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Perceptions of teachers of the application of science process skills in the teaching of Geography in secondary schools in the Free State province

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This article reports on teachers' perceptions of the application of science process skills in the teaching of Geography in secondary schools in the Free State province. A teachers' questionnaire on the application of the science process skills in the teaching of Geography was constructed and the questionnaire was content validated against the theoretical assumptions supported by the literature and practical applications of the subject. The questionnaires were distributed to 150 respondents and 71 completed questionnaires were returned for further analysis. The responses to the items of the questionnaire were subjected to a principal component factor analysis and a varimax method of rotation. Two prominent factors were identified and investigated. Factor 1 was labeled "basic science process skills" and reaffirmed teachers' understanding of the basic process skills as autonomous and independent functions. The second factor confirmed the existence of a higher level of advanced and integrated process skills that build upon the basic or foundational process skills. These results confirmed the researchers' assumption that respondents could distinguish cognitively between these two very prominent constructs. They were comfortable with the fact that the science processes applicable to the teaching of Geography could be grouped into two main distinctive clusters or factors. The homogeneous clustering of items also emphasized the understanding that the classical science process skills could easily be applied to the teaching of Geography. This assumption was supported by the empirical investigation and findings. In addition, the results supported the hypothesis that although teachers did not apply integrated science process skills to the teaching of Geography on a regular basis, they were well-acquainted with the fact that these skills remain an important facet in the teaching of Geography in schools.

Introduction

Education systems are currently undergoing transformational changes throughout the globe and one of these is a shift from a philosophy that focuses mainly on the transmission of information to an understanding that supports the constructivist paradigm of teaching and learning. The previous South African education system was mainly based on the principles of Christian National Education (CNE) which was, according to many scholars, "... used to divide and control, to protect white privilege and power — socially, economically and politically — and to ensure Afrikaner dominance" (Hartshorne, 1989, cited by McGregor, 1992:20). This resulted in gross inequalities among schools that catered for different races in South Africa (Department of Education, 2001a:10). As such, there had been an inadequate supply of resources in many schools and most teachers in historically black schools had low qualifications and poor morale (Hartshorne, 1992:79; McGregor, 1992:24).

Various studies indicate that this sad state of affairs affected the practice of teachers who resorted to survival teaching methods (Department of Education 2001:10; Hartshorne, 1992:79). It seemed as though the emphasis was on teaching for examination purposes only without encouraging learners' active participation in the learning programmes. The result was that the quality of teaching was unlikely to foster the development of independent, critical and creative thinking in learners. It was possible that this problem might have affected many secondary school subjects and learning programmes in general. Research also indicated that in most Geography classrooms learners were taught geographical facts and concepts with minimal understanding (Rambuda, 1994:57).

After the dawn of the new political dispensation on 27 April 1994, the government sought to address educational problems such as the low final year examination pass rates, poor school attendance by learners, segregated education, a poor work ethos prevailing among many teachers, teacher-centred instruction and predominant summative assessment applications. Two strategies were implemented with immediate effect. The first was the introduction of transformative Outcomes-based Education (OBE) and the other Curriculum 2005 (C2005) which was supposed to serve as a vehicle through which OBE could be driven. C2005 called for the adoption of an outcomes-based education (OBE) philosophy in South Africa, emphasizing a paradigm shift from a content-based education system to a system-based one regarding the achievement of outcomes in the classroom. This understanding called for a shift away from the traditional product-driven approach to a process approach in the teaching of Geography.

Hence it is envisaged that the introduction of science process skills to the teaching of Geography is likely to enable learners to learn geographical phenomena with insight and understanding. As a result of this, it might not be easy for Geography learners to forget the information they have investigated, discovered and 'felt'. Geography education at secondary schools is regarded as a burden to the memory because learners are expected to memorise too many facts. The application of science process skills is likely to reduce problems such as these since science process skills may encourage learning by doing. Furthermore, science process skills enable learners to learn how to learn by thinking critically and using information creatively (Martin, Sexton, Wagner & Gerlovich, 1994:11).

The science processes: an orientation

Science process skills are activities that scientists execute when they study or investigate a problem, an issue or a question. These skills are used to generate content and to form concepts (Sund & Trowbridge, 1973:3; Funk, Fiel, Okey, Jaus & Sprague, 1979:ix; Carin & Sund, 1985:4-10; Collette & Chiappetta, 1986:71; Wellington, 1994:27-28).

Furthermore, Martin, Sexton, Wagner and Gerlovich (1994:11) regard process skills as the way of thinking, measuring, solving problems, and using thoughts. This implies that thinking and reasoning are skills involved in investigative teaching and learning strategies. Hence teachers and learners can apply science process skills while developing teaching and learning inquiry competences.

