

https://dspace.org/

Learners' conceptions about astronomical concepts related to the sun and the earth

Mosoloane, Retselisitsoe

2006-11-16T10:18:48Z
http://hdl.handle.net/10539/1791

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

CHAPTER 3

METHODS AND APPROACH

This chapter discusses the paradigm and the approach used for this research project. The chapter also discusses how the instrument was designed, piloted and eventually administered in the main study.

3.1. RESEARCH PARADIGM

This study was based on a pragmatic paradigm, which uses both qualitative and quantitative methods. Data was used to generate hypotheses, *i.e.* hypotheses were not stated in the beginning, but emerged in the course of the study, and this is a characteristic of qualitative approaches (Fraenkel & Wallen, 1990). Another feature of qualitative paradigms that was employed is micro sampling, *i.e.* collecting data from 2 schools only.

Classrooms were used as the **natural** setting for questionnaire administration (a feature of qualitative methods). Qualitative studies are normally conducted over a long period of time, but this study was undertaken over a short period in the form of a survey (which is characteristic of quantitative methods). Data was collected in the form of words and pictures, and some narrative description (features of qualitative methods), but some numerical interpretation was made (a quantitative method). Thus the study was based on a paradigm that uses both qualitative and quantitative methods.

3.2. THE APPROACH

The approach that was used in this study is a **survey**, which "involves researchers asking a large group of people questions about a particular topic or issue" (Fraenkel & Wallen, 1990:342) in order to "describe characteristics of a population" (Sax, 1968:292). An advantage of using a survey is that a **sample** of the population is studied, as it would be difficult to collect data from every member of the population (Anderson, 1990). The population for this study consists of all grade-10 learners in South Africa, but data was collected from only two schools. Convenience sampling was used, *i.e.* one convenient school was used to pilot the instrument, and another school used to gather the research data.

3.3. THE INSTRUMENT

There are many instruments used to gather information in educational research, *e.g.* observation and written or verbal questions. For research focusing on misconceptions, observations are not appropriate because they do not give information about conceptions that people have, and this leaves questioning as the most appropriate method. Foddy (1993, cited by Sanders, 1995) has illustrated some inadequacies in questioning: small changes in question wording may result in major changes in responses given; respondents do not always say what they believe; question format and order may affect responses; respondents may misinterpret questions. Despite these problems, questioning remains a convenient method of data collection for this research, as compared to observations and other instruments.

The instrument used for data collection in this project is a diagnostic questionnaire. The following **advantages** of questionnaires have to be acknowledged, because they make questionnaires a suitable instrument for the study

- Questionnaires can be administered over a wide area to a large sample with minimum cost of money and effort (Ary, Jacobs, & Razavieh, 1972; Mouly, 1970).

- More objective data can be obtained from questionnaires if respondents remain anonymous (Ary *et al.,* 1972; Mouly, 1970).
- Answers obtained from the usage of a questionnaire can be more comparable because administration conditions are the same (Mouly, 1970).

The following **disadvantages** of questionnaires also have to be acknowledged.

- Subjects who are less competent in the language used for communication may introduce an element of invalidity by their inability to interpret questions or to express themselves properly (Mouly, 1970).
- Questionnaires do not allow the administrator to clarify misunderstood and poorly worded questions (Ramuel, 1964; Mouly, 1970).
- Questionnaires do not enable the administrator to monitor the reluctance and evasiveness of the respondents while answering, and to develop interest in the respondents (Ramuel, 1964; Mouly, 1970).
- Ramuel (1964) contends that the use of (mis)leading questions and the use of those questions that may be considered ridiculous or unimportant may result in invalid answers.

The following steps were followed when constructing and using the diagnostic questionnaire: defining content, obtaining information about students' misconceptions, developing the diagnostic questionnaire, designing the questionnaire layout and piloting.

3.3.1. Defining the Content

Research questions (shown in chapter 1) were used to define the content relevant to this research project. The following propositional knowledge statements were constructed from the research questions, as recommended by Treagust (1988). The first three were derived from the first research question while the rest were derived from the second research question.

Day and Night

DN1. The sun seems to rise and set because of the rotation of the earth on its axis.

DN2. The earth's rotation is in a West-East direction.

DN3. The side of the earth facing the sun experiences day, while the part of the earth facing away from the sun experiences night.

The Seasons

SS1. The earth revolves (travels) around the sun once each **earth year** (365¼ days).

SS2. Apparent movement of the sun in the sky seems to change from day to day. This is evidenced by:

- Changing length of the days in summer and winter.
- Changing positions of the sun in the sky as it moves South and North of the equator.

SS3. December 21st: the Southern solstice (longest day of the year in South Africa).

