CHAPTER 5

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

5.1 INTRODUCTION

The purpose of this chapter is to review the data processing procedures and the description of the statistical techniques applied in this study. The data collection techniques, the sample, and the research design are described, followed by a section on the data analysis procedure.

5.2 DATA COLLECTION TECHNIQUES

This section examines the techniques used to collect data in this study. Data were obtained through questionnaires and interviews according to quantitative and qualitative research methods. Questionnaires were used as research instruments (cf. 1.5.2.1 & 5.3) because of the large population (cf. 5.2.3.3). The questionnaires were mailed to the respondents. Qualitative research was used to supplement the open-ended questions in the questionnaires (cf. 1.5.2.2). Response to open-ended questions was poor, hence the researcher also interviewed a number of geography teachers and learners (cf. 5.5) to improve the validity of the study.

Interviews are vocal questionnaires although they differ from questionnaires because they involve direct interaction between individuals (McMillan and Schumacher 1997: 263). Fraenkel and Wallen (1996: 372) argue that a face to face interview is the most effective way of

enlisting the cooperation of the participants in a survey because rapport can be established. Furthermore, the researcher is also able to clarify the meaning of some of the questions to the respondents and to follow up on unclear or incomplete answers to the questions (Fraenkel and Wallen 1996: 372; and McMillan and Schumacher 1997: 263). The interview allows greater depth of response which is not possible through other means (Koul 1996: 176).

Borg and Gall (1989: 380) and McMillan and Schumacher (1997: 263) maintain that the primary disadvantage of an interview is subjectivity. Furthermore, to conduct interviews is expensive and time consuming (McMillan and Schumacher 1997: 264). It is expensive as it may involve travelling long distances to reach the interviews. As a result, a researcher is compelled to sample fewer respondents than could be obtained with a questionnaire. Koul (1996: 176) notes that the interview has the following limitations:

- ☐ it is a time consuming technique;
- ☐ its effectiveness depends on the skill of the interviewer not ordinarily possessed by inexperienced researchers;
- ☐ there is a constant danger of subjectivity on the part of the interviewer; and
- ☐ it is most difficult to employ successfully as some interviewees may not respond freely, frankly and accurately.

The purpose of an interview is to find out what is on the mind of the interviewees, i.e. what do they think or how do they feel about something (Fraenkel and Wallen 1996: 447). Koul (1996: 176) further maintains that the interview enables an interviewer to get information concerning

feelings, attitudes or emotions in relation to other questions.

In this study, interviews were conducted because 53 teachers (75%) and 315 learners (89%) did not respond to the open-ended questions of the questionnaires. McBurney (1994: 201) has also noted that the response rate is the main problem with written questionnaires. It is argued that the low response rate may invalidate data because of differences between those who responded and those who did not. Therefore, interviews were conducted to supplement the information gathered by the questionnaires.

Interviews collected data qualitatively from selected geography teachers and learners. They were carried out to explore problems geography teachers and learners experienced when they were engaged in inquiry teaching and inquiry learning respectively. Respondents were also requested to suggest solutions to the problems they had identified.

Furthermore, interviews were also conducted to establish problems geography teachers and learners experienced when science process skills were applied to the teaching of geography. Teachers and learners were also requested to suggest solutions to the problems they have identified. The following sections describe data collection procedure.

5.3 DATA COLLECTION PROCEDURE

This section reviews data collection procedures which include the pilot study, how the sample was selected, how the questionnaires were compiled and administered to the population and how interviews were conducted.

5.3.1 Permission to Conduct Research in the Free State Department of Education

Permission to administer the questionnaires and conduct interviews was sought from the Head of Education: Free State Education Department (Appendix 8). It was granted (Appendix 9) subject to the following conditions:

- ☐ the names of learners/educators must be provided by the principals;
- ☐ learning facilitators/Educators/Learners participate voluntarily in the project;
- ☐ the names of the schools and educators/learners involved remain confidential in all respects;
- ☐ completion of questionnaires by educators/learners must take place outside normal tuition time of the school;
- ☐ a copy of the letter granting permission must be shown to all participating persons;
- ☐ a copy of the thesis must be donated to the Free State Education Department; and
- ☐ the researcher had to accept the above-mentioned conditions in writing.

The researcher also wrote a letter to the principals of participating schools to ask for their permission and cooperation (Appendix 10). The researcher opted for mailed questionnaires due to time and financial constraints. The questionnaires together with stamped self-

addressed envelopes were sent to the school principals who were requested to hand them to the relevant respondents.

