported the view that there was a lack of communication between SEP managers responsible for managing the project's equipment and the teachers.

Informants in the debriefing also confirmed the need to analyse the intended and unintended outcomes and possible mismatches between intentions and reality relating to the implementation of a project (Stenhouse 1975; Rogan 1976 (a); (b); Macdonald and Rogan 1981; Morphet et al. 1986; Chen 1990; Macdonald 1993).

10.2.7 The role of the Research and Development Unit

The results in the empirical chapters suggested a lack of focus by SEP's RDU. According to these results, the official policy was that the RDU would play a significant role in the implementation of the project's innovation and change.

However, all former project managers and implementers in the debriefing restated concerns that there was insufficient consultation and cooperation between the regions and the RDU. According to the debriefing results, the RDU staff tended to organize their research topic from a vacuum and never went to the regional managers, implementers and teachers to identify relevant research priorities.

In addition, the RDU was felt to be the most relevant unit to develop the curriculum but in close collaboration with the implementers and users and not with the CDU as was the case. In the debriefing, informants echoed reservations that SEP's RDU unit was not utilized optimally and efficiently.

Strong suggestions were made by some former SEP staff that the project was not doing what it was preaching in terms of changing as an organization. It was argued that SEP was supposedly seeking to change the attitudes and perceptions of other stakeholders while it stuck to the old ways of doing things. Four former managers and implementers, three former RDU staff and two science educators who were closely associated with SEP endorsed the view that SEP was setting a good example as a change agent. However, individual informants disagreed with the perception that the project was a setting a good example of change.

The findings showed concerns about the continuation and maintenance of the project's implementers in the regions. Informants comprising members of the Board of Trustees, former and current sponsors and donors in the debriefing endorsed concerns that SEP's intervention through the implementers in the regions was too expensive.

10.2.8 SEP's model of INSET

Results showed that SEP's model of INSET was in many respects of a better quality compared to those provided by other projects because it operated through a nucleus of implementers (Macdonald 1993; Thorne 1993; Manana 1994). In addition, indications were that a healthy rapport existed between the implementers and the teachers and that INSET has a unique role in bringing about changes in the education system (Bolam 1975; Burgess et al. 1993). Informants confirmed the uniqueness of the project's INSET model and that pre-service training would play an invaluable role in subsequent implementation. A view suggesting that although INSET cannot be dispensed with, it is essential that pre-service training be reviewed was reiterated in the debriefing.

It was further affirmed that the expansion into newer regions, its attempt to cater for standards 9 and 10 and the increase in the number of implementers became too costly and that this partly contributed to the closure of the project. This view was validated and confirmed by members of the Board of Trustees, three former staff members who got involved with the project in the 1970s and early 1990s and sponsors in the debriefing who openly argued that this has undoubtedly contributed to the collapse of the project. However, all informants supported the view that the project's cluster model should change in such a way that SEP could become contracted to the education departments to deliver innovation successfully.

Results of debriefing supported the view that INSET would be meaningful and sustainable if it were based on action research whereby its contents would be derived from practice by the teachers.

10.3 RESEARCH QUESTION TWO

How was the teaching and learning of science conceptualized in SEP?

Table 27: Themes and trends explored in Research Question Two and sources of data

THEME AND TRENDS	SOURCES OF DATA
SEP teachers and schools change the ways in which science was taught and learnt SEP's portable kits had a unique place in the South African education system	- analysis of SEP's evaluation reports - interviews with SEP staff in the regions - analysis of SEP's evaluation reports, former managers and implementers
SEP followed the process approach in practice A shift from the process to constructivist approaches remained a policy within SEP	- analysis of SEP's documents and records - interviews with senior SEP staff members and former Executive Directors

THEME AND TRENDS	SOURCES OF DATA
Teacher demonstration in contrast to pupil experimentation was paramount in all SEP schools	- analysis of observation results - interviews within SEP teachers
Practical work was not taken seriously because it was not assessed Assessment of practical work was difficult in SEP because of insufficient approaches and unskilled teachers	- interviews with science educators and elite policy-makers within SEP and with science educators and elite policy-makers within SEP

10.3.1 The influence of SEP's innovation and change in the classroom

The results in the empirical chapters demonstrated that SEP schools and teachers were doing things differently compared with those who were not part of the project. This perspective was articulated in the external evaluator's report and endorsed by results of classroom observation as well as evidence from interviews. Results of debriefing authenticated conclusions that the project teachers and schools had changed the ways in which science was taught and learnt.

