AN EVALUATION OF THE IMPACT OF A LIFE SCIENCE MODULE ON TEACHERS' SCIENTIFIC LITERACY

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DECLARATION

I, Jaqueline Theresa Naidoo, declare that this dissertation is my own work and has not been submitted previously for any degree at any university. All sources that I have used have been indicated in the list of references.

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ABSTRACT

The Advanced Certificate in Education Programme was launched in 2002 at the School of Education, Training and Development, University of Natal, Pietermaritzburg, in an attempt to upgrade and retrain science educators, given the drastic shortage of qualified science educators in South Africa. This research study investigated the development of scientific literacy within a group of fifteen educators during the first semester of their two-year Advanced Certificate in Education Programme. The study focused on scientific literacy and the relationship between language comprehension skills, readability and scientific literacy.

This study aimed to examine whether the Natural Sciences and Biological Sciences module of the Advanced Certificate in Education Programme was effective in raising the level of scientific literacy of educators. Both quantitative and qualitative methods were employed in the collection of data. Students wrote a pre- test at the beginning of the first semester and the same test was written as the post-test at the end of the first semester. Semi-structured interviews with tutors were also conducted. Responses of students in the Student Evaluation Questionnaire, given at the end of their first year of study, were analysed to ascertain their perceptions about the tutors, their knowledge and understanding of the content and skills of the modules and the learning material.

The questions used in the achievement test were adapted from the question bank of the Science Achievement Test used for Grade 8 learners in the Third International Mathematics and Science Study-Repeat in 1998/1999. The same achievement test was used in the pre-test and post-test, using questions from the Life Science and Scientific Inquiry and the Nature of Science content areas.

The results from this research study indicated that although the level of scientific literacy of educators improved, it was not statistically significant. The study also highlights that language and comprehension skills and inability of students to express their answers in writing hampered their performance in the scientific literacy test. This was demonstrated by the significant positive correlation between language comprehension and readability with scientific literacy. Specific areas of conceptual difficulty were also highlighted in this study.

Implications of these findings for further research and delivery of mixed-mode programmes are discussed.

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CHAPTER ONE

INTRODUCTION

1.1 Crisis in Science Education in South Africa

Science education in many developing countries is the area in greatest need for quality improvement, both because of historic underdevelopment and the perceived importance Science education has for National development aspirations (de Feiter, Vonk and van den Akker: 1995).

South Africa is no exception to this general observation. The National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training is the South African government's response to the crisis in mathematics and science education in the country. Upgrading the knowledge and teaching skills of mathematics and science teachers is identified as one of the strategies to improve mathematics, science and technology education in South Africa.

The key findings of the Third International Mathematics and Science Study- Repeat (TIMSS-R) revealed that South African pupils performed the poorest in both mathematics and science of the 37 countries that participated. Generally, "South African pupils lacked fundamental mathematics and science knowledge required at Grade 8 level, lacked mathematical and scientific reasoning skills and did not have the language and comprehension skills to convey their answers in writing"(Howie: 2001, p150).

A significant point is that language was a major problem as the language of the test was not the home language for almost 80 % of the pupils who wrote the test. The TIMSS report also highlighted that in South Africa 27% of pupils were taught mathematics and 38% of pupils were taught science by teachers with no formal qualifications. Approximately half of the mathematics and science teachers did not feel confident and prepared to teach these subjects because they lacked adequate content knowledge and experience in teaching mathematics and science.

The Annual Survey conducted by the Department of Education and Culture, Kwazulu-Natal in 2001 revealed the following statistics concerning unqualified and under qualified teachers teaching Science:

Table 1: Annual Survey conducted by the Department of Education and Culture in 2001, showing the state of training of Science teachers in Kwazulu-Natal.
(Source: Department of Education and Culture, Pietermaritzburg)

Subject	Total Number of Teachers	Number of teachers with less than two years of training	Percentage of Unqualified and Under qualified Teachers
Biology	3701	1183	31.9
Natural Science	1530	688	45.0

Although the survey does not provide accurate information on the number of years of training in Biology or Natural Science, it is evident from the above statistics that a large percentage of science teachers are unqualified or under-qualified.

Table 1 also highlights the need for large-scale re-training and upgrading of science educators.

Another concern about science education is that the number of learners who participate and successfully pass science in Grade 12 is very low. Two important points concerning Senior Certificate science need to be highlighted. Firstly, the number of learners enrolling for Higher Grade Physical Science (from 13,7% to 12,4%) and Biology (from 29,3% to 25,2%) has been decreasing in the last five years. Secondly, the number of learners moving into Standard Grade Physical Science and Biology is increasing. Although the overall uptake in these gateway subjects is increasing, the performance in these subjects remains very poor.

Table 2: Kwazulu –Natal statistics for the enrolment and performance in Physical Science and Biology from 1997 to 2001 (Source: Arnott *et al:* 1997)

Subject	1997	1998	1999	2000	2001
Physical Science HG Enrolment	16 358	17 314	17 226	13 208	11 594
Physical Science HG Pass	8 026	8 106	7 127	5 869	5 898
Physical Science SG Enrolment	9 236	12 620	14 889	19 567	21 274
Physical Science SG Pass	9 760	11 690	11 995	13 113	11 799
Physical Science LG Pass	1 668	2 154	2 817	3 810	5 241

Biology HG Enrolment	59 224	49 189	39 622	28 295	23 545
Biology HG Pass	11 818	13 914	12 475	11 277	11 604
Biology SG Enrolment	25 883	37 143	39 056	42 269	41 117
Biology SG Pass	29 349	28 530	22 745	22 989	24 072
Biology LG Pass	6 677	8 004	8 740	9 453	9 703

The above statistics also highlight that there is a significant increase in the number of students obtaining Lower Grade passes in Physical Science and Biology.

1.2 Focus of this study

Given the poor performance of Kwazulu-Natal learners in science and the inadequate qualifications of many science teachers, the School of Education and Training at the University of Natal (Pietermaritzburg) introduced a suite of Advanced Certificates in Education (ACE), which comprise 128 credits on National Qualification Framework Level 6.

The ACE is a focussed qualification that aims to increase the content knowledge and teaching competence in a school subject or learning area. This study focussed on teachers enrolled in two ACE's: the Biological Science ACE and the Natural Science ACE. The structure of each ACE is shown in Table 3 and 4 and is comprised of eight

16 credit content or teaching modules. The minimum entry requirement for each ACE is a three-year diploma in education.

Table 3: Structure of Natural Science ACE

FIRST YEAR		SECOND YEAR	
Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Natural Science 610 (Life and Living)	Natural Science 620 (Matter and materials)	Natural Science 630 (Earth and Beyond)	Natural Science 640 (Energy and Change)
Learning and Teaching	Education, Policy, Context and Professionalism	Education Studies for Natural Science	Professional Practice in Natural Science Teaching

Table 4: Structure of Biological Science ACE

FIRST YEAR		SECOND YEAR	
Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Biological Science 610	Biological Science 620	Biological Science 630	Biological Science 640
Learning and Teaching	Education, Policy, Context and Professionalism	Education Studies for Biology	Professional Practice in Biology Teaching

Students registering for an ACE are practising teachers who study part-time. The mode of delivery is flexible mixed-mode, with students receiving self-study material, then receiving seven tutorials and one week of practical work (only for content modules). Tutorials take place on Saturdays, with the Education Studies module (listed in fourth row of Table 3 and 4) being delivered from 9:00 to 12:00 and the content module (listed in third row of Table 3 and 4) being delivered from 13:00 to 15:00. The practicals and tutorials constitute 45 notional study hours in each content module, excluding self-study hours.

Since South African learners had fared so badly in the TIMSS-R tests in 1998, the researcher was interested in the performance of teachers on the same test of scientific literacy.

1.3 Concerns about Science Education in South Africa

Concerns about Science and Mathematics Education were highlighted at a regional conference in Namibia aimed at identifying interventions to improve Science and Mathematics teaching in Southern Africa, Volmink :1996 (cited in Stoll, de Feiter, Vonk and van den Akker: 1996) identified the following educational and infrastructural problems in Science Education in South Africa:

- shortage of qualified teachers
- high student-teacher ratios
- inadequate teacher support services
- lack of equipment and laboratories
- shortage of textbooks

- no planning regime

McNamara (1991) and Creemers (1994) agree that if the aim of teaching is to enhance children's understanding, then teachers themselves must have a flexible and sophisticated understanding of subject knowledge in order to achieve this purpose in the classroom. Teachers' subject knowledge influences the way in which they teach and teachers who know more about the subject will be more interesting and adventurous in the ways in which they teach and consequently more effective. Teachers with only a limited knowledge of a subject may avoid teaching difficult or complex aspects of it and teach in a manner that avoids pupil participation and questioning and fail to draw on learner's experience. They both emphasise that the central factor in educational effectiveness is the quality of instruction.