5.3.2 Pilot Study

Before preparing the final format of the questionnaires, the items were tested by fifteen secondary school geography teachers and fifteen secondary school geography learners in a pilot study in Welkom Education District. Respondents were requested to comment in writing on the items contained in the questionnaires.

Some deficiencies were detected and additional items were suggested. For instances, twelve teachers requested that a question requiring their qualifications should be rephrased. They did not prefer to list their qualifications and they suggested that the item should ask if they have specialised in geography at tertiary level. Fourteen teachers also suggested that item 33 which requested them if they allowed learners to move freely while the lesson was in progress to be rephrased. It was changed to "*I allow learners to move freely in the classroom while they are engaged in group work activities.*" These changes were also applied to item 29 of the learners' questionnaire.

The questionnaires were also handed to six lecturers at Vista University - Welkom Campus (Sub-faculty of Education), for comments and improvement. Furthermore, the questionnaires were also handed to the Department of Statistics at the University of Pretoria, where the researcher was advised on suitable layouts of the questionnaires to make them compatible with the SAS statistical program that was used to analyse data. As a result of all these processes, the questionnaires were revised and modified, and the final drafts were prepared (Appendices 3 & 4) and mailed to the participants.

5.4 POPULATION AND RESEARCH SAMPLE

In 2000, the year in which the data for this study was gathered, there were 302 secondary schools in the Free State province offering the subject geography (Appendix 6) comprising the population of this study. It was not possible to post the questionnaires and interview all geography teachers and learners in these schools. This would have been an expensive exercise in terms of money and time. A number of schools were selected from which teachers and learners who participated in this research project were drawn. Borg (1981: 73) maintains that the size of the samples and the procedures used in selecting samples determine the degree of confidence with which the researcher can apply the research findings to the population. Charles (1995: 96-97) supports this idea by asserting that samples are a necessity, in research where findings are intended to be generalized to the population. Furthermore, selected samples should accurately reflect the distribution of trait variables within the population at large.

A sample is the portion of a population that provides the subjects of a research study (Langenbach, Vaughn and Aagaard 1994: 375; and McMillan and Schumacher 1993: 598). This implies that a sample is a group from which information for the study is acquired. Sampling is the process of selecting a number of individuals for a study in such a way that the individuals represent the larger group from which they were selected (Fraenkel and Wallen 1996: 91; Gay and Airasian 2000: 140; McMillan and Schumacher 1997: 165).

For the completion of the questionnaires, the researcher applied a simple random sample and a systematic random sample to select the sample for geography teachers and learners respectively. For interviews, the researcher applied purposive sampling which is a nonrandom sample selected, because prior knowledge suggests it is representative, or because those

selected have the needed information (Gay and Airasian 2000: 138; Fraenkel and Wallen 1996: 101; and McMillan and Schumacher 1997: 397). The following sections describe how the samples for the respondents were selected.

5.4.1 Geography Teacher Sample

The Free State Department of Education could not provide the accurate number of secondary school geography teachers because they were uncertain how many secondary school geography teachers were teaching in the province. It was subsequently assumed that there could be one geography teacher per school which totalled to 302 practising secondary geography teachers in the province. Questionnaires were sent to only 150 practising secondary school geography teachers, which represented 50 percent of the assumed total number of practising teachers. The researcher also decided on this figure because of time and financial constraints. Therefore, a description of the respondents from this population should be given in sufficient detail, so that interested researchers can determine the applicability of this research to their own situation (Fraenkel and Wallen 1996: 93).

As already mentioned, simple random sampling was conducted to select the sample for geography teachers. In a random sample, each individual has an equal chance of being included (Borg 1981: 73; Borg and Gall 1989: 220; McBurney 1994: 204; McMillan and Schumacher 1993: 166; Charles 1995: 97 and Howell 1999: 21). Furthermore, in a random sample the characteristics of each of the sample may reflect the characteristics of the total population (Leedy 1993: 201). This process ensured that each and every school that offered geography had an equal and independent chance of being selected. This was done by using a table of uniform random numbers (Appendix 6) to select 150 secondary schools that were included in the sample out of 302 schools that offered geography in 2000. The first school

was identified as school 0001, the second as school 0002 and school 299 as 0299 and so on. Using the Table of Uniform Random Numbers (Appendix 7) (Howell 1999: 450 - 451), the first two numbers did not form part of the sample because there were no 682 and 610 in the population. However, the third number in the column, 046 formed part of the sample as it was also in the population. Thus, school 0046 duly formed part of the sample. The fourth and fifth numbers were 320 and 281 respectively and school 0320 did not form part of the sample as it was not in the list of the schools provided by the Free State Department of Education but school 0281 formed part of the sample. This selection process went on until a total of 150 numbers each representing a school in the population were included in the sample. Of 150 teacher questionnaires mailed, 71 were returned which represented a return of 47 percent. This low rate of return might have led to research bias as it was not representative of the research population.

