

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In chapter two, a literature review was done on cooperative learning and science process skills. The literature review served as a basis to structure the empirical investigation. The empirical investigation will be explained in this chapter and will involve the application of cooperative learning in the development of learner's science process skills.

This chapter will provide the research design followed in the empirical investigation. The procedure followed in the investigation, as well as the description of the instruments used for data collection will be provided. In addition, the manner in which the data will be scored will be provided.

3.2 THE RESEARCH DESIGN

The research design used in this study is described below. The study basically involves two case studies at two different schools in the Northern Province of South Africa. Since the outcome of this dissertation of limited scope requires a focus on a single aspect of a phenomenon, an elaborate research design was beyond the scope of the dissertation. The study therefore did not evaluate either cooperative learning or science process skills, which are dealt with elsewhere in the literature, but focused on evaluating the possibility of an effect (although not in a causal manner) on the development of science process skills when cooperative learning is used as a teaching strategy. Since both cooperative learning and science process skills are extensive in scope, this study delimited the scope by focusing on only two cooperative learning methods (Group Investigation, Jigsaw) and four science process skills (observation, controlling variables, graphing, experimenting). The selection of these two methods and four process skills was arbitrary and therefore no comparison will be made between the different cooperative learning methods and the science process skills.

Given the background in the foregoing paragraph, the research design used in each of the case studies is explained below.

Case study one

This case study was conducted at school A in the Northern Province of South Africa. The department of education used school A as a pilot school during the initial implementation of curriculum 2005. In each province, the department of education selected few schools to try-out (pilot) the new curriculum. Pilot schools were expected by the department of education to use various learner centered teaching methods such as cooperative learning. As such, although the teacher at school A would use any method or methods as he liked, he was particularly requested to follow the Group Investigation method during the period of this study. Since pilot schools received additional support from the department of education, it may happen that learners at these schools could perform better with regard to science process skills than other non-pilot schools. This consideration impacted on the research design of this study and will be borne in mind in the interpretation of the results.

The research design notation followed at school A is represented in the following diagram.

N	O ₁	X	O ₁	at school A
---	----------------	---	----------------	-------------

The X in the diagram above refers to the treatment applied to a group of students at school A, namely the Group Investigation method of cooperative learning. The O symbols in the design notation represents observations. In this study the observations refer to the performance of learners with regard to the four process skills of observation, controlling variables, graphing and experimenting. The first O₁ represents the data obtained from the pre-test. The second O₁ represents the data obtained from the post-test. O₁ is used for both observations since the same instrument was used to collect data for both the pre- and post-tests. The use of the same instrument in both the pre- and post-tests ensures that the cognitive demand from learners is the same in both instruments. However, a limitation of this procedure is that learners may memorise or remember the answers from the pre-test and thus perform better in the post-test.

The N in the research design notation refers to the sampling method used in the case study. The limitations of the research design in this case study are the absence of a control group

and the use of a pilot school (pilot schools may have used cooperative learning before the initiation of this study).

Case study two

This case study was conducted at school B in the Northern Province of South Africa. School B, however, is located over a hundred kilometers from school A. The following research design notation represents the research design used in this case study.

N	O ₁	Y	O ₂	at school B
---	----------------	---	----------------	-------------

Y represent the Jigsaw method of cooperative learning that was used to teach a class of learners at school B. The researcher personally taught this class during the period of the study. It should be noted that the researcher has an extensive experience as a teacher and have studied and taught cooperative learning extensively before the initiation of this study. As such, it can be concluded, as in case study one, that the researcher (teacher) was competent to teach the Jigsaw method of cooperative learning.

O₁ represents the data obtained for the pre-test and using the same instrument as in school A. O₂ represent data obtained for the post-test, using a different instrument as that in school A. In other words, O₁ and O₂ are used for the second group since the instrument for the collection of the pre-test data was different from the instrument used to collect the post-test data. As stated earlier, two different tests were used in this case study to circumvent the effect of memorization of the solutions provided at the end of the pre-test. The two different tests used, however, measure the same process skills of observation, controlling variables, graphing and experimenting.