According to the findings of empirical chapters, portable science kits such as those used by SEP had a unique place in the South African education system because they are affordable and are accompanied by worksheets and properly trained teachers. This view was endorsed by all informants who participated in the debriefing. Accordingly, portable science kits were seen as a unique option of providing science to the majority of the population where resources are scarce (Ross and Lewin 1992; 1993).

The findings also showed some variations of response about the effectiveness of group work and those of individual pupils learning science. Further, it was shown that SEP's portable science kit could be used alongside formal laboratories and that portable kits could be used even if the project is no longer operating in schools.

The results of debriefing suggested no general opinion on whether pupils learn science more effectively through demonstration or in individual experimentations. Furthermore, informants participating in debriefing endorsed the cost-effectiveness of portable science kits in developing countries. These views were enhanced by input from informants who participated in further analysis of results in the debriefing.

10.3.2 Differing views on the process and constructivist approaches

The conclusion reached in the empirical chapters was that the process and constructivist approaches were erroneously regarded as one and the same thing in the project (Driver 1993; Manana 1994; Thorne 1993). SEP's former managers and implementers participating in the debriefing phase confirmed earlier conclusions by the investigator that the process and constructivist approaches meant one and the same thing to the majority of the project staff and that the nuance between the two was never clarified in the project's policy.

The results suggested that the project had abandoned the process approach in favour of constructivism. However, it was also clear that the policy of moving from process to constructivism never filtered through to the implementation structures.

The concerns that a shift from the process to constructivist approaches remained a policy or intention was authenticated by all former SEP's managers and implementers in the debriefing.

The findings indicated that the notion of prior knowledge inherent in constructivism may be a liability because it may reinforce misconceptions in science. The literature (Driver and Bell 1986; Driver and Oldham 1986; Novak 1988) authenticated observations on the role of prior knowledge in science. The research results further revealed uncertainties as to whether the knowledge of the sources of misconceptions in science may assist to prevent further appearance of misconceptions. The

uncertainty as to whether the identification of the sources of misconceptions could prevent further misconceptions and whether such knowledge is of value to improve curriculum was further authenticated by informants in the debriefing phase.

10.3.3 The data on classroom observations

The results of empirical chapters indicated that teacher demonstration, in contrast to pupil experimentation, was paramount in all SEP schools and that factors such as overcrowding and inadequate apparatus impeded successful implementation of the projects innovation and change. Informants within the project all concurred that teachers were unable to consider group/interactive methods because of lack of skills and perceptions and because in some instances was only one set of apparatus which could only be used by the teacher. Teacher demonstration and pupil experimentation were further exemplified through photographs according to informants (Bogdan and Biklen 1982; Burgess 1984; Diyane 1991; Thorne 1993; Walker 1993; Manana 1994; Clandinin and Connelly 1994). It was also argued that photographs taken during classroom observations do reflect typical SEP situations.

All SEP managers and implementers in the debriefing endorsed the view that teacher demonstration was preferred because of insufficient science kits and not because the project teachers were not aware of the need for pupil experimentation was generally taken for granted. Results of debriefing further supported the researcher's conclusion that these photographs exemplify typical situations in SEP classrooms.

10.3.4 Lack of practical work and its assessment

Feedback in the empirical chapters suggested that the majority of SEP members equated practical work with teacher demonstration. However, some informants

argued that teacher demonstration should not be equated with hands-on practicals by the pupils themselves was substantiated by its original proposers. In addition results showed consensus that practical work was not taken seriously and that this would remain so unless this component is formally assessed.

In the debriefing, some informants reiterated the view that practical work and teacher demonstration are one and the same thing while some confirmed the suggestion that a distinction between the two needs to be recognized. Informants further endorsed the view that the practical component needs to be examined so that it will be taken seriously.

Conclusions in the empirical chapters were that assessment of practical work was very difficult in SEP classrooms because of factors such as insufficient apparatus, overcrowding and unskilled teachers. It was further concluded that this problem was not confined to SEP but that it applies to assessment of practicals in science (Torrance 1985; Giddings, Hofstein and Lunetta 1991; Diyane 1991; Manana 1993; Naik 1994; O' Neil 1994). These views were endorsed fully by informants in the debriefing phase.

10.4 RESEARCH QUESTION THREE

How did the quality of the relationship between SEP and other stakeholders affect the implementation of the project's work during the period under review?