Rogan and Macdonald (1985) and Ware (1992) also believe that in-service activities aimed at improving the quality of teaching and developing the professional knowledge base of teachers, should focus on broadening teachers' pedagogical content knowledge. However, they emphasise that this is only possible when teachers have already acquired a substantial subject knowledge base.

The studies mentioned suggest that higher levels of learner achievement are associated with well-qualified and experienced mathematics and science educators. Clearly, science education in South Africa is in crisis, with serious concerns about teacher competence and strong evidence of learner under-achievement.

1.4 Definitions of Scientific Literacy

This study investigated the development of scientific literacy in a group of teachers enrolled in an upgrading programme at the University of Natal (Pietermaritzburg). Researchers have adopted different definitions of scientific literacy in the various studies conducted on scientific literacy.

According to Durant (1993) scientific literacy "stands for what the general public ought to know about Science". Jenkins (1994) suggests that scientific literacy "commonly implies an appreciation of the nature, aims and general limitations of science, coupled with some understanding of the more important scientific ideas". "Scientific literacy is now commonly acknowledged to consist of three dimensions: an understanding of the norms and methods of science, an understanding of key scientific terms and concepts and an appreciation of the impact of science and technology on society" (Laugksch and Spargo: 1999, p1). Scientific literacy is best defined as "a continuum of understanding about the natural and the designed world"(Bybee: 1997 cited in Murphy: 2001, p190). Murphy (2001, p191) defines scientific literacy as "the minimal scientific knowledge and skills required to access whatever scientific information and knowledge is desired". Colvill and Pattie (2002, p20) suggest that the basic element of scientific literacy is an understanding of science methodology.

A common feature that permeates the above definitions is that scientific literacy incorporates understanding of scientific ideas, terms and concepts and scientific methodology. This is the definition adopted in the present study.

1.5 Hypotheses that this study wanted to test

Data were collected in relation to the following hypotheses:

- The general scientific literacy of students improves as a result of studying a science module using a mixed mode of delivery.
- The performance of students in the scientific literacy test is related to their language competence in English.

1.6 What did this study aim to achieve?

This research study aimed to assess the development of scientific literacy of teachers. Also, the study aimed to establish the correlation between scientific literacy and language competence in English.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter examines literature on studies conducted on scientific literacy, the role of teacher knowledge in teaching Science, language in teaching and learning Science and the effectiveness of self-study programmes in improving Science knowledge.

2.2 Studies of Scientific Literacy

Murphy, Beggs, Hickey, O'Meara and Sweeney (2001) examined whether the general level of scientific literacy was raised following the introduction of compulsory school science for pupils in the United Kingdom in 1991. In their study, the scientific knowledge and understanding of B.Ed and PGCE students was compared. The B.Ed students had experienced compulsory school science, while the PGCE students had not. Both groups of students completed a simple science test that had been originally designed for 11 year old children. The study aimed to identify areas of the science curriculum in which students' demonstrated difficulty or misconceptions.

Analysis of the results obtained by the two groups revealed that the mean score of B Ed students was significantly higher than the mean score of the PGCE students ($p < 0.01$). The results suggest that compulsory science in the school curriculum is effective in raising the general level of scientific literacy. Both groups of students improved their scores in scientific literacy after a year's tuition in the subject.

Project 2061 (Nelson: 1998) represented a long-term effort launched by the American Association for the Advancement of Science (AAAS) in 1985, to reform science, mathematics and technology education. Project 2061 identifies the knowledge, skills and attitudes that all students should possess in order to be regarded as scientifically literate. Project 2061 had the following guiding principles:

- Science literacy consists of knowledge of certain important scientific facts, concepts and theories, an understanding of the nature of science, its connections to mathematics and technology, its impact on individuals and its role in society.
- The large amount of material that today's science curriculum tries to cover must be significantly reduced, in order for students to have sufficient time needed to acquire essential knowledge and skills of science literacy.
- Effective education for science literacy requires that every student be frequently and actively involved in exploring nature in ways that resemble how scientists themselves go about their work (Nelson: 1998 cited in Murphy *et al*: 2001).

Abell and Smith (1994) reported that student primary school teachers were not scientifically literate and yet would be teaching science at elementary schools in the United States. Harlen, Holroyd and Byrne (1995) highlighted that many primary school science teachers in the United States lacked confidence in their ability to teach science and a third of these teachers identified their own lack of background knowledge as a source of their problems in teaching science (Abell and Smith:1994, Harlen, Holroyd and Byrne:1995 cited in Murphy *et al*: 2001).

2.3 Measures of scientific literacy in South Africa

Laugksch and Spargo (1999) investigated levels of scientific literacy of 4 223 first year university and technikon students at five tertiary educational institutions in the Western Cape in 1994. The purpose of this survey was to examine the levels of scientific literacy of first year university and technikon students. The Test of Basic Scientific Literacy (TBSL) tested the Nature of Science, Science Content Knowledge and the Impact of Science and Technology on Society.

The results showed that the average level of scientific literacy of matriculants entering tertiary education in the Western Cape was 36%. Levels of scientific literacy correlated positively with matric results. Also, university students displayed a significantly higher literacy level than technikon students. Males had higher levels of scientific literacy than females in all population groups.

South Africa participated in the Third International Mathematics and Science Study (TIMSS) in 1995. This study investigated the concepts, processes and attitudes regarding mathematics and science learnt by Grades 7, 8 and 12 South African learners. The achievement tests were administered to 5 301 Grade 7 learners, 4 491 Grade 8 learners and 2 757 Grade 12 learners. The results showed that South African learners performed significantly worse overall in the mathematics and science literacy test than all other participating countries.

Also, South African learners performed marginally better in mathematics than science. Unlike the findings in the Laugksch and Spargo (1999) survey, there was no significant difference in the performance of boys and girls in either mathematics or science in TIMSS.

In 1998 / 1999 TIMSS was repeated for the Grade 7 and 8 populations. South African learners' performance did not improve between 1995 and 1999. Scores in both mathematics and science were lower in 1999. However, the difference was not statistically significant. Science scores decreased by 20 points compared to mathematics scores that decreased by 3 points. Although girls improved and boys did worse in mathematics and science, neither difference was statistically significant.

2.4 Conceptions of Curriculum

If science and technology education is to have an impact on improving society, relevance becomes an essential ingredient to any meaningful programme. Rollnick (1998) mentions that "Science for all" implies relevance and comprises the knowledge and skills needed to empower students to control their lives at an individual and a societal level. Ogunniyi :1986 (cited in Stoll, de Feiter, Vonk and van den Akker: 1996) highlights the fact that science teaching in South Africa is decontextualised as a result of universities dictating subject content. Taking cognisance of the above points, the Department of Education is now placing great emphasis on a science curriculum that is meaningful and relevant to equip students with the knowledge, skills and attitudes they require to participate in the global knowledge-based economy.

Since many studies imply that the science curriculum needs to be redesigned in order to produce scientifically literate students, the National Minister of Education, Professor Kader Asmal, called a Consultative Conference in September 2000 to consider interventions to improve science, mathematics and technology education. At this Consultative Conference, Professor Asmal emphasised the commitment of the Department of Education to achieve improved performance in science and mathematics, as well as ensuring that a relevant curriculum was in place. According to Professor Michael Kahn, in order to improve performance, a strategy should be drawn around four pillars: curriculum, human resources development, learning support materials and science, mathematics and technology literacy.

The broad mission of the National Strategy for Science, Mathematics and Technology Education in South Africa is to strengthen the teaching and learning of science, mathematics and technology in the Senior Phase and Further Education and Training band within five years, using appropriate curricula, learning support materials and competent human resources in collaboration with all role players. Teacher professional development plays an important role in the National Strategy.

Since the curriculum is seen as central to schooling and teacher training, the researcher therefore felt it necessary to provide the following background information with regards to conceptions of the curriculum.