Purposive sampling was used to select geography teachers interviewed. As interviews were conducted in 2001, matriculation results of the year 2000 were used as a criterion for identifying schools from which the respondents to be interviewed where drawn.

McMillan and Schumacher (1997: 401) suggest that a purposeful sample size should range from one to forty or more participants. Twenty schools with between 70 -100 percent pass rates were identified and included in the sample. Twenty geography teachers in these schools were individually interviewed and their teaching experiences ranged from two to twenty-four years. A number of thirteen male teachers and seven female teachers were interviewed.

It was assumed that these teachers could be knowledgeable and informative about the application of science process skills to the teaching of geography. It is important to note that Gay and Airasian (2000: 138) argue that the shortcoming of purposive sampling is inaccuracy

in the researcher's criteria and resulting sample selections. The interview schedule for geography teachers can be found in Appendix 11. The following section highlights how geography learners were selected for the sample.

5.4.2 Geography Learner Sample

The targeted geography learner population was all Grade 8 to Grade 12 geography learners in all education districts in the Free State. However, due to time and financial constraints, the accessed geography learners' population was only conducted at fourteen secondary schools. It was assumed that all the characteristics of the 302 schools could be found in the selected fourteen schools. A systematic sample was used to select this sample.

In a systematic sample, every *n*th individual in the population list is selected for inclusion in the sample (McMillan and Schumacher 1993: 167, and Fraenkel and Wallen 1996: 98). Systematic sampling implies the selection of certain items in a series according to a predetermined sequence (Leedy 1993: 211). The fourteen schools that were sent learner questionnaires were selected in the following manner.

The researcher started by determining the sampling interval, i.e. the distance in the list between each school selected for the sample. The following formula (Fraenkel and Wallen 1996: 99) was used to determine the selection of the schools:

$$\textit{Sampling Interval} = \frac{\textit{Population Size}}{\textit{Desired Sample Size}}$$

$$\frac{302}{14}$$

$$21{,}57$$

$$22$$

School 0022, school 0044, school 0066, school 0088 and so on were selected from Appendix 7 until a sample of fourteen schools was reached. This process indicated that the origin of the sampling sequence was controlled by chance. Fifty questionnaires were sent to each selected school with an instruction to the school principal (Appendix 10) that ten questionnaires should be given to the learners of each Grade. Of 700 questionnaires mailed, 355 were returned which represented a return of 51 percent. It should be noted that this return rate resulted to the problem of bias as it was not sufficiently representative of the population.

Geography learners who were interviewed were from ten of the twenty secondary schools with pass rates of between 70 and 100 percent which could have resulted in an extremely biassed sample. Only five Grade 12 learners per selected school were interviewed as a group, hence ten groups of Grade 12 geography learners were interviewed. The researcher interviewed only Grade 12 learners because it was assumed that they would be able to give adequate and accurate information on the problems they experienced in inquiring learning and science process skills. It was also assumed that Grade 12 learners would also be able to suggest quality solutions to the problems identified. The interview schedule for geography learners can be found in Appendix 12.

5.5 ARRANGEMENT FOR CONDUCTING INTERVIEWS

Approximately five months after receiving the last questionnaire, the researcher telephoned the school principals of the identified schools to arrange for interviews. Most principals referred the researcher to their geography teachers. The researcher requested the teachers for interviews not lasting more than fifteen minutes. The purpose of the interview was explained and the information sought was made clear. Teachers of the ten schools were requested to identify and prepare five Grade 12 geography learners who could be interviewed.

After the telephonic conversation, the researcher sent the interview schedule to the geography teachers and requested the teachers to suggest times at which the schools could be visited. Where there was a time conflict, the teachers concerned were phoned and alternative times that were available were suggested. Interviews in all schools were conducted during their forty-five minutes break time.

Two days before each interview, the researcher phoned the geography teacher concerned and reminded him/her of the interview. On the day of the interviews, the researcher tried to arrive in the schools twenty minutes before break. The researcher introduced himself to the school principals who took him to the geography teachers. The researcher introduced himself and stated briefly that he had come in accordance with previously made arrangements. Some small talk followed to make the interviewees as comfortable as possible. The interviews were conducted in a professional manner and the researcher kept to the questions sent to the teachers earlier. As the interview schedule consisted of only six questions, the researcher wrote down the answer to each question. After the interview, the teachers were thanked for their courtesy of giving their time and a word of appreciation was also expressed.