- The sun is overhead the tropic of Capricorn.
- The sun sets south of the Western horizon as seen from the equator.

SS4. After December 21st, the sunset starts to move slowly further North along the Western horizon.

SS5. March 21st: the autumn equinox in South Africa.

- Day and night are equal: 12 hours each.
- The sun sets due west as seen from the equator.

SS6. June 21st: the Northern solstice (longest night in South Africa).

- The sun is overhead the tropic of Cancer.
- The sun sets north of the western horizon as seen from the equator.

SS7. After June 21st, the sunset starts to move slowly further South along the Western horizon.

SS8. September 21st: the spring equinox in South Africa.

- Day and night are equal; 12 hours each.
- The sun sets due west as seen from the equator.

SS9. The path of the earth around the sun is almost, but not exactly circular. This ellipse defines the plane of the ecliptic.

SS10. The sun is nearest to the earth in December/January (148 million km) than in June/July (153 million km). This, however, does not cause seasons. If it were the

cause of seasons then both the Southern and the Northern hemispheres would experience summer in December and winter in June.

SS11. The tilt of the earth at 23½^{o} towards the plane of the ecliptic causes seasons. If the earth were not tilted, different parts of the earth would experience the same season through out the year.

SS12. The hemisphere that is tilted towards the sun is warmer for two reasons:

- The days are longer: the earth receives the sun's energy for a longer time.
- The sun is high in the sky: its energy strikes the earth more directly.

SS13. The hemisphere that is tilted away from the sun is colder for two reasons:

- The days are shorter: the earth receives the sun's energy a few hours.
- The sun is lower in the sky: the sun rays heat the earth more obliquely.

The propositional knowledge statements were used to construct a concept map (Figure 3.1), which shows how the concepts relate. Treagust (1988) suggests that to validate the content, the propositional knowledge statements and the concept map have to be checked by other knowledgeable people in the field in which research is conducted. For this research, they were checked by the researcher's colleagues and supervisor. They checked whether the knowledge statements were related to the research questions, and whether all the concepts in the knowledge statements were shown in the concept map.