Hirst (1965) claims that there are distinctive forms of knowledge, which are the result of the way in which humans have made meaning of their experiences over the years. Hirst argues that the curriculum should be based on the nature of knowledge. The distinguishing feature of these forms of knowledge is that each has its own concepts, its own procedures and its own ways of testing the claims it makes. Hirst's "forms of knowledge" are based on distinctive disciplinary procedures, for example, mathematics is built on deductive procedures and the sciences use experimental and observational procedures. According to Hirst (1965) it is important for children to 'acquire' these forms of knowledge, because this gives them a framework with which to interpret their world.

The idea of knowledge as intrinsically worthwhile forms the basis for the Curriculum as Content Model. According to Kelly (1989) there are two broad arguments about selecting knowledge for inclusion in a curriculum. The first argument is that some knowledge is worthwhile in itself, has intrinsic value and its presence in a curriculum does not need to be justified. The second argument is that content should be a selection from the culture of our society, which could be very problematic in a pluralistic society like South Africa.

Stenhouse (1975) is closely associated with the Curriculum as Process Model, which has a strong link with Hirsts' (1965) "forms of knowledge". According to the Curriculum as Process Model, what matters is that within the chosen content, learners use appropriate procedures and concepts. Therefore the aim of the Curriculum as Process Model is not to teach specific subject matter / content, but rather to provide opportunities for learners to use the procedures and concepts to construct knowledge (Bertram, C; Fotheringham, R and Harley, K: 2000).

The revised curriculum statements reflect a shift in South African science education from a "Curriculum as Content" model to a "Curriculum as Process" model. This shift needs to be taken into account in teacher education programmes.

2.5 Role of teacher knowledge in teaching Science

Since the mid-1980s there has been considerable discussion and a growing body of research on the forms of knowledge required by teachers to perform their roles (Banks: 1995).

With regard to teaching as a profession, Doyle (1990 cited in de Feiter, Vonk and van den Akker: 1995, p 55) defined a profession as:

" an occupation the members of which are reputed to possess high levels of knowledge, skills, commitment and trustworthiness".

At the core of this definition is the idea that a profession bases its practices on a body of specialised knowledge and skills. Verspoor and Leno (1986 cited in de Feiter, Vonk and van den Akker: 1995, p 63) identify four consecutive stages that impact on the quality of teaching: "unskilled", "mechanical", "routine" and "professional". Many teachers in sub-Saharan Africa operate at the stage of mechanical / routine. These teachers are inadequately trained for the subject they are teaching, have not mastered the subject content, emphasise memorisation and rote learning and have limited access to textbooks and laboratory equipment.

In South Africa, the TIMSS-R study (Howie: 2001) and the National Audit of Mathematics and Science Teaching (Arnot *et al*: 1997) highlighted that many science teachers lacked adequate preparation in terms of content knowledge. These teachers felt ill-prepared to teach their pupils. Since many of the schools in the TIMSS-R study lacked resources, the teacher was often the only resource for learning for the pupils.

Shulman (1986) and Cladinin and Connelly (1995) identify the following kinds of knowledge that teachers require: content knowledge, pedagogical content knowledge, knowledge of aims and purposes, knowledge of learners and knowledge of educational context, settings and governance. Barnett and Hodson (2000) use Cladinin and Connelly's (1995) metaphor of a *knowledge landscape* to propose a model called 'pedagogical content knowledge', which elaborates on four kinds of knowledge that teachers utilise in their classroom practice:

- **Academic and research knowledge** includes science content knowledge (concepts, facts and theories), knowledge about the nature of science and the relationships among science, technology, society and environment, knowledge about how and why students learn.

- **Pedagogical content knowledge** includes knowing how to set teaching goals, organise the sequence of lessons, introduce and conduct lessons and allocate sufficient time for the development of concepts, knowing how to best present certain concepts and ideas and relate them to students' existing knowledge.

- **Professional knowledge** is the knowing of teaching by unconsciously reflected experience. It refers to what teachers know, feel and do and is passed on by experienced teachers to young teachers and those new to the school.

- **Classroom knowledge** refers to the knowledge that a teacher has of his own classroom and students, and is situational and particular, and is rooted in the day-to-day experience of particular educational situations.

A significant aspect highlighted is that teaching is a complex and subtle activity that requires many forms of knowledge.

Shulman (1986) recommended that science teachers had their own specific knowledge associated with teaching content knowledge, which he called pedagogical content knowledge (PCK). He defined PCK as the "blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of the learners, and presented for instruction" (Shulman: 1986 as cited in Veal, Kubasko Jr. and Fullagar: 2002, p133). Shulman (1986) also suggests that teachers' pedagogical content knowledge is the most important element that makes the process of pedagogical reason and action possible. In-service programmes aimed at improving the quality of teaching should therefore focus on broadening teachers' pedagogical content knowledge. However, teachers still need to have a strong foundation of content knowledge in their subject (de Feiter, Vonk and van den Akker: 1995).

Van Driel, De Jong and Verloop (2001) and Veal, Kubasko Jr. and Fullagar (2002) investigated the development of pedagogical content knowledge (PCK) in teachers. Their findings correspond with Shulman's suggestion that development of PCK depends to a large extent on teachers' subject matter knowledge.

The integration of content and pedagogy is clearly a strength that should be included in all preservice and inservice programmes. This helps teachers focus on the integration of content and teaching.

It is apparent from the above review of literature that teacher knowledge and related competences are important, but not the only factor in improving the performance of teachers. There has to be an improvement in classroom teaching and instruction, to improve the quality of education.

2.6 Language in teaching and learning science

According to Osborne (2002, p204), "a core feature of science is that it is a cultural activity undertaken through the medium of language". Therefore, teachers need to give students the opportunity to read, discuss, argue, write and communicate in the language of science, if they are to understand the nature of scientific reasoning. Currently, a major obstacle to the learning of science is the failure to recognise that language is a central activity to science. It is crucial that students become literate in science, that is, be able to talk, read and write science. Postman and Weingartner (1971) as quoted in Osborne (2002, p207) also emphasise that "the key to understanding a subject is to understand its language". Therefore from a linguistic perspective, the central goal of science education should be to help students use the languages of science to construct and interpret meaning.

According to Osborne (2002), the complexities of scientific language confronting the learner are:

- **The polysemic nature of language**: this refers to the existence of many meanings of a word. For example, the word "electricity" is used to refer to "electric charge", "electric power", "electric voltage" or "electric current". To determine the precise meaning of the word "electricity", the context of its use in the sentence needs to be examined.

- **The role of logical connectives**: these are essential to the process of constructing an argument, generating the relationships between claims and contrasting and comparing phenomena. Gardner (1975 cited in Osborne 2002) and Byrne *et al.* (1994 cited in Osborne 2002), highlighted problems with the comprehension and use of logical connectives in scientific language. McNaught (1994) also identified some logical connectives as being problematic for Zulu-speaking students since they had no direct equivalents in Zulu. However, Wellington and Osborne (2001) suggested that logical connectives are commonly used to improve readability.

- **The multi-semiotic nature of its discourse**: Some of the concepts and ideas communicated by science are so complex that its language is dependent on a multi-semiotic mode of communication: symbols to represent elements, quantities and units, graphs and charts to summarise relationships, frequencies and patterns and tables to summarise numerical data. It is problematic for science that natural language is very limited in its ability to describe variation, shape and interrelationships of structure, form and function.

Lemke (1998 cited in Osbourne: 2002, p210) emphasises that science is a multi-semiotic language:

" Science does not speak of the world in the language of words alone, and in many cases it simply cannot do so. The natural language of science is a

synergistic integration of words, diagrams, pictures, graphs, maps, equations, tables, charts and other forms of visual mathematical expression"

- **<u>Science's unfamiliar genres</u>**: Students are familiar with the narrative, subjective form of writing. However, in science, students are encouraged to write in the passive voice, since science seeks to be objective and distance itself, thereby portraying its knowledge as something which is independent of any observer. So, instead of writing "we took the Bunsen burner and heated the copper sulphate", the standard genre of science would be "the copper sulphate was heated" (Osborne: 2002).

According to Osborne (2002), 'scientific literacy' exists on a continuum from totally illiterate (dependent on others) to acknowledged expertise (minimal intellectual dependence). It is essential for students to know and use the language of science appropriately in order to become scientifically literate.

In South Africa, the problems of learning the language of science are exacerbated by the fact that English is the medium of instruction, but the second language of most learners.