Then, the teachers selected the five learners to be interviewed. Learners were mostly seated in the school library or laboratory when the interviews took place. The researcher introduced himself to the learners and explained the purpose of his visit to them. He further explained the information he was seeking from them and why he was seeking it. He then started by explaining the meaning of inquiring teaching and inquiry learning. Thereafter, he explained what science process skills were by means of examples. The interviews were also conducted in a professional manner and the researcher kept to the questions sent to the schools earlier. After the interview, learners were thanked for their courtesy of giving their time. Each learner was given a bar of chocolate as a token gesture. Twenty-nine female learners and twenty-one male learners were interviewed. The interviewing process took twenty-five days to complete.

5.6 CONSTRUCTION OF QUESTIONNAIRES

A questionnaire is an instrument which attempts to obtain comparable data from all members of a population or sample because the same questions are asked of all research participants (Gay and Airasian 2000: 280). It is an instrument for gathering data beyond the physical reach of the researcher (Leedy 1993: 187). A researcher constructs a set of questions and requests the subjects to answer them, usually in a form that asks the respondents to check the response (McMillan and Schumacher 1997: 46). A questionnaire has some limitations. For instances Koul (1996: 150-151) maintains that:

- it can not be used with children and illiterates;

- the return rate is as low as 40 percent to 50 percent, hence the data obtained are of limited validity. The respondents who return the questionnaires may not be representative of the entire population. It will make a sample a biassed one

thus nullify the findings;

- ☐ sometimes respondents do not like to respond in writing to the questions of intimate nature and confidential nature or to the questions involving certain controversial issues;

- ☐ sometimes it is difficult to formulate and phrase questions on certain complex, delicate and intricate problems;

- ☐ there is no check on a respondent who may misinterprets a question or gives incomplete or indefinite responses; and

- ☐ sometimes the respondent may modify his earlier original responses to the questions when he finds that his responses to latter questions are contracting the previous ones.

Questionnaires were used to obtain data on the application of science process skills to the teaching of secondary school geography in the Free State Province. This section describes the constructions of the geography teachers' questionnaire (Appendix 3), and the geography learners' questionnaire (Appendix 4).

Gay and Airasian (2000: 282) maintain that a questionnaire should be attractive, brief and easy to complete. A researcher should carefully plan, its content and format. A sloppy, crowded, misspelled, and a lengthy questionnaire could put respondents off causing the research to yield too few responses. The researcher should include items and questions that have been properly thought and that directly relate to the topic and objectives of the study (Gay and

Airasian 2000: 282; McMillan and Schumacher 1997: 253).

The geography teachers' questionnaire consisted of five sections whilst the learners' questionnaire consisted of four sections. The teachers' questionnaire was constructed to look into the application of science process skills to the teaching of geography. The learners' questionnaire was designed to determine if learners concur with their teachers' perception of their application of science process skills to the teaching of geography.

- Part one of the teachers' questionnaire was designed to obtain personal information of the surveyed population. Respondents were requested to state their gender. This information was needed for statistical purposes and for the application of analysis of variance (ANOVA) (cf 6.3). Teachers were also requested to indicate if they took geography as a school subject up to matric standard, and if they had specialised in geography at tertiary level. This information was used to determine if geography teachers were qualified to teach the subject.

- Part two was designed to obtain data regarding geography teachers' experience in the teaching of geography. Teachers were requested to state their teaching experiences in years. This information was requested to determine the experience of the teachers teaching the subject. Teachers were also requested to indicate if on appointment to their present school they were interested in teaching geography and whether they found geography easy to teach. This information was used to find out if geography teachers were enthusiastic about their subject.

- Part three was designed to obtain school details of the respondents. Teachers were requested to indicate if their schools were in rural or urban area. This information was

needed for statistical purposes only. They were also asked to indicate if their schools were public, independent, farm, missionary or mine schools for use in ANOVA.

- Part one of the learners' questionnaire was also designed to obtain personal information of the surveyed population. Learners were requested to indicate their gender and age in completed years as well as to indicate their present Grade at school. They were also requested to indicate if they found geography easy to learn. Gender and Grade information was used in the application of ANOVA (cf. 6.3)

- Part two was designed to gather data on the schools learners were attending. Learners were requested to indicate if their schools were in rural or urban area. They were also requested to classify their schools as public, independent, farm, missionary or mine schools. These items were included in the questionnaire for the application ANOVA.

Parts four and five of the teachers' questionnaire and Parts three and four of the learners' questionnaire, were drawn from the theory in the literature review chapters hence, the following paragraphs highlight content validation of the questionnaires.