Science process skills can be classified as either basic science process skills or integrated science process skills (Carin & Sund, 1985: 4-10; Collette & Chiappetta, 1986:71;Wellington, 1994:27-28). Integrated science process skills are regarded as more advanced than basic process skills (Collette & Chiappetta, 1986:71). Brotherton and Preece (1995:5) argue that scientists are only able to use integrated skills effectively once they have mastered the basic skills.

Basic science process skills

Basic science process skills apply specifically to foundational cognitive functioning in especially the elementary grades. In addition, these skills also form the backbone of the more advanced problem-solving skills and capacities. They represent the foundation of scientific reasoning learners are required to master before acquiring and mastering the advanced integrated science process skills (Brotherton & Preece, 1995:5). Funk *et al.* (1979:1) maintain that basic science process skills are interdependent, implying that investigators may display and apply more than one of these skills in any single activity.

For instance, to *measure* a distance between two points on a map, the investigator may start by *observing* the two points, then *measuring* the distance and *communicating* the same distance by means of a symbol. Thereafter, the investigator may *predict* how long it takes a person to travel from one point to another. The investigator may then *infer* the best form of transport to use to travel between the two points. In this scenario, the investigator was involved in the skills of observing, classifying, predicting, measuring, inferring and communicating. It appears as if basic skills provide the intellectual ground work in problem-solving. Children who can perform these skills are likely to show understanding of basic science processes (Martin *et al.*, 1994:11) and perform integrated science process skills.

Integrated science process skills

These are immediate skills that are used in problem-solving. Integrated skills include skills such as identifying variables, constructing tables of data and graphs, describing relationships between variables, acquiring and processing data, analysing investigations, constructing hypotheses, operationally defining variables, designing investigations and experimenting (Funk *et al.,* 1979:83). As the term *integrated* implies, learners are called upon to combine basic process skills for greater expertise and flexibility to design the tools they apply when they study or investigate phenomena. This process can lead to the realization and achievement of integrated science process skills as observable and demonstrable outcomes.

The curricula and related processes

The envisaged achievement of the science process skills as specific outcomes in the teaching of Geography is well defined in national policy documents. The National Curriculum Statement for Geography Grades 10–12 states very specifically that one of the purposes of Geography in the FET band is to "... acquire, arrange and use geographic information" and to "develop tools and skills to ... interpret, analyse, and make judgements based on the information gathered" (Department of Education 2002b:9). The draft document also explains that learners should be able to gather, observe, read and record information and to interpret maps and other graphic representations (Department of Education 2002b:9-12). The document also lists the importance of understanding the spatial dimensions of Geography and to perform a range of skills such as the execution of certain measurements, spatial sampling, taking of notes and the drawing of sketches. Many of these activities are listed as so-called geographical skills and bear a strong resemblance to the science process skills referred to earlier in this article.

The revised National Curriculum Statement for the Social Sciences Grades R–9 outlines the first learning outcome for geographic enquiry as the ability "to use enquiry skills to investigate geographical and environmental concepts and processes" (Department of Education 2002c:7-94). A closer assessment of the suggested outcomes reveals a large number of skills outlining activities such as enquiry processes and communication skills. The document also lists the importance of spatial relationships (direction and position of objects), observation, the enquiry process, map symbols, classification, the categorisation of information, measuring distances, the recording of information and the correlation of information.

Finally, the assessment guidelines that apply to the Human and Social Sciences (with specific reference to Geography) refer specifically to map reading and other analytical activities such as the interpretation of symbols, the use of scales and the application of basic map reading techniques (Department of Education, s.a.:45-46). Other data processing skills such as the analysis and interpretation of data, the presentation of findings, the use of graphs and tables, the transfer of information from one format to the other (graphs and written reports), the evaluation of data when drawing conclusions, the tabling of predictions and the offering of recommendations, are documented as examples and requirements each learner has to achieve as specific outcomes in the Geography classroom (Department of Education, s.a.:42). As from 2004 "learning outcomes" will replace the use of the concept "specific outcomes" in South African schools.

Research design

In this study a quantitative approach was deemed most appropriate as it provided secondary school Geography teachers with an opportunity to rate the frequency of use of different science process skills in their classrooms. The primary aim of the research was to investigate teachers' perception of the application of science process skills to the teaching of Geography in secondary schools in the Free State province. The specific research objectives were to establish

- teachers' perceptions of the application of basic science process skills in the teaching of Geography, and
- teachers' perceptions of the application of integrated science process skills in the teaching of Geography.