In a study examining learning Science at the interface between Zulu and English, McNaught (1994) analysed linguistic differences between Zulu and English, which appear to impinge on pupil learning. She studied the learning of science by student teachers and learners who were more proficient in Zulu than in English.

She suggested that the greater the difference between Zulu and English usage, the more difficulties learners would encounter in learning Science. According to McNaught (1994), the teachers' scientific conceptions should interact with those of the pupils in a dynamic construction of meaning for all participants. She found a disparity in the modes of explanation used in basic chemistry when it was taught through the medium of Zulu and the medium of English. The findings also noted problems with logical connectors, as some logical connectors have no direct equivalent in Zulu, as is the case in many African languages.

According to Henderson and Wellington (1998), "For many learners, the greatest barrier to learning science is language". South African blacks encounter additional problems because there are no direct translations of concepts in vernacular. For example, the terms force, energy and power may all be referred to as "amandla" in Xhosa.

Damonse (1996) investigated Grade 8 learners' performance in General Science at a secondary school in Pietermaritzburg. Damonse (1996) devised a test of science literacy based on test items from the Assessment of Performance Unit in the United Kingdom. She adapted the test items for South African learners and had the test translated into Zulu by Zulu-speaking Grade 12 learners. The results of this study illustrated that scientific skills and concepts are poorly developed in most Grade 8 learners tested. English second language learners performed at a lower level than English first language learners. When English second language learners were tested in their mother tongue, results improved on some but not all questions. They did not achieve the same level of competence as English first language learners, even when tested in their own language.

Damonses' (1996) study confirmed the relationship that exists between the linguistic background of the learner and the construction of meaning in Science. According to Damonse (1996), "the acquisition of knowledge is also hampered when pupils receive instruction in a language that is not their mother tongue". (p131)

Feltham and Downs (2002) assessed background knowledge of English second language biology students on the Science Foundation Programme (SFP) along a continuum of language dependency. Three forms of assessment of prior knowledge and improved performance were used, following an enrichment programme within the context of a marine theme. This study also examined student profiles and attitudes to biology.

The sample included 130 SFP students of 1998 and 138 SFP students of 1999. In addition to the pre- and post-test given in 1998, a retention test was also given in 1999. The three assessment probes consisted of the following:

- A drawing quiz in which students were presented with 16 drawings of marine organisms and had to match the letter given to each organism to the list of names. This probe required very little reading and writing ability, but relied on visual literacy.

- Twenty four multiple choice questions, the stem of each written in simple, unambiguous English. Students had to choose the correct answer from a set of four options. This probe required reading ability.

- Questionnaire with twenty four open-ended questions. This probe required reading and writing ability.

The 1998 and 1999 pre-test results revealed significantly poorer performance in the open-ended questionnaire than in the multiple choice or drawing probes, highlighting a misguided perception among students that language associated with Biology was not problematic. Post-test results revealed that students performed marginally better in the open-ended questionnaire following the enrichment programme. However, since students performed significantly better in the drawing and multiple choice question probes in the post-tests, it can be concluded that students were disadvantaged by their inability to communicate their responses in writing. This finding corresponds to that of the TIMSS-R study.

The TIMSS-R study (Howie: 2001) and the National Strategy for Science, Mathematics and Technology Educators (Department of Education: 2001) emphasise that teachers lack English language skills. Therefore, the researcher acknowledges that the language competence of English second language teachers may affect their performance in this study. An assessment of English language competence was thus a critical component of this study.

2.8 The Effectiveness of Self-Study Programmes in improving Science knowledge

The National Strategy for Science, Mathematics and Technology Educators (Department of Education: 2001) sets as one of its goals the retraining of unqualified and under-qualified science and mathematics teachers. Most programmes for retraining teachers in South Africa involve a measure of self-study, so that teachers can complete the course with a minimum of disruption to schools. The effectiveness of such self-study programmes in increasing teacher knowledge and skills has rarely been evaluated.

Sokhela (1998) evaluated the "Into Science" Programme and materials designed by the Open University using the perceptions of college of education students taking the course. The trialing took place in three KwaZulu - Natal colleges of education with 120 third-year primary teacher diploma students. The "Into Science" course was offered as a self-study programme, with support in the form of a weekly tutorial.

Students' and lecturers' views were obtained through the use of open-ended questionnaires, focus group interviews, individual interviews with lecturers / tutors and participant observation during tutorial sessions. Her findings established that the students who participated in this study did not perceive a problem with the language used in the material. A criticism that could be levelled at this research is that the researcher did not directly evaluate the reading skills of the students, but based the above finding on the responses of students to a questionnaire.

In a similar, related study, Bailey (2000) highlighted the role of in-service training and distance education to improve the quality of science educators. The aim of his research was to contribute towards the evaluation of the "Into Science" course, by investigating to what extent there was an improvement in the participating students' understanding of scientific concepts and their command of science skills. Students selected for the programme were science teachers who wished to improve on their understanding of science and how to teach it. The test instrument used questions from the Assessment of Performance Unit in the United Kingdom. The final sample group selected for this study was made up of 127 students from three different colleges of education. The course was offered as a self-study programme with tutorials at weekly intervals. The results indicated that although almost all students showed an improvement between the pre-test and post-test, many students still scored poorly on very simple questions.

This literature review highlights the importance of teacher knowledge in science teaching, the relationship between language competence and performance in science and the inability of English second language learners to communicate their responses in writing. These points are relevant for the interpretation of the findings of the present research.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

There is diversity of opinion with regards to theoretical perspectives from which to examine science teacher education. This diversity can be illustrated using the following dichotomous structural and conceptual alternatives suggested by Feiman-Nemser (1990) and Kennedy (1990). Feiman-Nemser (1990) describes five conceptual orientations for teacher education: academic, practical, technological, personal and critical / social. Kennedy (1990) provides an additional way of looking at structural and conceptual alternatives and identifies two approaches: teaching an extensive body of knowledge and teaching students to think. It is within this context of diverse perspectives that this research on teachers' scientific literacy is being reviewed. This study was guided by the concept of teachers' knowledge proposed by Shulman (1986).

3.2 Research Design and Setting

The survey questionnaire / achievement test was a quantitative strategy that generated statistical data and enabled the researcher to assess the scientific literacy of students. The semi-structured interviews and analysis of students' evaluation questionnaires were qualitative strategies that elaborated upon tutors' and students' perceptions of the impact of the ACE programme on scientific literacy.

The researcher therefore combined quantitative as well as qualitative methods of gathering data to enhance the validity of this study.

This research was conducted at three levels: the survey questionnaire / achievement test level, the semi-structured interview level and the student evaluation questionnaire level. The Natural Sciences and Biological Sciences students registered on the ACE Programme participated in a pre-test - post-test design to evaluate their scientific literacy at the start and finish of modules covering basic biological concepts. Semi-structured interviews with tutors and students' evaluation questionnaires were analysed to supplement data obtained in the survey questionnaire / achievement test.

The "one group pre-test – post-test design" was used. A sample of students were given the pre-test, exposed to seven tutorial and practical sessions as well as working through self- study material, and then the post-test was administered. The advantage of the pre-test-post-test design is that selection bias is eliminated. However, two basic problems with this design need to be acknowledged. Firstly, the subjects may change over time, and secondly, the number of subjects, the methods used for measurement and accuracy of measurement may change over time (Mitchell and Jolley: 1988).

The one group pre-test – post-test design can be represented as follows:

Experimental	O_1	X	O_2

This design can be explained as follows: the researcher measured a group of students on a dependent variable (O_1), and then introduced an experimental manipulation (X). The experimental treatment was followed by the researcher again measuring the group on the same dependent variable (O_2). (Cohen, Manion and Morrison: 2001)

In this study, O_1 represents students' achievement in the pre-test, X represents exposure to seven tutorial and practical sessions as well as students working through self-study material, and O_2 represents students' achievement in the post-test. A limitation of the one group pre-test post-test design is that it relies on only one observation before and one observation after treatment. (Bless and Achola: 1988)

The researcher acknowledges the following variables as limitations of the one group pre-test-post-test design that may threaten the validity:

- **History**: it is possible that events, other than the experimental treatment, could have caused the difference in the pre-test-post-test scores.

- **Testing**: the "testing effect" refers to the changes brought about by the pre-test itself. Therefore, the practice and experience which subjects get on the pre-test could influence their results on the post-test.