5.6.1 The Content Validation of the Questionnaires

- Part four of the teachers' questionnaire and Part three of the learners' questionnaire were designed to establish if geography teachers were inquiry teachers (cf. 5.3 and 6.2.2). In items 15 to 42, teachers were requested to indicate the frequency to which they did as described in the statements. This was done with the aid of the numeric or Likert-type scales. This is a self-reporting instrument in which the respondent replies

to a series of statements by indicating the extent of agreement (Fraenkel and Wallen 1996: 584; and Gay and Airasian 2000: 625). Each choice was given a numerical value and the following categories were used to categorise each item:

Never	1	Sometimes	2	Often	3	Always	4

In items 11 to 38, learners were requested to indicate the degree to which they agreed or disagreed as described in the statements. This was also done according to the numeric or Likert-type scales and the following categories were used to categorise each item:

Strongly Disagree	1	Disagree	2	Agree	3	Strongly Agree	4

Items 43 to 46 in the teachers' questionnaire and items 39 to 42 in the learners' questionnaire were designed to establish the difficulties which teachers and learners experienced while they were engaged in inquiry teaching and inquiry learning respectively (cf. 6.4.2.1 and 6.4.2.3). Respondents were also requested to suggest how the identified difficulties could be alleviated (cf. 6.4.2.2 and 6.4.2.4). Questionnaire items which measured inquiry teaching methods applied to the teaching of geography were taken from sections 2.2, 2.3 and 2.4 of this study. Thirty-two items in both teacher and learner questionnaires established the extent of inquiry teaching.

- Part five of the teachers' questionnaire and Part four of the learners' questionnaire were designed to gather data on the application of science process skills to the teaching of geography. This section was divided into two sections, namely, Section A which dealt with the application of basic science process skills whilst Section B dealt

with the application of advanced science process skills. Teachers were requested to indicate the degree to which they did as described in the statements whilst learners were requested to indicate the degree to which they agreed or disagreed as described in the statements according to the numeric or Likert-type scales as explained in the previous paragraph.

Section A in both questionnaires dealt with basic science process skills applied to the teaching of geography. Items 47 to 54 and items 59 to 63 in the teachers' questionnaire, and items 43 to 55 in the learners' questionnaire were designed to establish basic science process skills that geography teachers applied to the teaching of geography (cf. 6.2.3.2). These items were constructed to elicit information on whether teachers devised exercises and activities that enabled learners to practice and develop the following skills, which is to:

- ***identify*** *and* ***observe*** *geographical problems and to* ***observe*** *geographic phenomena* (items 47, 52 and 60 of the teachers' questionnaire and items 43, 48 and 52 of the learners' questionnaire).

  These items were included in the questionnaires to find out if learners are engaged in activities that enable them to look for patterns through their senses (observation). The items measured the application of *observation* skill to the teaching of geography. This is the skill on which all other science process skills are based.

- ***classify*** *geographical features and* ***order*** *them according to their structures.* (items 48 and 63 in teachers' questionnaire and items 44 and 55 in learners'

questionnaire).

These items were constructed to find out if learners are able to look for similarities and differences in phenomena. The items measured the application of *classifying* skill to the teaching of geography.

- ***communicate*** *information through drawing maps, charts, symbols, graphs and diagrams*; (items 49, 50, 59, 61 and 62 in teachers' questionnaire and items 45, 46, 51, 53 and 54 in learners' questionnaire).

Maps, charts, symbols, graphs and diagrams are communication tools which are used in geography. These items were included in the questionnaires to find out if learners are given activities that allow them to communicate orally or in writing what they know or are able to do. The items measured the application of the *communicating* skill to the teaching of geography.

- ***observe*** *and* ***measure*** *geographical phenomena and to compare objects using standardized units of measure and suitable measuring instruments*. (items 51 and 52 in teachers' questionnaire and items 47 and 48 in learners' questionnaire).

These items were structured to find out if learners are engaged in exercises in which they measure geographical objects and events through instruments and equipment. For instance, the use of rulers to measure distances and the use of climatological instruments to measure the elements of weather. The use of instruments enables learners to quantify descriptions of objects and events.

These items of the questionnaire assessed the application of the *measuring* skill to the teaching of geography.

- *use observations to **predict** future geographical events.* (item 53 in teachers' questionnaire and item 49 in learners' questionnaire).

  This item was included to find out if learners are encouraged to predict possible events before they are actually observed. The item evaluated the application of the *predicting* skill to the teaching of geography

- *use various forms of data to determine the **correctness of geographical theory**.* (item 54 in teachers' questionnaire and item 50 in learners' questionnaire).