Research sample

Questionnaires were sent to 150 practising secondary school Geography teachers after a simple random sampling was applied to select the target population. In a random sample, each individual has an equal chance of being included (McBurney, 1994:204; McMillan & Schumacher, 1993:166; Howell, 1999:21). Furthermore, in a random sample the characteristics of each individual in the sample reflect the characteristics of the total population (Leedy, 1993:201). This process ensured that each school that offered Geography had an equal and independent chance of being selected. This was done by using a table of uniform random numbers to select 150 secondary schools that were included in the sample of 302 schools that offered Geography in the Free State province in 2000.

The first school was identified as school 0001, the second as school 0002, school 299 as 0299, and so on. Using the table of uniform random numbers, the first two numbers did not form part of the sample because there were numbers 682 and 610 in the population (Howell, 1999:450-451). However, the third number in the column, namely 046, formed part of the sample as it was also in the population. Thus, school 0046 duly formed part of the sample. This selection process was repeated 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.

Data collection strategy

Statisticians from the Department of Statistics at the University of Pretoria assisted in the construction of a questionnaire that included items on the science process skills as applicable to the teaching of Geography in secondary schools. To design a questionnaire and items with a high reliability, content validity and construct validity, a literature survey was conducted and questions set in terms of the assumptions underpinning teachers' understanding of the process skills in the teaching of Geography. The application of the questionnaire was followed by a classical items analysis and first level factor analysis.

Analysis of the responses of teachers

A principal component factor analysis with a varimax method of rotation, known as the PRINCOMP Procedure (SAS/STAT User's Guide, 1990:1241-1263), was applied to teachers' responses to the questions.

The varimax method of rotation used in this factor analysis has proved very successful as an analytic approach to obtaining an orthogonal rotation of factors (Kachigan, 1991:238; Nunnally, 1967:333). Nunnally (1967:306) argues that " when the loadings of variables on factors are inspected, it is hard to find clear-cut patterns of loadings.". Therefore, "the rotated factors explain the same amount of variance as the original factors, but they 'slice it up' in a way that is more interpretable".

Factors were identified by means of the following strategies: the weighting and retaining of eigenvalues (less than one eigenvalue) (Kachigan, 1991:246; SAS/STAT User's Guide, 1990:1242), the interpretation of the scree test (variance of a set of scores equals the square of the standard deviation) (Cattell, 1966:245-276), the consideration of the total variance accounted for or "explained" by the factors (Kachigan, 1991:246-247), taking into account Nunnally's (1967:357) suggestion that only variables with loadings of 0.30 and higher should be considered, and the degree to which each of the variables correlated with each of the factors (Anastasi, 1982:364; Guilford, 1956:466-467; Kachigan, 1991:243). Cronbach's correlation coefficient alpha formula was used to estimate the reliabilities of the responses on which the factor analyses were based (Anastasi, 1982:117; Ebel & Frisbie, 1991: 85; Nunnally, 1967:210). Test reliability addresses the question whether or not a measuring instrument is consistent (Vockell, 1983:22), or as Sax (1974:172) puts it, to describe the extent to which measurements can be depended on to provide consistent, unambiguous information. The Cronbach alpha formula provides a good estimate of reliability in most situations for a set of two or more construct indicators (Hair, Anderson, Tatham & Black, 1992:428), or composes a measure on scores with values other than 0 and 1 (Cronbach [1951], in Ebel & Frisbie, 1991:84).

The SAS statistical program was used to compute the collected data. A so-called FACTOR procedure was applied to the data set by the statisticians who assisted with the empirical analyses of the responses. 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 a factor analysis where a number of factors are established that have something in common with some of the variables which are used in the research (Mulder, 1989:113). In this study, the items of the questionnaire were not grouped when response data were loaded onto the computer. Hence the researchers conducted an investigative factor analysis which involves a search for "clusters" of variables which are all correlated with one other (Fraenkel & Wallen, 1996:314; Gay & 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. The method of extraction used was the principal component analysis (Table 1). The method for rotation applied was the varimax. 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.

The first step in factor analysis was the construction of an intercorrelation matrix. The factors to be singled out were determined with the aid of the eigenvalues of the intercorrelation matrix. After the initial factor analysis, the factors were subjected to a scree test that is an analytical technique derived from factor analysis (Race & 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 ordinate (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 while eigenvalues that are less than one are discarded (SAS User's Guide: Statistics, Version 5, 1985:339).

An inspection of the factor loadings in Table 1 reveals that two factors are retained by the analysis. The first principal component accounted for 11.5 eigenvalues whilst the second principal clarified 1.9 eigenvalues. The fact that factorial analysis could distinguish between two factors, that could be identified as basic and integrated science process skills, confirmed the assumption that the respondents distinguished cognitively between the two constructs. It also indicated that the respondents have come to terms with the fact that these two factors include skills that can be applied to the teaching of Geography. The aim of the factor analysis was to determine whether certain factors can be isolated and after this was done, the factors were identified and labelled as basic and integrated science process skills. Figure 1 represents a graphical representation (scree curve) of the percentage of variance explained by each consecutive factor.