- **Regression**: regression to the mean refers to "the tendency for scores that are extremely unusual to revert back to more normal levels on the retest". (Mitchell and Jolley: 1988: p 97). This implies that there is a possibility that subjects scoring highest on the pre-test may score lower on the post-test.

- **Mortality**: subjects may drop out of the study before it is completed. Therefore, the fact that fewer subjects were measured on the post-test than the pre-test, may lead to differences between pre-test and post-test scores. (Cohen , Manion and Morrison : 2001: p126/7)

Maturation refers to natural development that may lead to subjects becoming more mature, which could result in differences between the pre-test and post-test scores. It is unlikely that this variable will threaten validity since the students in this sample were adults.

Instrumentation effect refers to the change in a subject's score from pre-test to post-test due to different measuring instruments being used on the pre-test and post-test. It must be noted that this variable will not threaten validity since the same measuring instrument was used on the pre-test and post-test. Also, since the same group of Natural Sciences and Biological Sciences students wrote the pre-test and post-test, the threat of selection bias was eliminated.

The tutors for the Natural Science and Biological Science modules were interviewed using semi-structured interviews, which according to Cohen, Manion and Morison (2001), is the most popular interview technique used in qualitative interviewing. The researcher prepared an interview guide of open-ended questions. Although both tutors were asked the same questions, the researcher had the freedom to adapt the formulation and order of the questions. It was also possible for the researcher to use probes to elaborate on vague or incomplete responses. Also, responses of students from an evaluation questionnaire were used to highlight perceptions of students about their performance on the course. It was envisaged that the qualitative responses of the tutors and students would be used to supplement and verify quantitative data obtained from the survey questionnaire / achievement test.

The procedures carried out in this research can be summarised as follows:

1. An appeal was made to all Natural Science and Biological Science students at registration in the form of a letter. (See appendix 1)

2. Pre-test: twenty two Natural Science and Biological Science students completed a written test at the beginning of the semester.

3. Post-test: twenty five Natural Science and Biological Science students completed the same written test at the end of the semester.

4. Semi-structured interviews were conducted with the tutors of Natural Science and Biological Science at the end of the semester.

5. Students completed an Evaluation Questionnaire in the last lecture period.

Although the number of students registered for the Natural and Biological Science modules increased from twenty two at the beginning of the first semester to twenty five at the end of the first semester, only fifteen students wrote both the pre-test and post-test. The results of only those fifteen students were used in the analysis.

3.3 Sample size and sampling procedure

According to Huysamen (1994), when researchers are determining the size of the sample, they should bear in mind the size of the population. He also suggests that to obtain satisfactory results, the smaller the total population, the relatively larger the sample should be. Since the total number of students registered for the Natural and Biological Science modules on the Advanced Certificate of Education Programme was only twenty two at the beginning of the first semester and acknowledging Huysamen's (1994) suggestions mentioned above, the researcher decided to include all members of the population in this research study.

The researcher also heeded the advice of Krejcie and Morgan (1970 cited in Cohen, Manion and Morrison: 2001) who emphasise that if the entire population constitutes thirty or fewer, the researcher is strongly advised to include the entire population as the sample. In the case of this research study, the entire population of Natural Sciences and Biological Sciences students was included as the sample.

The researcher's decision to include the entire population in this research study was also influenced by the following factors:

- **Expense**: since there were only twenty two subjects in the entire population and this study did not make use of postal questionnaires , telephonic interviews or much travelling , the only expense incurred was for photocopying the questionnaire , tape recording and transcribing the semi-structured interviews.

- **Time**: the time interval between the pre-test and the post-test was five months , giving the researcher sufficient time to mark and code the pre-test , before the post-test was written. Also, there were only two tutors who needed to be interviewed and it was envisaged that each interview would be of one hour duration.

- **Accessibility:** a written appeal was made to all students registered for the Natural and Biological Science modules. All students indicated their willingness and availability to participate in this research study.

Since the aim of this research is to evaluate the impact of the Natural and Biological Science modules on scientific literacy of teachers registered for these modules, the researcher acknowledges that she would not be able to make generalisations to the wider population of teachers.

3.4 Research Instruments

3.4.1 TIMSS-R achievement instruments

Since one of the research instruments used in this study was adapted from the Science achievement test used in TIMSS-R, the researcher felt it significant to discuss the achievement instruments used in TIMSS-R, so that the results of this study can be contextualised. The TIMSS-R achievement instrument assessed six content areas that included the following topics:

Earth Science: earth features, earth processes, the universe.

Life Science: diversity, organisation and the structure of living things, life processes and systems enabling life functions, life spirals, genetic continuity and diversity, human biology, health.

Physics: efficiency, phase change, thermal expansion, properties of light, gravitational force.

Chemistry: classification and structure of matter, physical and chemical properties, chemical transformations.

Environmental and Resource Issues: pollution, conservation of land, water and sea resources, conservation of material and energy resources, effects of natural disasters.

Scientific Inquiry and the Nature of Science: the nature of scientific knowledge, the scientific enterprise, the interaction of science, technology and society (Howie: 2001).

Since the test items in TIMSS achievement tests emphasised content, it can be criticised for not adequately assessing general scientific literacy, since it does not emphasise or test skills.

The TIMSS test instrument was considered appropriate for the present study because the questions in the Life Science and Scientific Inquiry and the Nature of Science categories were relevant to the content and skills covered in the first Natural and Biological Science modules of the ACE Programme.

The TIMSS-R test instruments were collaboratively developed by an international team. Large scale surveys conducted by the International Association for the Evaluation of Educational Achievement (IEA) have traditionally used multiple choice questions. According to Howie (2001, p8), multiple choice questions are very popular since "the test conditions can be standardised, the cost is low and they can be machine scored". Treagust (1988) and Duit *et al.* (1996) agree that multiple choice questions are valuable diagnostic probes to identify misconceptions and lack of background knowledge in specified content areas.

Multiple choice questions are also considered to be most useful and flexible in comparison to other forms of testing, according to Ebel and Frisbie (1991) and Gronlund (1991) cited in Slavin (1997).

However, Howie (2001) also emphasises the following limitations of using multiple choice questions:

- They cannot adequately measure some important achievement outcomes.
- They are unsuitable for assessing skills of communicating mathematical or scientific findings or constructing a mathematical proof.

Although Wright and Stanbrook (1986) suggest that multiple choice questions are an advantage to English Second Language learners since they do not require expressive linguistic skills, they also criticise them for assessing only rote memory.

TIMSS-R achievement tests selected for this study comprised two different types of questions, namely, multiple choice questions and short-answer questions. In the multiple choice questions, four or five alternatives were given, while in the short-answer questions, the responses were a short verbal answer. Although the TIMSS-R test items assessed six content areas, only two content areas, namely Life Science and Scientific Inquiry and the nature of Science, were assessed in this study because the modules students studied covered these areas.

A two-digit coding scheme was used for the open-ended questions, using the rubric provided by TIMSS-R. The first digit indicated the degree of correctness while the second digit combined with the first, represented a diagnostic code that identified specific types of approaches, strategies or common errors and misconceptions.
Two items of the TIMSS-R achievement test were modified by adapting language and reviewing the context for the items. For example, "corn" was changed to "mealie plant", "oak tree" was changed to "thorn tree" and "wolves" changed to "jackals", which are more relevant to the South African context.

3.4.2 Achievement Instruments of this Research Study

The achievement instrument used in this research study comprised three sections:
(See Appendix 2)

Section One: consisted of 25 questions selected from TIMSS achievement instrument. Twenty questions were multiple choice questions and five were free-response questions.

Twenty one questions tested content from the Life Sciences category and four questions tested content from the Scientific Inquiry and the Nature of Science category. Seventeen of the multiple choice questions had four alternatives and three had five alternatives to choose from.

Table 5: Distribution of Science items by Content Reporting Category

	ITEM TYPE			
Reporting Category	**Multiple Choice Questions**	**Short Answer**	**Number of Items**	**Score Points**
Life Science	17	4	21	22
Scientific Inquiry and The Nature of Science	3	1	4	5
TOTAL	**20**	**5**	**25**	**27**

Table 6: Distribution of Science Items by Performance Category

Performance Category	Percentage of Items	Total Number of Items	Number of Multiple Choice Questions	Number of Free-Response Items	Number of Score Points
Understanding simple Information	52	13	13		13
Understanding complex Information	28	7	5	2	8
Theorising, Analysing and Solving Problems	8	2		2	2
Investigating the Natural World	12	3	2	1	4
TOTAL	**100**	**25**	**20**	**5**	**27**

Each multiple choice question had a score point of one, therefore the score points for the 20 multiple choice questions was 20. Question 21 and 23 of the short-response questions had score points of two, therefore the score points for the five short-response questions was seven. The total score points for Section One was 27.