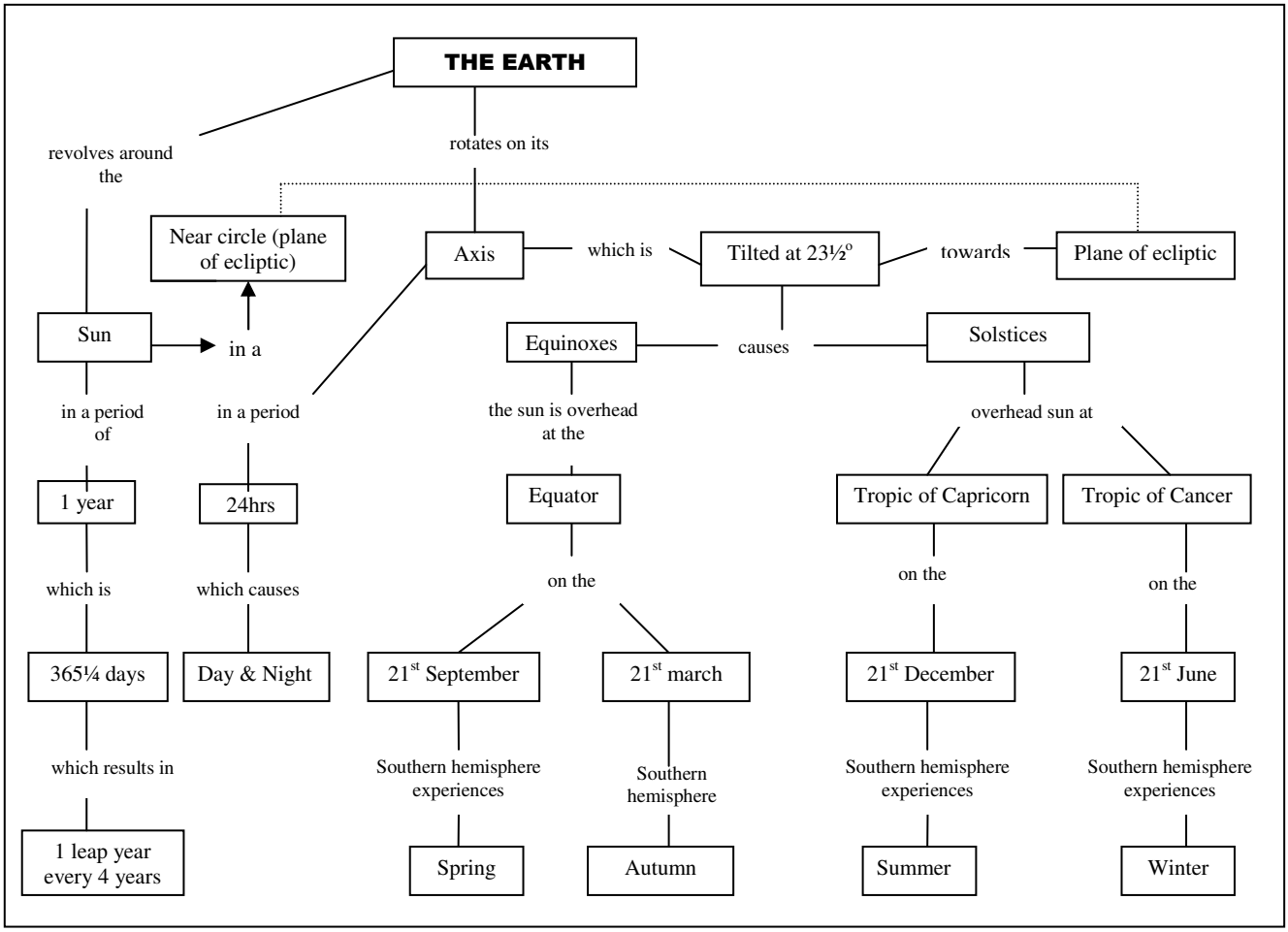


FIGURE 3.1: The concept map

3.3.2. Information about Documented Misconceptions

Mouly (1970) and Treagust (1988) suggest that literature has to be consulted to find documented misconceptions. This has been covered in chapter 2, and it has given a broad scope about what to expect from subjects of the study. Papillon (1978) suggests that in addition to literature, experts in the field have to be consulted. The researcher consulted the supervisor and colleagues working on related topics. They helped with ideas that were not obtainable from literature (*e.g*. personal experience).

3.3.3. Developing the Diagnostic Questionnaire

Before developing a test, one has to decide on the question format (Oppenheim, 1966; Bell, 1987; Fraser, 1991) and then begin to draft items (Behr, 1973). The diagnostic questionnaire used in this research consists of open-ended questions. The following table shows some advantages and disadvantages of open-ended questions.

TABLE 3.1: Advantages and Disadvantages of Open-Ended Questions

Advantages	Disadvantages
Open-ended questions • Allow each learner to respond to the question as it applies to his situation (Behr, 1973; Foddy, 1993). • Do not suggest answers (Behr, 1973; Foddy, 1993). • Probe deeper and give richer responses (Behr, 1973). • Help respondents to avoid format effects *e.g.* ticking the middle answer (Oppenheim, 1966; Foddy, 1993).	Open-ended questions • Require time and effort when answering, and some items may remain unanswered (Papillon, 1978). • Are difficult to code and to summarize (Ary *et al.*, 1972; Behr, 1973; Foddy, 1993).

Despite the disadvantages of open-ended questions, they seemed the most appropriate format for obtaining in-depth understanding of learners, and were therefore used. Ten question items were constructed (Appendix 1), based on research questions and the propositional knowledge statements. Some of these items were taken from internet articles, and the sources of such items are shown in Table 3.3. Fraser (1991) and Treagust (1988) suggest that a specification table should be designed to ensure content validity, *i.e.* to ensure that the test fairly covers the scope required by the research questions. Table 3.2 below shows how the above propositional knowledge statements were covered by the items in the diagnostic questionnaire.

TABLE 3.2: The Specification Table

Item	Knowledge Statements
1	SS3 & SS6
2	SS5 & SS8
3	SS10, S11, SS12 & SS13
4	SS5 & SS8
5	DN1, DN2, & DN3
6	DN1 & DN3
7	SS1
8	SS9, SS10 & SS11
9	SS3, SS4, SS5, SS6, SS7 & SS8
10 a)	SS11
10 b)	SS11, SS12 & SS13

Table 3.3 below shows the sources of some items in the questionnaire.

TABLE 3.3: Sources of Some Items in the Questionnaire

Item Number	**Source**
1	http://regentsprep.org/Regents/core/questions/questions.cfm?Course=ESCI&TopicCode=08
5	http://www.kn.pacbell.com/wired/fil/pages/huntweathers.html
9	http://www.phys.uri.edu/~chuck/ast108/samples/exam1/samples1.html
10	http://jura.astro.utoledo.edu/~bjorkman/astr1010/exam1sg_f03.htm

3.3.4. Designing the Questionnaire Layout

Anderson (1990) says that as the first step to designing a questionnaire layout, a title and an introductory paragraph have to be written. This advice was followed, and the introduction explicated the purpose of the questionnaire to learners, asked them to provide their personal information, and informed them that findings from the study would

remain confidential. The next step was to write instructions, following Bell's advice (1987). The instructions asked learners to answer all the questions, and to use diagrams to explain their answers. Learners were also asked to mention (any) problems encountered while answering the questionnaire. Following further advice from Anderson (1990), printing was made on both sides of the paper so that the questionnaire appeared thinner than when printed on one side of the paper.