Table 28: Themes and trends explored in Research Question Three and sources of data

THEMES AND TRENDS	SOURCES OF DATA
It was easier for SEP to obtain funds from donors in the 1970s and 1980s than it is in the 1990s Sponsors and donors are likely to fund projects with more than one aspect, eg., improving learning and teacher development Donors and sponsors paid little attention to the outcomes but depended on the evaluation reports showing qualitative improvements in SEP Donors and sponsors did not wish to give money to an illegitimate system of education in the 1970s and 1980s	- interviews with SEP fund-raiser in its early days of development - interviews with SEP current Executive Director, former project managers and implementers - interviews with members of the Board of Trustees and former and current Executive Directors - interviews with members of the Board of Trustees, SEP fund-raiser and Directors
SEP was one of the few projects that managed to carry on with its work regardless of the minimal support from the education authorities Relationship between SEP and the education departments was more cordial in the former homeland than it was in the former central government	- analysis of SEP documents and records - interviews with members of the Board of Trustees and former Executive Directors - analysis of SEP documents and records - interviews with members of the Board of Trustees
SEP targeted disadvantaged areas which were largely in former homelands The success and failures of the project's innovation depended largely of individuals rather than the education departments	- interviews with the former Executive Directors - analysis of SEP documents and records - interviews with former project managers and implementers

THEMES AND TRENDS	SOURCES OF DATA
Structural changes in education affected the operation of SEP	- interviews with current Executive Directors - interviews with former project managers and implementers
SEP had to change its operation in line with structural changes taking place in the country There were shifts in SEP culture and ethos from the one of brotherhood/sisterhood, cooperation and support to the one governed by formal procedures Implementation of innovation should be left to the NGOs because they are usually small and less bureaucratic	- interviews with the former and current Executive Directors - analysis of SEP documents and record - interviews with former SEP staff who were involved with the project in the 1980s and early 1990s - analysis of SEP documents - interviews with elite policy-makers within SEP - interviews with former and current Executive Directors
SEP and other NGOs need to enter into partnership with the government to deliver innovation	- interviews with Education representatives and members of the Board of Trustees
The channelling of funds to the government led to bottlenecks in the system which disrupted a smooth flow of funds to the provinces SEP would have to work in the provinces regarded as very poor	- interviews with current Executive Director - interviews with members of the Board of Trustees - interviews with the current Executive Director - interviews with members of the Board of Trustees

THEMES AND TRENDS	SOURCES OF DATA
An evaluation of what innovation projects were actually doing and their accountability did not emerge as primary concern in the 1970s and 1980s	- analysis of SEP documents and records - interviews with members of the Board of Trustees
NGOs in general including SEP enjoyed a huge degree of autonomy prior to 1994 election The changed conditions have resulted in more organized reporting of how funds are used	- analysis of SEP documents and records - interviews with former and current SEP Executive Director- analysis of SEP documents and records - interviews with education representative - interviews with the current Executive Director

10.4.1 Stakeholders' relationships and implementation

The findings in the empirical chapters demonstrated that the quality of relationships between the different stakeholders, their motives, interests and their value systems are major determinants of whether implementation will succeed or not. It was also evident that the success of innovation and change depends largely on the extent to which it is advocated by stakeholders. The importance of the advocacy of innovation was authenticated in the debriefing.

10.4.2 SEP and the donors

Conclusions in the empirical chapters were that because of existing political, social and economic conditions in the 1970s and 1980s, it was easier for the project to obtain funds from the donors than it is currently. The results of the debriefing confirmed the conclusions relating to SEP and the donors:

- SEP was funded in the 1970s and 1980s because donors and sponsors felt that it was better to invest money in long-term projects such as SEP instead of funding small projects with short-term objectives. According to the data in the debriefing, the trend was therefore to channel money into development projects that could be sustained rather than charity organizations.
- that submissions to the funders of the project were favourably received because SEP's innovation and change had multiple facets or aspects. The aspects included: provision of portable science kits, worksheets and its model of INSET which operated through a nucleus of implementers. Accordingly, results of debriefing affirmed the view that sponsors and donors are likely to fund projects with more than one aspect or facet. i.e. a project may be funded because it appears to improve learning even if it does not contribute towards teacher development.
- that SEP was making qualitative changes regarding the teaching and learning of science according to the sponsors and donors in the 1970s and 1980s and that it was probably the most evaluated project.
- SEP's staff in the 1980s and early 1990 was small and was characterized by a spirit of brotherhood/sisterhood, a shared culture and mutual support.
- that donors and sponsors funded SEP because the education system was generally viewed as illegitimate in the 1970s and 1980s. This view further endorsed the dilemmas both the NGOs and sponsors found themselves in the 1970s and 1980s.
- that the donors and sponsors paid little attention to the outcomes but depended on the evaluation results which indicated that the project was pursuing its original aims and objectives. The other informant further confirmed that as long as the project would defy the system, the business community was prepared to fund it. Consequently, costs were not looked at as long as the project existed and sponsors were satisfied that no single individuals ever attempted to hijack the project for their own interests.
- that sponsors did not wish to give money to an illegitimate system of education in the 1970s and 1980s and that support of NGOs was itself regarded as part of the struggle.