To sum up, the Group Investigation method of cooperative learning was evaluated at school A for the development of learner's science process skills of observation, controlling variables, graphing, and experimenting, while the Jigsaw method of cooperative learning was evaluated at school B for the development of learner's science process skills of observation, controlling variables, graphing and experimenting. Data were collected, analyzed and interpreted separately for the two schools. In other words, the data was not compared between schools A and B.

3.3 RESEARCH QUESTIONS

The empirical investigation attempted to answer the following research questions.

3.3.1 *Question one*

What effect does the group investigation method of cooperative learning have on the development of learners' science process skills of observation, controlling variables, graphing and experimenting?

3.3.2 *Question two*

What effect does the Jigsaw method of cooperative learning have on the development of learners' science process skills of observation, controlling variables, graphing and experimenting?

3.4 HYPOTHESES

The following null hypotheses were statistically tested.

3.4.1 *Hypothesis one*

As a null hypothesis, it was hypothesized that the Group Investigation method of cooperative learning has no effect on the development of learners' science process skills of observation, controlling variables, graphing and experimenting.

3.4.2 *Hypothesis two*

As a null hypothesis, it was hypothesized that the Jigsaw method of cooperative learning has no effect on the development of learner's science process skills of observation, controlling variables, graphing and experimenting.

3.5 SUBJECTS

Learners from one grade eight class were selected as the subjects for the collection of data at school A. One class was selected for inclusion in the study, as their teacher was willing to implement the Group Investigation method of cooperative learning. This class contained thirty-seven learners. The use of such limited subjects implies that no generalizations will be made from the results obtained in this study. School A was selected because the teachers had to use, amongst others, cooperative learning in their instruction since they were a pilot school for the implementation of Curriculum 2005.

The subjects for the collection of data at school B were the 2002 grade nine learners. There were 64 learners during the pre-test and 62 learners during to post-test. The school was not selected for piloting Curriculum 2005 in the District. However, the researcher, with extensive knowledge of cooperative learning and science process skills, taught the class at this school.

3.6 INSTRUMENTS AND DATA COLLECTION

Data was collected at school A by means of the Common Assessment Task prepared by the Department of Education for the 2001 grade eight pilot schools. The task consisted of the practical part (Appendix A), and the theoretical part (Appendix B). In the practical part learners followed instructions to do an experiment as described in Appendix A. In the theoretical component learners used pen and pencil to answer questions in the open spaces of the question paper.

At school B, pre-test data was collected by means of the Common Assessment Task prepared for pilot schools (Appendices A and B). Post-test data were collected by means of the Natural Sciences Test (Appendix E). The Natural Sciences Test (NST) is a self-constructed test based on content learners were exposed to during the period in which cooperative learning was used at school B. Learners responded to the NST by writing their answers in the open spaces of the question paper. The test was administered after learners were exposed to the Jigsaw method of cooperative learning in learning some natural science concepts (Appendix D).

The facilitator for the implementation of the Group Investigation method of cooperative learning at school A was a qualified natural science educator at the school. The educator attended in-service workshops arranged by the district curriculum advisors for the implementation of the Group Investigation method of cooperative learning. The foregoing workshops are different from the normal curriculum implementation workshops that pay less attention to teaching methods. He attended both the workshops for all natural science educators and those meant specifically for pilot schools. Curriculum advisors visited the school regularly to monitor the implementation of the method. Both the investigator and the facilitator administered the practical task and the theoretical task.

The facilitator and the administrator of both the pre-test and the post-test at school B was the investigator. The facilitator at school B made an extensive literature research on cooperative learning methods and how they are implemented. He also attended a number of workshops on the implementation of cooperative learning methods.

3.6.1 Procedure for the Administration of the Common Assessment Task

The CAT was administered to the thirty-seven learners at school A and the sixty-four learners at school B. At school A, the CAT was administered first in October 2001 and thereafter in April 2002. At school B, the CAT was only administered once in April 2002.

The practical part of the CAT is described in detail in appendix A. A brief description of the activity is provided below. The practical activity is based on a simulation of how the Human Immunodeficiency Virus (HIV) can spread through sexual activity. Individuals who are not infected with the virus are represented in the activity by neutral water and those who are infected are represented by an alkaline solution of sodium hydroxide. The two solutions are both clear and will only be distinguishable at the end of the game when an indicator is added to each solution.