The varimax method of rotation was also used as an analytical approach with an orthogonal rotation of factors. Its purpose was to obtain as many highly positive and near zero loadings as possible. This application of the varimax rotation method also revealed that there were two categories of science process skills. Table 2 shows this rotated factor pattern. The homogenous clustering of items with high internal consistencies (correlations) implies that respondents were comfortable with their assumption that science process skills can be grouped into two main clusters. It therefore confirms a high construct validity of the questionnaires.

Table 2 indicates that in Factor 1, values with correlation coefficients higher than 0.5 account for one category of science process skills and values which are below 0.5 contribute to another category. An analysis of Factor 2 also reveals the same pattern. Values that are smaller than 0.5 also form one category of science process skills and values which are larger than 0.5 form another category. As such, in Factor 1, values above 0.5 can be classified as basic science process skills while values below 0.5 can be classified as integrated science process skills. In Factor 2 values smaller than 0.5 may be classified as basic science process skills while values larger than 0.5 may be classified as integrated science process skills.

As a result of the factor analysis, data are analysed under the identified two principal components. Item analysis is used to investigate teachers' perception of the application of basic science process skills (Table 3) and integrated science process skills (Table 5) in the teaching of Geography in secondary schools in the Free State.

Discussion of findings

Tables 3 and 4 show the application of basic science process skills to the teaching of Geography according to teachers' perceptions.

The teachers' responses to items 1 to 13 of the questionnaire enabled the researchers to apply the means procedure to establish the extent to which teachers think they apply basic science process skills to the teaching of Geography. Table 4 illustrates the means procedure for the application of basic science process skills according to teachers' responses.

Table 4 indicates that the respondents achieved an arithmetical mean of 2.6 across the different options or categories. As such, teachers' responses to the basic science process skills' questionnaire items revealed that they think they often apply science process skills to the teaching of Geography. This implies that the following basic science process skills are likely to be applied in Geography classrooms:

Observation

This is the principal way in which people obtain information about their environment through the five senses, namely, sight, smell, touch, taste and hearing (Rezba, Sprague, Fiel, Funk, Okey & Jaus, 1995:3). This is classified as qualitative observation. Sometimes learners can use a standard unit of measurement for more precise information than the senses alone can provide, which is quantitative information that helps in the communication of specifics and provision for comparisons.

Classification

This requires people to organize their observations in ways that carry special meaning (Martin *et al.*, 1994:12). People classify these in order to comprehend them. Classification takes place through observing similarities, differences and interrelationships.

Table 1 Eigenvalues of the correlation matrix for science process skills: Total = 22; Average = 1; N = 71

Questionnaire items on science process skills	Eigenvalue	Difference	Proportion	Cumulative
1. I give my learners many opportunities to **identify** geographical important problems.	11.5	9.7	0.5	0.5
2. I organize classroom activities in which learners **classify** the observed geographical features.	1.9	0.6	0.1	0.6
3. I encourage learners to use any means to **communicate** learned information, i.e. to draw maps, charts, symbols, graphs and diagrams to **communicate** the information.	1.2	0.3	0.1	0.7
4. I link the work in geography on **diagrams** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion in class.	1.0	0.2	0.1	0.7
5. I organize activities in which my learners **compare** objects using standardized units of measure and suitable measuring instruments.	0.9	0.4	0.0	0.7
6. I organize my learners to **observe** geographical phenomena such as maximum and minimum air temperatures, wind direction and speed, atmospheric pressure, relative humidity, amount and type of rainfall.	0.7	0.0	0.0	0.8
7. I encourage my learners to **predict** future geographical events based upon their observations.	0.7	0.0	0.0	0.8
8. I encourage learners to use various forms of data to determine the **correctness of geographical theory**.	0.6	0.1	0.0	0.8
9. I encourage learners to **describe** a geographical feature's position in relation to other geographical features.	0.5	0.0	0.0	0.9
10. I give my learners many opportunities to **observe** geographically important problems.	0.5	0.0	0.0	0.8
11. I encourage learners to use any means to **communicate** investigated information.	0.4	0.0	0.0	0.9
12. I link the work in geography on **graphs** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion.	0.4	0.0	0.0	0.9
13. I organize activities in which my learners arrange geographical features in logical **order** according to their structures.	0.3	0.0	0.0	0.9
14. I encourage learners to **identify variables** that affect geographical phenomena, e.g. how variables such as air temperature, air pressure, humidity, and cloud cover influence the occurrence of rainfall.	0.3	0.1	0.0	0.9
15. I devise exercises in which my learners have to **construct tables of data**.	0.2	0.0	0.0	0.9
16. I devise exercises in which my learners have to **construct graphs**.	0.2	0.0	0.0	1.0
17. I devise exercises in which my learners **conduct investigations**.	0.2	0.0	0.0	1.0
18. I devise exercises in which my learners **identify the variables** under investigation.	0.2	0.0	0.0	1.0
19. I give my learners geographical problems in which they are encouraged to **construct hypotheses**.	0.1	0.2	0.0	1.0
20. I give exercises in which my learners **define** geographical features by using observable characteristics of the features.	0.1	0.0	0.0	1.0
21. I give my learners hypotheses and request them to **design investigations** to test the given hypotheses.	0.1	0.0	0.0	1.0
22. I devise exercises in which learners have to **describe the relationship between variables** on a graph.	0.1	0.0	0.0	1.0