10.4.3 SEP and the education departments

The findings in the empirical chapters demonstrated that SEP was one of the few innovation projects that managed to carry on with its task regardless of the minimal support it received from the education authorities. Informants in the debriefing concurred with the perspective relating to the project's operations in the 1970s and 1980s.

Results also endorsed that the relationship between the project and the education departments was more cordial in the former homelands than it was in the former central government schools. The debriefing results confirmed that the former homelands' departments had more room for improvement. New insights from debriefing supported the argument that officials who gravitated to the homelands were more committed to improving the quality of science teaching and learning than those who remained at the centre. One of the SEP fund-raisers in the debriefing phase endorsed a suggestion that education officials who remained at the centre were more conservative and were so in order to ensure that the system was not disrupted. Accordingly, many innovation projects such as SEP and the Molteno Project which were considered a threat to the establishment in what was then central South Africa, found their roots in the former homelands (Macdonald 1989; Hartshorne 1989; Morphet et al. 1986). Furthermore, input from informants in the debriefing phase endorsed perceptions that officials in the periphery were mostly black and tended to be more susceptible to new innovations.

The findings in the empirical chapters showed that SEP from the outset targeted disadvantaged areas which were largely in the former homelands that the relationship between the project and the education departments depended largely on the individuals who held local power in science education. The data confirm the general mistrust between education departments and the project which attempted to improve science without at the same time becoming part of the discredited system. Informants who had a long association with the project and were in charge of developing its policy endorsed perceptions that the success and failure of the project's innovation depended largely on individuals rather than the education system.

Informants who had a long experience with the project, and who participated in the debriefing authenticated perceptions that individuals in charge of innovation in science had a crucial influence on the success or failure of SEP's innovation and change. Further, the debriefing suggested that it was important for the project to remain outside the system. Informants further argued that although the apartheid system controlled every aspect of education at the highest level, it was surprising that certain projects such as SEP continued to operate almost contrary to the official policy. According to this view, the government was apparently making a gesture towards what was seen to be internationally accepted practise in education and therefore that there was a grudging acknowledgement that projects like SEP were doing something good.

The latest findings therefore reinforced propositions that small innovation projects normally succeed (whereas bureaucratic education authorities are likely to be less effective) because communication is maximized and participants are likely to own such innovation.

10.4.4 Structural changes in education

The findings of empirical chapters suggested that the changes in structural conditions in education in South Africa affected the operations of SEP. Accordingly, the structural changes in society precipitated changes in the relationship between the

project and the education departments. Structural changes identified included the legitimated government and its role in the provision of education, accountability of NGO projects, the combination of eleven education departments, the organization of school education in the provinces and the new education policies committing the government to address issues of equity and efficiency. All informants participating in subsequent interpretation of results confirmed previous conclusions that structural changes influenced the operation of SEP.

10.4.5 Changing relationship with the education departments

Indications from the results of empirical chapters suggested that SEP needed to change its policy regarding its strategy to improve science radically. Results from informants and elite policy-makers in the debriefing phase confirmed earlier conclusions that:

- SEP had to change its operation in line with structural changes taking place in the country.
- there were concerns raised about the general complacency in the post-election society that all innovation and change should be undertaken by government.
- the majority of informants were of the opinion that the delivery of education and the implementation of innovation and change should be left to the NGOs and the civil society because governments are by nature too big and bureaucratic and cannot be as effective as small NGOs.

Furthermore, the debriefing enhanced propositions on the envisaged relationship between SEP and the democratically-elected government, the effectiveness of small NGOs such as SEP to improve science and the need for partnerships between SEP and the education department. The findings further strengthened prior propositions that relations between NGOs and the democratically elected government need to change significantly from being oppositional to one of partnerships.

Author Ntshoe I M
Name of thesis Implementation And Institutionalization Of Innovation And Change In Science Education: The Case Of Sep Ntshoe I M 1999

PUBLISHER:
University of the Witwatersrand, Johannesburg
©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.