The practical activity takes the form of a game in which learners are instructed to exchange parts of their solutions. However each learner is assigned a role that determines his or her actions. Three roles are assigned, namely to exchange solutions whenever asked by another learner, to exchange with only one learner who acts as your partner, or no exchange at all. The roles are kept a secret on a piece of paper given by the teacher. As such the game tends

to have a fun component. Based on the effect of exchanging solutions, the number of infections are determined after a given time period. The whole group thereafter discusses the effects of exchanging solutions (being an analogy for exchange of fluids during sexual activity).

In all administrations of the CAT, learners were put into three groups for the purpose of the practical task. As explained in Appendix A, learners in a group assume particular roles assigned by the teacher. The number of learners playing a particular role in a group was not the same in all three administrations. However, the number of learners starting the play with infection was kept the same throughout. In other words, the number of learners starting to play with infection was kept at two learners in all groups.

Each learner brought an old clear juice container and a used drinking straw as an improvisation for test tubes and medicine droppers. In each group the facilitator poured 10 ml of clear liquid in the containers, with two clear solutions containing sodium hydroxide (NaOH), and the rest in each group being water. The strip, which indicates the role each learner had to play, was kept confidential for the individual learner. After five minutes of the play, which involved the exchange of five drops of the solution using the straw, each learner brought their solutions to the facilitator. The facilitator put five drops of phenolphthalein indicator in each container. The clear solutions, which contained NaOH , changed to red, and those that did not exchange with NaOH remained clear. The number of “infections” was summarized in table form and learners given some time to discuss the findings in small groups.

After the practical activity learners were given the theoretical task to write using pen and pencil. The theoretical task (Appendix B) consisted of structured questions out of sixty marks. Learners responded by writing their answers in the open spaces of the question paper. The task was written individually under normal examination conditions. That is, learners did the practical activity in groups, but wrote the theoretical component as individuals. The facilitator used the marking memo (Appendix C) to mark the learners’ responses.

3.6.2 Procedure for the Administration of the Natural Science Test at School B

After the administration of the pre-test at school B, learners were exposed to the Jigsaw method in learning some natural science concepts as described in appendix D. Learners learnt the concepts in cooperative groups during the normal science periods. They discussed and manipulated objects in groups with the final findings reported to the whole class.

The Natural Sciences Test (NST), which contained questions on science process skills and general skills, was prepared for the quarterly examinations at school B. The learners wrote the test individually under normal examination conditions. They responded to the questions that required science process skills theoretically using pen and pencil. That is, learners had to answer without performing the activities in the examination, but using the knowledge gained during the learning sessions. They responded to the questions by writing the answers in the open spaces of the question paper. The marking memo (Appendix F) was used to mark the responses of the learners.

3.7 DISCUSSION OF THE QUESTIONS FOR THE SCIENCE PROCESS SKILLS UNDER INVESTIGATION AND HOW THEY WERE SCORED

Table 3.1 below shows the questions that test the science process skills under investigation.

Table 3.1: Science process skills under investigation and their question numbers

	Common Assessment Task		Natural Science Test	
Science Process Skill	Question Number	Maximum Marks	Question Number	Maximum Marks
Observation	1.1	1	1.1 and 1.2.1	4
Controlling variables	1.6	4	6.5	3
Graphing	2.1	6	9.1	12
Experimenting	1.7.1	6	1and 7	16

The following sub-sections will concentrate on the questions for the science process skills under investigation and how they were scored.

3.7.1 Observation

The science process skills of observation was tested by question 1.1 in the CAT and counted one mark (see Appendix B), while in the NST it was tested by question 1.1 and 1.2.1 (Appendix E) and counted four marks.

In the CAT, learners had to compare the three roles as they observed during the practical component of the task. They had to indicate that the role of swapping as often as possible with anybody caused the highest infection rate.

In the NST, the question wanted learners to respond by writing what they observed during the learning of the concepts, in this case electrostatics. For question 1.1, learners had to respond by indicating that the pieces of tissue paper did not stuck to the balloon while for question 1.2.1 they had to indicate that the pieces of tissue paper stuck to the balloon.