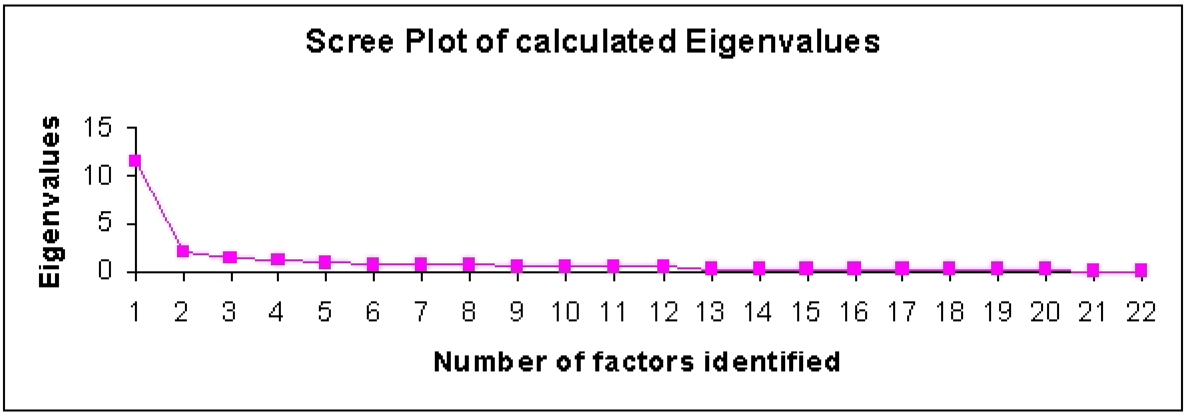

Figure 1 Scree plot of the calculated eigenvalues

Table 2 Orthogonal transformation matrix of the results of the varimax rotation procedures applied to the item mix of basic and applied science process skills (N = 71)

	Questionnaire items on science process skills	Factor 1 Basic science process skills	Factor 2 Integrated science process skills
1.	I give my learners many opportunities to **identify** geographical important problems.	0.7	0.2
2.	I organize classroom activities in which learners **classify** the observed geographical features.	0.6	0.4
3.	I encourage learners to use any means to **communicate** learned information, i.e. to draw maps, charts, symbols, graphs and diagrams to **communicate** the information.	0.5	0.4
4.	I link the work in geography on **diagrams** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion in class.	0.5	0.5
5.	I organize activities in which my learners **compare** objects using standardized units of measure and suitable measuring instruments.	0.7	0.3
6.	I organize my learners to **observe** geographical phenomena such as maximum and minimum air temperatures, wind direction and speed, atmospheric pressure, relative humidity, amount and type of rainfall.	0.6	0.3
7.	I encourage my learners to **predict** future geographical events based upon their observations.	0.8	0.2
8.	I encourage learners to use various forms of data to determine the **correctness of geographical theory**.	0.9	0.2
9.	I encourage learners to **describe** a geographical feature's position in relation to other geographical features.	0.7	0.3
10.	I give my learners many opportunities to **observe** geographically important problems.	0.7	0.3
11.	I encourage learners to use any means to **communicate** investigated information.	0.6	0.5
12.	I link the work in geography on **graphs** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion.	0.6	0.5
13.	I organize activities in which my learners arrange geographical features in logical **order** according to their structures.	0.6	0.4
14.	I encourage learners to **identify variables** that affect geographical phenomena, e.g. how variables such as air temperature, air pressure, humidity, and cloud cover influence the occurrence of rainfall.	0.7	0.4
15.	I devise exercises in which my learners have to **construct tables of data**.	0.0	0.8
16.	I devise exercises in which my learners have to **construct graphs**.	0.3	0.8
17.	I devise exercises in which my learners **conduct investigations**.	0.3	0.8
18.	I devise exercises in which my learners **identify the variables** under investigation.	0.3	0.8
19.	I give my learners geographical problems in which they are encouraged to **construct hypotheses**.	0.4	0.7
20.	I give exercises in which my learners **define** geographical features by using observable characteristics of the features.	0.5	0.6
21.	I give my learners hypotheses and request them to **design investigations** to test the given hypotheses.	0.4	0.6
22.	I devise exercises in which learners have to **describe the relationship between variables** on a graph.	0.4	0.7

Factor 1 (Basic science process skills) explained 7.1382852 of the variance whilst factor 2 (Integrated science process skills) explained 6.2380386 of the variance.