Section Two: was made up of an extract on Plant Breeding from the materials developed for the ACE Natural Sciences module. Students were required to read the passage and then answer seven short-response questions based on it. Questions one, two, three and four were low-order questions and tested recall from the extract.

Questions five, six and seven were higher order questions and tested application, understanding and analysis. The total score points for this section was 19. This section aimed to assess students' understanding of a representative passage from their study materials.

Section Three: used an extract on "Parasites" from the materials developed for the ACE Natural Sciences module, to estimate readability levels. A cloze test was prepared and every eighth word was deleted, and replaced by a blank of uniform length. Cloze tests are used to gain information about individual students' ability to read specific materials, and take into account the interactions between and among reader, material and reading situation. It is recommended by Wright (1982) that the passage should contain fifty blanks.

A criticism that could be levelled at the cloze test used in this research study, is that it only contained thirty blanks, and not the recommended fifty. The researcher justifies the choice to use thirty blanks instead of fifty, since the cloze test is analysed using the percentage of correct completions.

When scoring the cloze test, the number of correct completions are counted. Only the exact words of the original text are counted as correct, and not synonyms or words that fit the context (Wright: 1982).

The following key is used to analyse cloze tests:

Table 7: Rubric used for analysis of cloze test

PERCENTAGE SCORED	ANALYSIS AND IMPLICATIONS
41 % to 53 %	This indicates that students can read the material with understanding when teachers provide sufficient help. This score indicates that the material is at the students' **instructional level**.
54 % or higher	This indicates that students can read and comprehend the material with ease. This score indicates that the material is at the students' **independent level**.
40 % or lower	This indicates that students have difficulty comprehending the material. This score indicates that the material is at the students' **frustration level**.

(Adapted from Wright: 1982 : p 61)

3.5 Qualitative methodologies employed

The semi-structured interviews with tutors and student evaluation questionnaires were employed to add a qualitative dimension, given that a substantive part of the data analysis and discussion would be the quantitative results of the pre-test and post-test. The researcher regarded the perceptions of the students and tutors and their impressions as important, as students' confidence, self-esteem and conceptual understanding in certain topics may have improved, even if there was no significant difference between their pre-test and post-test scores.

3.5.1 Semi-structured interviews

Semi-structured interviews were conducted with the Natural Science and Biological Science tutors. The Interview Schedule that follows was compiled by the researcher to guide and direct the discussion during the semi-structured interviews:

Interview Schedule

1. Comment on the knowledge and skills that the Natural and Biological Science students possessed at the beginning of the module.
2. What knowledge or skills were mostly absent?
3. Comment on participation of students during tutorial discussions.
4. Did language/linguistic ability of students hinder your teaching of certain content/ concepts?
5. How did you modify/adjust your facilitation methods to accommodate second language learners ?
6. Comment on the performance of students in assignments/activities.
7. Were the characteristics of insects covered adequately in the content?
8. Did the content cover the "Role of proteins in a healthy diet"?
9. Were adaptations/characteristics of prey that are mammals discussed?
10. Did you discuss "territoriality" of animals in any contact session?
11. Were the characteristics of homeothermic/poikilothermic animals discussed?
12. Did you discuss estimation of experimental error in investigations/experiments?
13. Was the concept of formulating an hypothesis, when doing laboratory experiments, discussed?
14. Did you discuss evaporation of different substances like water, oil or vinegar?
15. Was "Plant Breeding" discussed during any tutorial session?

16. In your opinion, was the learning material accessible to students?

17. Based on your assessment of students, has the scientific literacy of students improved from the beginning of the semester ?

Although both tutors were asked the same questions, they were given latitude to respond freely. Both tutors agreed to have their interviews tape recorded.

3.5.2 Student Evaluation Questionnaire

Student Evaluation Questionnaires for Natural and Biological Sciences.
(Appendix 3 and 4)
The student evaluation questionnaire was drawn up by the Quality Promotion Unit (QPU) evaluators in conjunction with the tutors of the modules. The questionnaire was administered in the final lecture of the second semester of 2002 to Natural Science 610 and Biological Science 610 students. Students were asked to comment on the following:

- The clarity with which the tutor outlined and explained the objectives of the module.
- The thoroughness of the tutors' knowledge of the topic/subject.
- Whether the tutor stimulated their interest in Natural Science/Biological Science.
- Whether the tutors' relationship with the class facilitated the development of a productive learning environment.
- The tutors' preparedness for tutorials.

- Whether the tutor encouraged their participation in tutorials.
- The appropriateness of the level of the tutors input on issues.
- The effectiveness of the examples that the tutor used.
- Whether the modules taught them how to teach concepts and information.
- Whether the assessment in the modules helped them to develop expected skills in this field.
- The strengths of the modules.
- Aspects of the modules they wanted to see changed and how they wanted these changes to be made.
- Whether they are now capable of analyzing situations in Science and applying the skills that they had learned.
- Whether they are now capable of applying Biological skills to practical situations.

3.6 Analysis of Data

After scoring using the supplied rubrics, scores on the achievement test, reading comprehension and readability were analysed using SPSS. Students' performance in the multiple choice questions, short response questions, reading comprehension and readability was compared using a non-parametric test called the Wilcoxon's Matched -Pairs Signed-Ranks Test, which compares the central tendency of two matched or related samples. The researcher made use of the SPSS 11 Programme to compare the pre-test and post-test scores obtained in this research study. (Howell: 1995)

In order to determine whether students' performance in the Pre-test and Post-test was related to their performance in the Final Examination, Spearman's correlation coefficient for ranked data (r_s) was applied to these variables. The same test was used to test hypotheses relating to the correlation between English language competence and scores on scientific literacy.

CHAPTER FOUR

ANALYSIS OF RESULTS AND DISCUSSION

4.1 Introduction

Given that the main aim of this research is to assess the improvement in scientific literacy and general scientific skills of teachers enrolled for the ACE Natural Science and Biological Science modules, this chapter will focus predominantly on the analysis of Section one and Section two of the pre-test and post-test since these directly addressed scientific literacy and general scientific skills. The responses obtained from the semi-structured interviews with the two tutors and the student's evaluation questionnaire will be used to supplement the results obtained from the pre-test and post-test.