  This item was structured to find out if learners are given opportunities to use data to infer their explanations of theories and to change their explanations as new information becomes available. The item assessed the application of the *inferring* skill to the teaching of geography.

Questionnaire items which measured basic science process skills applied to the teaching of geography were taken from sections 2.5.1, 4.4 and 4.6 of this study. Theoretical discussions of these sections revealed that geography teachers should provide learners with opportunities to be engaged in basic science process skills' exercises and activities.

Section B in both questionnaires dealt with the application of advanced science

process skills to the teaching of geography. Items 64 to 72 in the teachers' questionnaire, and items 56 to 58 and items 63 to 68 in the learners' questionnaire were designed to elicit information from the respondents on whether teachers devised exercises and activities that enabled learners to practice and develop the following integrated science process skills, which are to:

- ***identify variables*** *that affect geographical phenomena, for example, how variables such as air temperature, air pressure, humidity, and cloud cover influence the occurrence of rainfall.* (item 64 in teachers' questionnaire and item 56 in learners questionnaire.

  This item was structured to find out if learners are encouraged to identify variables that affect a geography phenomenon such as rainfall. The item assessed the application of the skill of *identifying variables* to the teaching of geography.

- ***construct table of data*** (item 65 in teachers' questionnaire and item 57 in learners' questionnaire).

  This is a skill that is needed to record the results of an investigation, hence the construction of this item in the questionnaire. Organizing data into tables helps to see pattern of the results (Rezba et al. 1995: 133).

  The item was used to measure the application of the skill of *constructing tables of data* to the teaching of geography.

- *use the tables of data to* ***construct and interpret graphs*** (items 66 and 72 in teachers' questionnaire and items 58 and 68 in learners' questionnaire).

  Items' 58 and 66 were designed to find out if learners are given exercises in which they communicate information through graphs instead of using a spoken or written message. These items assessed the application of the skill of *constructing a graph* to the teaching of geography.

  Items' 68 and 72 were formulated to find out learners are given exercises in which they interpret the graphs by describing the relationship between variables on the graphs.

  These items evaluated the application of the skill of *describing relationships between variables* to the teaching of geography.

- ***design and conduct investigations***. (items 67 and 71 in teachers' questionnaire and items 63 and 67 in learners' questionnaire)

  These items were formulated to find out if learners are given opportunities to design and conduct investigations to test hypotheses.

  These items were used to measure the application of the skill of *designing and conducting investigations* to the teaching of geography.

- ***identify the variables under study*** (item 68 in teachers' questionnaire and item 64 in learners' questionnaire).

The item was included in the questionnaire to find out if learners are given exercises in which they identify the manipulated and responding variables. This may enable them to recognize the parts of a typical investigation (Rezba et al. 1995: 205). Identification of the variables under study is done when analysing investigations hence this item measured the application of the skill of *analysing investigations* to the teaching of geography.

- ***construct hypotheses*** (item 69 in teachers' questionnaire and items 65 in learners' questionnaire).

The item was included in the questionnaire to establish if learners are given opportunities to state hypotheses when solving problems as hypotheses provide guidance on what data to collect.

The item evaluated the application of the skill of *constructing hypotheses* to the teaching of geography.

- **defining operationally** (item 70 in teachers' questionnaire and 66 in learners' questionnaire).

The item was included in the questionnaire to establish if learners are encouraged to define geographical phenomena by using the observable characteristics of the phenomena.

The item assessed the application of the skill of *defining operationally* to the teaching of geography.

Items in this section of the questionnaires were formulated from sections 2.5.2 and 4.5 of this study. Theory in these sections indicated that integrated science process skills are applicable to the teaching of geography. This implies that geography learners should be provided with opportunities to acquire and master these skills in order to participate in social life as critical and active citizens.

- Furthermore, in Part five of the teachers' questionnaire, question 73 requested the respondents to state problems which they experienced when applying science process skills to the teaching of geography. Item 74 requested teachers to suggest how the problems they have identified could be alleviated.

  In Part four of the learners' questionnaire question 69 requested the respondents to state problems which they experienced when science process skills were applied to the teaching and learning of geography. Item 70 requested them to suggest how the problems they have identified could be alleviated.

  These questions were included in the questionnaires because it was assumed that teachers and learners were bound to meet some problems when science process skills were applied to the teaching of geography.