Communication
This is important in whatever people do. Teachers communicate knowledge, ideas and instruction to their learners. Learners also communicate knowledge and ideas to their teachers and peers. In Geography, learners can use communication tools such as graphs, charts, maps, symbols, diagrams, mathematical equations, visual demonstration and written and spoken words to communicate vital information.

Measuring
This is the process by which learners measure angles, numbers, sizes, lengths or distances, volumes and mass. The acquisition and practising of skills needed to do these measurements are essential for learners to be able to think in metric terms.

Prediction
Funk *et al.* (1979:57) defined this as "a forecast of what a future observation might be". Predictions are kinds of thinking that require learners' best guesses based on the information available to them (Martin *et al.,* 1994:13). Geographers are supposed to be able to forecast the weather and the occurrence of other phenomena like drought, floods, tornadoes, volcanoes and hurricanes.

Inferring
This is a process of concluding about the cause of an observation. Direct observation of objects or events enables people to suggest something, to interpret and explain things and activities happening in their environment. For instance, an explanation or interpretation of an observation is indeed an inference (Funk *et al.,* 1979:72). Table 5 indicates teachers' perceptions of the application of integrated science process skills to the teaching of Geography.

The teachers' responses to items 14 to 22 of the questionnaire also enabled the researchers to apply the means procedure to establish the extent to which teachers think they apply integrated science process skills to the teaching of Geography. Table 6 illustrates the means procedure for the application of integrated science process skills.

The data given in Table 6 reveal an arithmetic mean of 2.3. This value implied that teachers think they sometimes apply the integrated science process skills to the teaching of Geography. These results also implied that, according to teachers' perceptions, most Geography learners are not as often exposed to the following integrated science process skills as one might expect.

Identifying variables
Fraenkel and Wallen (1996:51) point out that "a variable is a concept — a noun that stands for variation within a class of objects, such as chair, gender, eye colour, achievement, motivation, or running speed". It is something that can vary or change (Fraenkel & Wallen, 1996:51; Rezba *et al.,* 1995:123). Liebenberg (1986:156) regards a geographical variable as a geographical phenomenon whose characteristics change from place to place or time to time, for example, "The temperature for an area (Welkom) is influenced by the time of the day"; for instance, on the same day it can be –2°C at 02:00 and 18°C at 14:00.

Constructing a table of data
When identifying the variables, the information on the variables can be presented in tables. One is able to establish trends and patterns by

Table 3 Perceptions of geography teachers on the application of the basic science skills as percentage (%) scores (N = 71)

Questionnaire items on basic science process skills	Never	Sometimes	Often	Always
1. I give my learners many opportunities to **identify** geographical important problems.	4.2	32.4	43.7	19.7
2. I organize classroom activities in which learners **classify** the observed geographical features.	5.6	42.3	40.9	11.2
3. I encourage learners to use any means to **communicate** learned information, i.e. to draw maps, charts, symbols, graphs and diagrams to **communicate** the information.	4.2	29.6	29.6	36.6
4. I link the work in geography on **diagrams** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion in class.	2.8	35.2	31.0	31.0
5. I organize activities in which my learners **compare** objects using standardized units of measure and suitable measuring instruments.	21.1	38.0	31.0	9.9
6. I organize my learners to **observe** geographical phenomena such as maximum and minimum air temperatures, wind direction and speed, atmospheric pressure, relative humidity, amount and type of rainfall.	14.0	26.8	32.4	26.8
7. I encourage my learners to **predict** future geographical events based upon their observations.	12.7	29.6	35.2	22.5
8. I encourage learners to use various forms of data to determine the **correctness of geographical theory**.	9.9	39.4	32.4	18.3
9. I encourage learners to **describe** a geographical feature's position in relation to other geographical features.	7.0	43.7	39.4	9.9
10. I give my learners many opportunities to **observe** geographically important problems.	9.9	35.2	38.0	16.9
11. I encourage learners to use any means to **communicate** investigated information.	11.3	31.0	39.4	18.3
12. I link the work in geography on **graphs** to the everyday life of the learners, i.e. getting learners to bring examples from newspapers and magazines for discussion.	5.6	38.1	32.4	23.9
13. I organize activities in which my learners arrange geographical features in logical **order** according to their structures.	18.3	38.0	35.2	8.5