In the CAT, one mark was allocated to the correct answer, and zero mark for an incorrect answer. The following rubric was used to assess and record the learners' responses in the NST. For all the data reported in this chapter, the levels were used in the data analysis, unless otherwise indicated.

Table 3.2: Assessment and recording of learners' observation skill

SPS	Level	Marks CAT	Marks NST	Level descriptor	Assessment Criteria
Observation	1	0	0 – 1	Not achieved	Did not attempt the question or got incorrect answer
	2	-*	2 – 3	Partially achieved	Gave one correct observation
	3	1	4	Achieved	Gave both observation correct

* The results may be skew for level 2 of CAT because of the absence of a value.

3.7.2 Controlling variables

For question 1.6.1 of the Common Assessment Task (Appendix B), learners had to identify from the games that the number of players that swap as often as possible, and the number of

players that claim to swap with one partner only, are kept constant. Question 1.6.2 wanted learners to indicate that the number of players that claim to swap with one partner only, changes. By answering the question learners shall have identified the independent variable. Question 1.6.3 wanted learners to indicate that the number of learners that become infected are measured. By answering the question learners shall have identified the dependent variable.

In the Natural Sciences Test the skill of controlling variables is tested by question 6.5. The question requested learners to identify the dependent variables from the independent variables. They had to give the reason for keeping other variables constant in the investigation. Learners had to indicate that the reason for keeping equal number of cells and bulbs is that only the effect of series and parallel connections is investigated.

The following rubric was used to record the learners' responses on the skill of controlling variables for both the CAT and NST.

Table 3.3: Recording of learner's skill of controlling variables

	CAT marks	NST marks	Level	Level descriptor
Controlling variables	0-1	0	1	Not achieved
	2	1	2	Partially achieved
	3	2	3	Achieved
	4	3	4	Excellently achieved

3.7.3 Graphing

The graphing skill was tested by question 2.1 in CAT (Appendix B) and question 9.1 in NST (Appendix E). The questions requested learners to use the information as given in the tables and convert the figures to graph form.

The following list of criteria was used to assess the learners' achievement of the skill of graphing.

- The skill is correct in most respect including:
- A suitable heading;
- Both axes are correctly labeled;
- Scale for both axes is appropriate;
- All the coordinates are plotted correctly.

The following rubric was used to assess and record learners' responses.

Table 3.4: Assessment and recording of the skill of graphing

	Level	CAT marks	NST marks	Assessment Criteria	Level descriptor
Graphing	1	0 – 1	0 – 5	4 or more mistakes on the list of criteria	Not achieved
	2	2 – 3	6	Up to 3 mistakes on the list of criteria	Partially achieved
	3	4 – 5	7 – 8	Up to 2 mistakes on the list of criteria	Achieved
	4	6	9 – 12	Achieved all listed criteria	Excellently achieved

3.7.4 Experimenting

In the Common Assessment Task (Appendix B) the skill of experimenting was tested by question 1.7.1. The question requested learners to give the procedure in testing an HIV drug. With the help of a jumbled list, learners were expected to give a sequence starting with the testing of the drug on animals and then on humans.

In the Natural Science Test the skill of experimenting was tested by questions 1 and 7. Learners responded to the questions by giving their observations as they performed the

experiments during the learning of science concepts using the Jigsaw method of cooperative learning.

The following rubric was used to assess and record the learners' responses on the skill of experimenting

Table 3. 5: Assessment and recording of the skill of experimenting

	Level	CAT marks	NST marks	Assessment Criteria	Level descriptor
Experimenting	1	0 – 1	0 – 6	No observations and conclusions	Not achieved
	2	2 – 3	7 – 8	Very little observations and no conclusions	Partially achieved
	3	4 – 5	9 – 11	Satisfactory observations with little conclusions	Achieved
	4	6	12 – 16	Full observations and conclusions	Excellent achieved

3.8 SUMMARY

In this chapter the research design, the research questions, the hypothesis, the subjects and the collection of data were discussed. The questions for the science process skills under investigation and the facilitators were also discussed.

Chapter four will concentrate on the analysis and interpretation of results.