In conclusion twenty- four items that dealt with the application of science process skills to the teaching of geography were formulated. After the questionnaires were constructed and finalised, they were administered to their respective respondents

5.6.2 Instructions for the Completing of the Questionnaire

The purpose for the instructions was to clarify what was expected from to the respondents and how they should complete the questionnaire. Instructions were clear and concise and the information that was given in the questionnaires was as follows:

- respondents were told that the study attempted to describe and explain the application of science process skills to the teaching of geography;

- respondents were also informed that the study was likely to provide useful information which could be of supportive nature to geography teachers in general and outcomes-based education in particular;

- respondents were told that the study also attempted to gain information on inquiry teaching methods applied to geography teaching and learning. They were also informed that the adoption of inquiry teaching and inquiry learning was likely to lead to the application of science process skills to the teaching of geography. It was also assumed that acquisition of science process skills might develop critical understanding of issues and the ability to solve problems;

- respondents were informed that the survey was approved by the Free State Education Department;

- the researcher indicated that he was grateful for the responses and ensured them that their responses would remain completely confidential and anonymous;

- in closed-form statements, the respondents were requested to answer by making a cross (X) over the appropriate number in the shaded area whilst in open-ended questions, the respondents were requested to write their answers in the shaded block provided;

- respondents were requested to send the questionnaire by the due date after completing it; and

- respondents were thanked in advance for their co-operation.

5.7 PROCEDURES FOR ANALYSING QUESTIONNAIRE DATA

A research study usually produces a mass of collected data that should be correctly scored and efficiently organised to facilitate data analysis. Descriptive and inferential statistics were used to analyse data.

5.7.1 Descriptive Statistics

Descriptive statistics enables the researcher to describe data with numerical indices or in graphic form (Fraenkel and Wallen 1996: 629). It is also concerned with describing or summarising data from the sample (Gay and Airasian 2000: 437 and Rowntree 1981: 21). Analysis procedure in descriptive statistics involves calculating and interpreting statistics. The major types of descriptive statistics are measures of central tendency, measures of variability, measures of relative position, and measures of relationships (Fraenkel and Wallen 1996:437: and Gay and Airasian 2000: 437). Measures of a central tendency are used to determine the average score of a group of scores (Fraenkel and Wallen 1996: 437). These measures are

the mode, the median and the arithmetic mean. Measures of variability show how spread out a group of scores is (Fraenkel and Wallen 1996: 437). The range, standard deviation and variance are the most commonly used in educational research. Measures of relative position describe a respondent's performance compared to the performance of all other respondents. Measures of relationship indicate the degree to which two sets of scores are related (correlation)(Fraenkel and Wallen 1996: 437).

The SAS statistical program was used to compute the collected data. The statisticians who assisted in the research applied the FACTOR procedure to the collected data. The FACTOR procedure performs a variety of common factors and component analyses and rotations (SAS User's Guide: Statistics, Version 5: 1985: 336). The FACTOR procedure also performs factor analysis (cf. 6.4.1) where a number of factors are established which have something in common with some of the variables which are used in the research (Mulder 1986: 113). In this study, the items of the questionnaire were not grouped when response data were loaded onto the computer. Hence the researcher conducted an investigative factor analysis.

5.7.1.1 Factor Analysis

Factor analysis involves a search for 'clusters' of variables, all of whom are correlated with each other (Fraenkel and Wallen 1996: 314; and Gay and Airasian 2000: 336). Therefore, each cluster represents a factor. This implies that factor analysis reduces a set of variables to a small number of factors. It is used to determine whether certain items in the inventory have something in common (Motseke 1998: 153). The method of extraction used was the principal component analysis (Table 6.7). The method for rotation applied was the varimax (Table 6.7). Its purpose was to obtain as many high positive and zero loadings as possible. The varimax method of rotation's output included means, standard deviations , eigenvalues

and a scree plot (6.2.3).

The first step in factor analysis was the construction of an intercorrelation matrix (cf. Table 6.7). The factors to be singled out were determined with the aid of the eigenvalues of the intercorrelation matrix (cf. Figure 6.1 and Table 6.7).

After the initial factor analysis, the factors were subjected to a Scree-test (cf. Figure 6.1) which is an analytical technique adopted from factor analysis (Race and Planek 1992: 173). Cattell (1966) as cited in Race and Planek (1992: 173) describes a scree test as a graph of eigenvalues plotted along the ordinated (y-axis) and factors plotted along the abscissa (x-axis). Its first roots show a 'cliff' of important factors and the other roots denote the 'rubble' (unimportant factors). All eigenvalues of greater than one are considered priority items (cf. 6.4.1) whilst eigenvalues which are less than one are discarded (SAS User's Guide: Statistics, Version 5: 1985: 339).

Principal component analysis is a multivariate technique for examining relationships among several quantitative variables (SAS User's Guide: Statistics, Version 5: 1985: 621). Plots of principal components are valuable tools in exploratory data analysis. Its output is all eigenvalues of greater than 1 (SAS User's Guide: Statistics, Version 5: 1985: 339). Data were also subjected to frequency distribution.