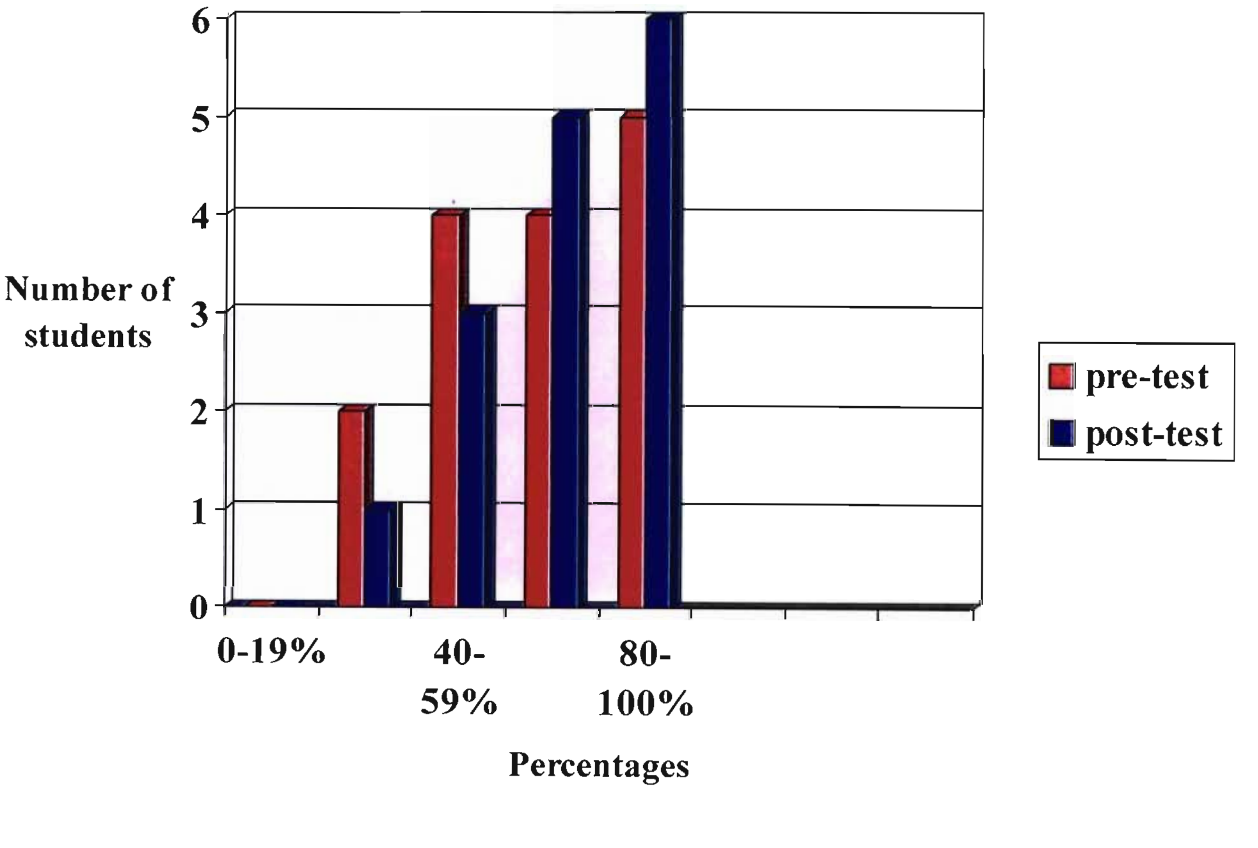
Although the pre-test was written by 22 students and the post-test was written by 25 students, only 15 students wrote both the pre-test and the post-test. Reasons for this are some students registered late and therefore missed the pre-test and some students who wrote the pre-test dropped out of the course and therefore did not write the post-test. It is also possible that some students may have written incorrect student numbers fearing that their results would be used for assessment purposes, and did not want to be correctly identified. Therefore, only the results of the corresponding 15 pre-tests and post-tests are analysed and discussed in this chapter.

4.2 Comparison of results of the Pre-test and Post-test

4.2.1 Section One of Pre-test and Post-test: Multiple Choice Questions and Short Response Questions

As mentioned in Chapter Three, each multiple choice question answered correctly scored one point and each question answered incorrectly scored zero points.

Figure 1: Frequency distribution of scores for the Multiple Choice Questions in the Pre-test and Post-test



Analysing the above graph, ten students obtained above 50%, while five students obtained below 50%, for the Multiple Choice Questions in the Pre-test. In the Post-test, 13 students obtained above 50% while only two students obtained below 50%. Students' performance in the multiple choice questions increased by 20%, that is, three more students obtained above 50% in the Post-test than in the Pre-test. Three responses were marked incorrect because students ringed two alternatives, and there were five nil responses. An analysis of questions in which student's performance was less than 67% will follow later in this chapter.

The Wilcoxon's matched-pairs signed-rank nonparametric test was used to compare the pre-test and post-test results. There was no significant difference between performance in the multiple choice questions of the pre-test and post-test (Wilcoxon's matched-pairs signed-ranks test, 14 d.f, $p > 0,05$). The small sample size of 15, increases the probability of committing a Type II error, as well as decreases the power of the statistical test.

The following descriptive statistics apply to the multiple choice questions for the pre-test and post-test:

Table 8: Descriptive Statistics for Multiple Choice questions in the Pre-test and Post-test.

	N	Minimum Score	Maximum Score	Mean Score	Standard Deviation
Pre-test	15	5	19	12,8	4,5
Post-test	15	5	19	13,8	3,8

Table 8 reflects the minimum and maximum scores out of a maximum mark of 20. It can be seen from the above statistics that the minimum and maximum scores are the same for the pre-test and post-test. However, the mean score has increased and the marks are less scattered around the mean in the post-test, since the standard deviation decreased from 4,5 to 3,8. The mean percentage in the multiple choice questions increased from 64% to 69%.

Although the statistical test revealed no significant difference between the multiple choice questions in the pre-test and post-test, the researcher believes that it is valuable to highlight the difference in individual students' performance.

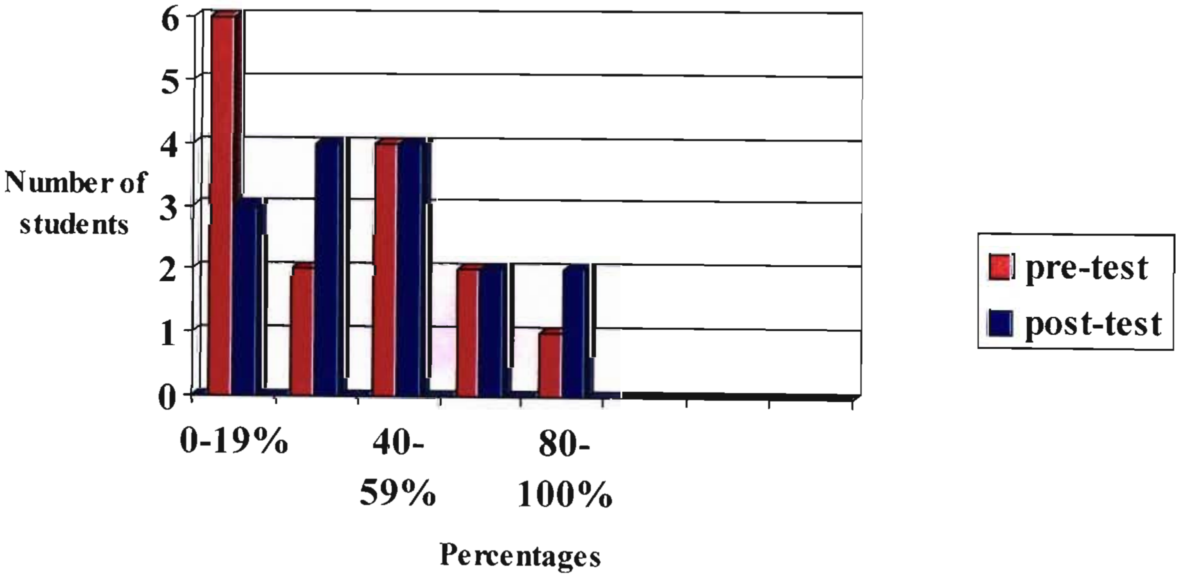
Table 9 compares the scores of individual students in multiple choice questions in the pre-test and post-test out of a maximum mark of twenty, and highlights that eight students increased their scores, with two substantial increases (+4 and +6), while five students tied their scores on the pre-test and post-test. Only two students' scores decreased, with one substantial decrease (-6).

Table 9: Scores obtained for multiple choice questions in the pre-test and post-test.

Student Number	Score in Pre-test	Score in Post-test	Difference in score
1	16	18	+2
2	16	16	0
3	8	10	+2
4	18	16	-2
5	14	17	+3
6	19	19	0
7	19	13	-6
8	11	15	+4
9	7	10	+3
10	9	9	0
11	9	15	+6
12	15	16	+1
13	5	5	0
14	12	14	+2
15	14	14	0

Section One also comprised 5 short response questions, which required students to provide a short, written answer.

Figure 2: Frequency distribution of scores for the Short Response Questions in the Pre-test and Post-test



Only three students obtained above 50% in the pre-test, while in the post-test, four students obtained above 50%. There was no statistically significant difference between performance in the Short Response Questions in the pre-test and post-test. (Wilcoxon's matched-pairs signed-ranks test, 14 d.f, $p > 0.05$)

From the analysis of the short response questions, it appears that students were unable to articulate their answers in writing. This is highlighted in the actual responses of students to the short response questions quoted later in this chapter.

This corresponds with the results obtained in the TIMSS-R (Howie: 2001) achievement test with students performing better in the multiple choice questions than in the short response questions. Similar findings emerged in the Feltham and Downs (2002) study with students performing better in the multiple choice and drawing probes than in the open-ended questions, suggesting that these students were disadvantaged by their inability to express their answers in writing. The following descriptive statistics apply to the short response questions for the pre-test and post-test:

Table 10: Descriptive Statistics for Short Response questions in the Pre-test and Post-test.