3.3.5. Piloting the Questionnaire

The diagnostic questionnaire was administered to a pilot group, as suggested by Sax (1968). The purpose of piloting is to determine whether the time given is enough to finish the test, and to check ambiguity in the instructions (Bell, 1987, Anderson, 1990). Piloting also checks ambiguities in questions so that they can be re-worded, and meanings clarified (Oppenheim, 1966; Behr, 1973; Bell, 1987; Anderson, 1990).

Oppenheim (1966) and Bell (1987) say that respondents used in the pilot study should be as closely similar to the research sample as possible. Following this advice, the questionnaire was administered to a class of 41 grade-10 learners in a school in the same township as the school whose learners were to be used for the final study. Learners in the two schools have the same culture and beliefs because they come from the same society. Also, the performance of the two schools in final matric examinations is almost the same. The biographic information provided shows that all learners in the pilot group were **black** in South African definitions. The learners had covered the topic **The Earth and Beyond** in grade-9. They answered the questionnaire in a 50-minutes lesson. The questionnaire was administered by the researcher in the presence of the teacher. Instructions were explained to the learners, and they were allowed to ask the researcher for more clarifications. Most learners asked the researcher to clarify question 1, which means they did not understand the wording.

Bell (1987) suggests that after a questionnaire has been piloted, the methods of data analysis have to be tried out. A detailed analysis of these results is reported in chapter 4. The analysis shows that most learners did not use diagrams to clarify their responses,

which means they had not considered the instructions. Also, the results show that most learners did not answer questions towards the end of the questionnaire, which shows that there was insufficient time to complete the questionnaire.

3.3.6. Questionnaire Modification

Many modifications were made to the questionnaire after the pilot study. More explanation was given in question 1, which required learners to interpret a diagram. More explanation was added because learners in the pilot study did not understand the question. Question 2, which required learners to draw the earth-sun relationship during an equinox in a given location, was clarified by stating that the location is along the tropic of Capricorn. This helps to investigate whether learners know that the day time is equal to night time in the location when the sun is overhead the tropic of Capricorn. For question 3, that required learners to explain why summer is hotter than winter in a given location, most learners attributed seasonal change to geographical features of the place. The location was not specified in the modified question, so that that learners could give a reason why generally summer is hotter than winter.

Pilot results show that learners did not understand the term **overhead sun.** Question 4 was modified by stating that shadows are not formed when the sun is overhead. This enabled the researcher to see whether learners did not understand the term **overhead sun** or do not know that the sun is never overhead at noon in their area. For question 7, which required learners to explain the cause of one extra day after four years, most learners said that an extra day is caused by a leap year. The question was modified by stating that an extra day is found in a leap year. This was intended to help learners to give the cause of the leap year, not to give the name of this year. Another modification was made on question 9 that required learners to describe **how** the change in rising and setting points of the sun occurred throughout the year. The modified question required learners to explain **why** the position of sunrise changes, in order to elicit deeper understanding. The questionnaire was shortened by removing question 10, which was not answered by learners in the pilot study. The position of items was changed in the questionnaire, *i.e.*

questions that seemed to give pilot learners problems were not placed together. The modified questionnaire is shown in appendix 2. The following table shows the modifications that were made on each question and the new position of each question in the modified questionnaire (appendix 2).

TABLE 3.4: Questionnaire Modifications

Question number (in appendix 1)	**Modifications**	**New numbering (in appendix 2)**
1	More explanation	4
2	States that the place is along the tropic of Capricorn	3
3	Removed the name of the location	2
4	Added that shadows are not formed when the sun is overhead at noon	6
5	Some minor wording modifications	1
6	None	9
7	Stated that a leap year comes once in every 4 years	5
8	Some minor wording modifications	7
9	Students asked to explain **why** instead of **how**	8
10	Deleted	None

The modified questionnaire was administered to the main study group in the second school on the 1st September, a day celebrated in the school as **spring day**. The group consisted of 60 grade-10 learners in two classes. The first class had 34 learners while the second class had 26 learners. Learners from the first class were given numbers 1 to 34 according to the way they were seated, while learners from the second class were numbered 35 to 60 in the same way. The biographic information shows that all learners were **black** in South African definitions.

The questionnaire was administered by the researcher in the presence of the teachers. The researcher explained instructions to learners, putting more emphasis on the usage of diagrams to explain responses. Learners were allowed to ask the researcher for more clarification where necessary. Results obtained from this study are shown in the next chapter.