5.7.1.2 Frequency Tabulation

Frequency distribution which showed all the scores in each item of the questionnaires was used to tabulate data. Frequency data was converted to percentage indicating the number of the respondents who marked a particular item in relation to the total number of respondents.

Frequency tables were used to indicate biographical data (cf. Tables 6.1 and 6.2) of the respondents and to tabulate data for inquiry teaching method (cf. Tables 6.3 and 6.5). Frequency tables were also used to indicate responses to basic and integrated science process skills' items respectively (cf. 6.2.3). Data were also subjected to the measure of a central tendency of arithmetic mean.

5.7.1.3 Measures of Central Tendency

The means procedure, one of the indices of measures of a central tendency was used to establish if geography teachers used inquiry methods (Tables 6.4 and 6.6). It was also used to establish if geography teachers applied basic science process skills (Tables 6.10 and 6.12) and integrated science process skills to their teaching (Tables 6.13 and 6.15).

The arithmetic mean is the most important and frequently used measure of central tendency (Fraenkel and Wallen 1996: 589; Gay and Airasian 2000: 43; Mulder 1986: 17). It is calculated by adding up all the scores and dividing the total by the number of scores. The arithmetic mean is expressed by the following formula:

$$\bar{x} = \frac{\sum X}{N}$$

Where $\bar{x}$ = the arithmetic mean;

$\sum$ = the symbol for "the sum of";

x = any raw score value

N = the total number of scores

This formula indicates that the mean is computed by dividing the sum of all the scores in the distribution by the total number of scores in the distribution. Data were also subjected to index

of variability of standard deviation.

The standard deviation is the most frequently used index of variability (Gay 1987: 349 and Mulder 1986: 25) and it is a measure of the spread (variation) around the mean (Gay 1987: 349). The first step in calculating the standard deviation entails discovering how far each score is from the mean. This process involves squaring each difference, adding all the squares, and dividing by the number of scores. This measure of variability is called variance. The higher the deviation (variance), the more variation is the data around the mean (Gay 1987: 349). This implies that the scores are spread out. If the variance is small, it implies that the scores are close together. The square root of the variance is called the standard deviation. If the standard deviation is small, the scores are closer together whilst if the standard deviation is large, the scores are spread out.

If the distribution of the scores is normal, then the mean plus 3 standard deviations and the mean minus 3 standard deviations encompass about all the scores, over 99 percent of them (cf. 6.3.1, 6.3.2, 6.4.1.1 and 6.4.1.2). The following is the formula for calculating the standard deviation:

$$SD = \frac{1}{N}\sqrt{N\Sigma X^2 - (\Sigma X)^2}$$

where SD = standard deviation

N = number of scores

X^2 = each score squared

$(X)^2$ = the sum of all the scores squares

After descriptive statistics, inferences were made to predict about the similarity of the sample to the geography teacher and learner population from which the sample was drawn. Hence,

the following discussion on inferential statistics.

5.7.2 Inferential Statistics

Inferential statistics are certain types of techniques that allow researchers to make inferences and generalize about a population based on findings from a sample (Borg and Gall 1989: 350; Gay and Airasian 2000: 469; Fraenkel and Wallen 1996: 205; Langebach et al. 1994: 240).

Simple, or one-way analysis of variance (ANOVA) is used to determine whether there is a significant difference between two or more means at a selected probability level (Gay and Airasian 2000: 491). Therefore, the researcher used teachers' responses to conduct a series of one-way analysis of variance (ANOVAs) to determine if there were any statistically significant differences among the independent variables (*Gender, Teachers with or without matriculation geography, Grade and Location of the school*) with respect to the dependent variables (*Inquiry teaching methods, Basic science process skills and Integrated science process skills*).

Learners' responses were also used to conduct a series of one-way ANOVAs to determine if there were any statistically significant differences among the independent variables (*Gender. Grade and Type of the school*) with respect to the dependent variables (*Inquiry teaching methods, Basic science process skills and Integrated science process skills*).

Selaledi (1996: 64) points out that findings of no difference support a decision to combine the participants into one sample, regardless of membership in any education district. In this study the districts were combined because some districts had very few respondents. The results of one-way ANOVAs are presented in section 6.3.

5.8 CONCLUSION

Chapter 5 has reviewed the data processing procedures followed in this study. It initially supplied a rationale for a detailed description of the procedure employed in the development of the science process skills' questionnaire. Finally, the chapter concluded with a description of the statistical techniques applied to the data analysis. Chapter 6 presents the results of this study.