Table 4 The means procedure for the application of the basic science process skills (BSPS) according to the responses of geography teachers

Variable	N	Mean	Standard deviation	Minimum	Maximum
BSPS	71	2.6	0.7	1.4	4.0

Table 5 Perceptions of geography teachers on the application of the integrated science skills as percentage (%) scores (N = 71)

Questionnaire items on integrated science process skills	Never	Sometimes	Often	Always
14. I encourage learners to **identify variables** that affect geographical phenomena, e.g. how variables such as air temperature, air pressure, humidity, and cloud cover influence the occurrence of rainfall.	2.8	25.4	45.0	26.8
15. I devise exercises in which my learners have to **construct tables of data**.	22.5	46.5	22.5	8.5
16. I devise exercises in which my learners have to **construct graphs**.	12.7	59.1	19.7	8.5
17. I devise exercises in which my learners **conduct investigations**.	14.1	54.9	23.9	7.1
18. I devise exercises in which my learners **identify the variables** under investigation.	19.7	42.3	28.0	10.0
19. I give my learners geographical problems in which they are encouraged to **construct hypotheses**.	19.7	43.7	29.6	7.0
20. I give exercises in which my learners **define** geographical features by using observable characteristics of the features.	16.9	25.4	45.0	12.7
21. I give my learners hypotheses and request them to **design investigations** to test the given hypotheses.	25.4	42.2	25.4	7.0
22. I devise exercises in which learners have to **describe the relationship between variables** on a graph.	14.0	46.5	31.1	8.5

Table 6 The means procedure for the application of the integrated science process skills (ISPS) according to the responses of geography teachers

Variable	N	Mean	Standard deviation	Minimum	Maximum
ISPS	71	2.3	0.7	1.1	4.0

analysing the tables (Rezba *et al.,* 1995:153) which can be the measurements of temperature, rainfall, time or volume.

Plotting a graph
Geographers draw graphs and diagrams to represent temperature figures, population figures, economic production figures or rainfall figures. These types of graphical representation may also appear in newspapers and magazines. In order to understand and attach meaning to what is happening around them, people should be able to interpret graphs. Liebenberg (1986:156) argues that graphs and diagrams enlighten the hidden qualities of the data and make the implications easier to understand.

Describing relationships between variables
Once a graph has been constructed, learners may realize that the graph is a coded message which needs to be interpreted. The description should give a summary of the relationship between the manipulated and the responding variables. The learners should indeed be able to interpret the trends and patterns revealed by the graphs.

Acquiring and processing data
Investigation requires researchers to observe, to collect and analyse data, and to draw conclusions in order to solve a problem (Martin *et al.,* 1994:15). Consequently, an investigator should be able to conduct an investigation and compile a table related to the data. If an investigation involves the measurements of mass, length, temperature, force and volume, the researcher should be able to construct a table of data using the measuring units of these elements.

Analysing investigations
Before one conducts an investigation, one should determine the variables under investigation (Fraenkel & Wallen, 1996:48). One should then formulate the hypotheses being tested (Gay & Airasian, 2000:71). The investigator can also use a supplied description of an investigation to identify the hypotheses being tested (Rezba *et al.,* 1995:205). Analysing investigations enables the investigator to identify the manipulated and responding variables (Gay & Airasian, 2000:151; Fraenkel & Wallen, 1996:54; McMillan & Schumacher, 1997:88). The manipulated variable should be the only variable affecting the responding variable. If there is a constant factor that may affect the investigation, it should be prevented from doing so (Rezba *et al.,* 1995:206). Analysing investigations also enables the investigator to test, accept or reject and revise hypotheses (Gay & Airasian, 2000:77; Fraenkel & Wallen, 1996:212: McMillan & Schumacher, 1997:358). If the hypotheses are accepted, the investigator may move to the next problem. A revision of the hypotheses may compel the investigator to redefine the problem and gather new data that are needed to test the constructed hypotheses.

Constructing hypotheses
An inquiry involves an investigation of a question, a problem or an issue. This entails an investigator striving to obtain a solution to the problem. Finding a solution to the problem involves decision-making (Lambert & Balderstone, 2000:74). Before an inquiry is conducted, the investigator should suggest tentative answers to the problem. These tentative solutions are hypotheses (Gay & Airasian, 2000:71; Fraenkel & Wallen, 1996:56; McMillan & Schumacher, 1997:95). Hypotheses are predictions about the relationships between variables (Rezba *et al.,* 1995:219). They guide the researcher with regard to which data to gather. Sometimes a problem is provided and the re-searcher is expected to find a solution to it. The researcher may also identify a problem and make predictions about the relationship be-tween variables. Rezba *et al.* (1995:222) maintain that "prediction can be based on fact, opinion, hunch, or whatever resources one may possess". Martin *et al.* (1994: 15) also claim that forming hypotheses is similar to prediction al-though hypothesising is more controlled and formal. Subsequently, it is imperative to formulate a testable hypothesis which directs the way the investigation should be designed and eventually take place. The gathered information should be used to make the best educated guess about the expected outcome of the investigation (Martin *et al.,* 1994:15).

Defining variables operationally
A definition that attributes meaning to a concept by specifying the procedures that must be conducted in order to measure or manipulate the concept, is an operational definition (Ary, Jacobs & Razavieh, 1990: 29; Borg & Gall, 1989:26: McMillan & Schumacher, 1997:89). Variables can be defined operationally by applying some kind of a measurement (a measured operational definition) or by listing the steps taken in an experiment to produce research conditions (an experimental operational definition) (Ary *et al.,* 1990:35).

Designing investigations
After constructing hypotheses, the investigator designs an investigation to test the hypotheses. The designed investigation should be simple to enable the researcher to collect usable data. The collected data should either support or reject the formulated hypotheses.

Experimenting
An opportunity to practice all the science process skills, that have been discussed, is provided by experimenting. Experiments are a way of learning something by varying some conditions and observing the effect on something else (McMillan & Schumacher, 1997:313). An experiment is a scientific investigation in which the researcher controls some independent variables and observes the effects of these manipulations on the dependent variables (Ary *et al.,* 1990:298). The investigator starts with a question which needs to be solved. The first step to find solutions to the problem will be to identify the variables, to formulate the hypotheses, to identify the factors that should be held constant, to define variables operationally, to design an investigation, to rerun trials, to collect data and then interpret data (Ary *et al.*, 1990: 298; McMillan & Schumacher, 1997:315; Rezba *et al.*,1995:251). All these activities include the science process skills that have been discussed in this article.

Conclusion

The main purpose of the factor analysis was to determine to what extent consensus would be reached among teachers in terms of major behavioural characteristics underpinned by the items selected for the factor analysis. The focus of the factor analysis was on the description of teachers' understanding and opinions regarding the application and utilisation of the science processes skills during the teaching of Geography. This was done by reducing the number of categories from an initial multiplicity of test variables or, in this specific case, the items in the questionnaires to a few common factors or traits. The research revealed that according to the perception of Geography teachers, a very clear distinction can be drawn between the basic science process skills and the more advanced integrated science process skills. The investigation confirmed the researchers' assumption that Geography learners are exposed to a limited number of science processes during the teaching of Geography and that these skills are mostly confined to the basic processes. Geography teachers should therefore conduct some simple experiments in their classrooms since this is likely to expose learners to a variety of integrated science process skills.

However, the investigation revealed a number of 'classical' instructional problems so often encountered in classrooms where investigative strategies have to be applied. These problems are surely not confined to the teaching of Geography alone and readers should be able to associate them with various subjects and learning areas. In a previous investigation, Rambuda (2002:289) exposed the lack and willingness of learner involvement during the mediation of Geography. The use of English as medium of instruction was problematic in this investigation since it restricted communication and reflection in the learning environment. Related variables such as independent thinking skills, understanding and implementation of the science processes, the ability to substantiate and validate findings and claims, the generation of questions and the lack of a general reading culture were also found to contribute to an inadequate implementation of the science process skills during the teaching of Geography in secondary schools (Rambuda, 2002:290-291).

The content-based or so-called 'traditional' approaches towards teaching and learning have been severely criticized by advocates of the outcomes-based paradigm of thinking since the introduction of OBE in South Africa more than seven years ago. However, the view of science as a body of established knowledge should not be ignored and this interpretation of science has been the point of departure for many teachers in the past three decades (Collette & Chiappetta, 1986:5). Viewing science as a "way of thinking" or as a "way of investigating phenomena" supports the notion of finding a logical and rational balance between the importance of facts, concepts, principles, laws, hypotheses and theories, and the premises supporting a metho-dology that could be followed in the exposition of new and creative assumptions and rational arguments.

The science process skills fit this premise of understanding and collectively contribute to the establishment of the skills as operational outcomes whose mastery should be regarded as foundational to all learners' understanding of Geography as social or physical science. It has become axiomatic that facts and concepts can change and become redundant in an information environment that changes quickly. However, the methods, skills and strategies required to expose and reveal the sources of information, are captured more easily and retain their holt for longer periods of time.

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