	N	Minimum Score	Maximum Score	Mean Score	Standard Deviation
Pre-test	15	0	6	2,5	1,9
Post-test	15	0	6	3,1	1,9

The maximum mark for the Short Response questions was seven. As in the Multiple Choice Questions, the minimum and maximum scores remained the same in the pre-test and post-test. Also, the mean score increased in the post-test. The mean percentage for the Short Response questions increased from 36% to 44%.

Table 11: Scores obtained for Short Response questions in the pre-test and post-test

Student Number	Score in Pre-test	Score in Post-test	Difference in score
1	4	6	+2
2	3	3	0
3	1	1	0
4	4	4	0
5	5	4	-1
6	6	5	-1
7	5	6	+1
8	1	2	+1
9	0	1	+1
10	0	0	0
11	1	3	+2
12	2	2	0
13	2	2	0
14	1	5	+4
15	3	2	-1

Table 11 reflects actual scores, out of a maximum mark of seven, obtained by students. One student (Number 10) did not attempt the short response questions in both the pre-test and post-test.

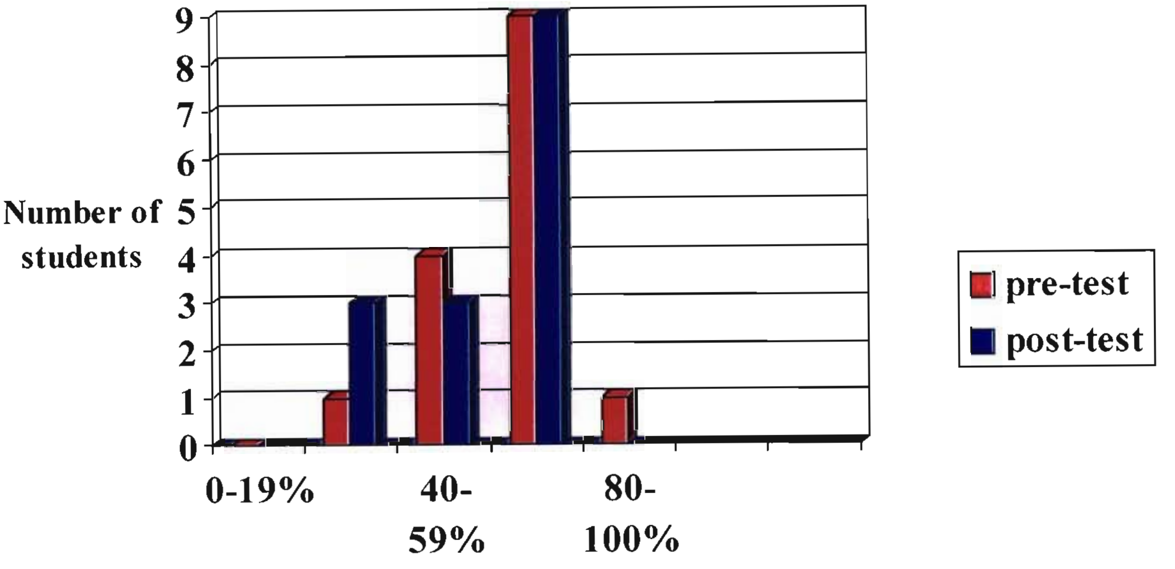
Although the statistical test revealed that there was no significant difference between the pre-test and the post-test for the short response questions, an examination of Table 11 reveals that six students increased their scores in the post-test, with three increases being substantial. Two students increased their scores by 2, while one students' performance increased by 4. There were also six students whose results remained the same on the post-test. Three students' scores decreased, however, these decreases were not as substantial as the increases.

4.2.2 Section Two of Pre-test and Post-test: Language Comprehension exercise on "Plant Breeding"

This section consisted of an extract from the study material on "Plant Breeding", followed by questions based on it. The researcher expected students to perform poorly in this section, given that they seemed to experience difficulty in answering the short response questions in section one.

Students scored higher marks in language comprehension than in scientific literacy. A possible reason for this could be that about 60 % of this exercise tested recall of facts and information from the extract, while about 40 % tested application, understanding and comprehension. Also, since these are practising educators, "Plant Breeding" or "Pollination" may be topics that they are familiar with, and therefore performed better in this section.

Figure 3: Frequency distribution of scores for the Language Comprehension Exercise in the Pre-test and Post-test



It is evident from the graph that fourteen students obtained above 50 % in the pre-test while only one student obtained below 50 %. There was a decrease in performance in this section in the post-test, with eleven students obtaining above 50 % and four students obtaining below 50 %. This result was unexpected, as more than 60 % of the questions tested recall of information from the passage. Since the same passage was used in the pre-test and post-test, the researcher expected the results to improve or, at least, remain similar. These results correspond with Damonse's (1996) finding that the acquisition of knowledge is hampered when students receive instruction in a language that is not their mother tongue.

Comparison between tests showed that there was no statistically significant difference between performance in the Language Comprehension Exercise on "Plant Breeding" in the pre-test and post-test (Wilcoxon's matched-pairs signed-ranks test, 14 d.f, $p > 0.05$).

The following descriptive statistics apply to the language comprehension exercise for the pre-test and post-test:

Table 12: Descriptive Statistics for the Language Comprehension Exercise on "Plant Breeding" in the Pre-test and Post-test.

	N	Minimum Score	Maximum Score	Mean Score	Standard Deviation
Pre-test	15	7	17	12,3	2,3
Post-test	15	5	15	11,4	3,3

Scores are out of a maximum mark of 19. It is evident from Table 12 that the minimum and maximum mark decreased by two. Mean marks decreased and were more scattered around the mean in the post-test. It is likely that when students realised that it was the same test that they had written in the pre-test, they did not give the post-test the same concentration that they gave the pre-test.

Table 13 compares the performance of students in the Language Comprehension Exercise in the pre-test and post-test. The maximum mark was 19.

Table 13: Scores obtained for the Language Comprehension Exercise on "Plant Breeding" in the pre-test and post-test.

Student Number	Pre-test Score	Post-test Score	Difference in Score
1	14	15	+1
2	13	15	+2
3	11	9	-2
4	14	13	-1
5	14	12	-2
6	17	11	-6
7	14	11	-3
8	11	14	+3
9	12	7	-5
10	7	14	+7
11	10	5	-5
12	12	12	0
13	12	6	-6
14	13	15	+2
15	11	12	+1

Six students improved their performance in the post-test, with +3 and +7 being the two largest increases. However, there were eight students whose performance decreased in the post-test, with -5 and -6 being the two largest decreases. Only one students' performance remained the same.

4.2.3 Section Three of Pre-test and Post-test: Readability Exercise (Cloze Test)

A Readability Exercise called a cloze test was given in this section. Students were given a passage with every eighth word deleted, and were required to fill in the missing words.

Table 14: Student's performance in the Readability Exercise (Cloze test) in the Pre-test and Post test

Analysis of Cloze test	Number of students Pre-test	Number of students Post-test
Independent level: > 54 %	7	8
Instructional level: 40 – 54 %	2	2
Frustration level: < 40 %	6	5

Analysis of student's performance in the cloze test indicates that the material was at the independent level for one more student in the post-test. However, comparison between tests showed that there was no significant difference in the cloze test in the pre-test and post-test (Wilcoxon's matched-pairs signed-ranks test, 14 d.f, $p > 0.05$).

The material was at the instructional level for two students, both in the pre-test and post-test. These students would require help from the teacher in order to read the material with understanding. The number of students that had difficulty comprehending the assigned material, which is said to be at their "frustration level", decreased by one student in the post-test. Wright (1990) recommends that study material should be at the instructional or independent level of 40% of the group of students. The material used in this study met this requirement, since it was at the instructional or independent level of 60% of the group.

The following descriptive statistics apply to the readability exercise for the pre-test and post-test:

Table 15: Descriptive Statistics for the Readability Exercise (Cloze Test) in the Pre-test and Post-test.

	N	Minimum	Maximum	Mean	Standard Deviation
Pre-test	15	4	22	14,7	6,8
Post-test	15	5	24	16,2	6,4

The scores for the readability exercise (cloze test) are out of 30. Table 15 shows that the minimum mark increased by 1, and the maximum mark by 2. It is also evident that the mean marks increased with a high standard deviation in both the pre-test and post-test. The mean percentage increased from 49% to 54%.

Table 16 shows the scores of students in the Readability Exercise (Cloze test) in the pre-test and post-test:

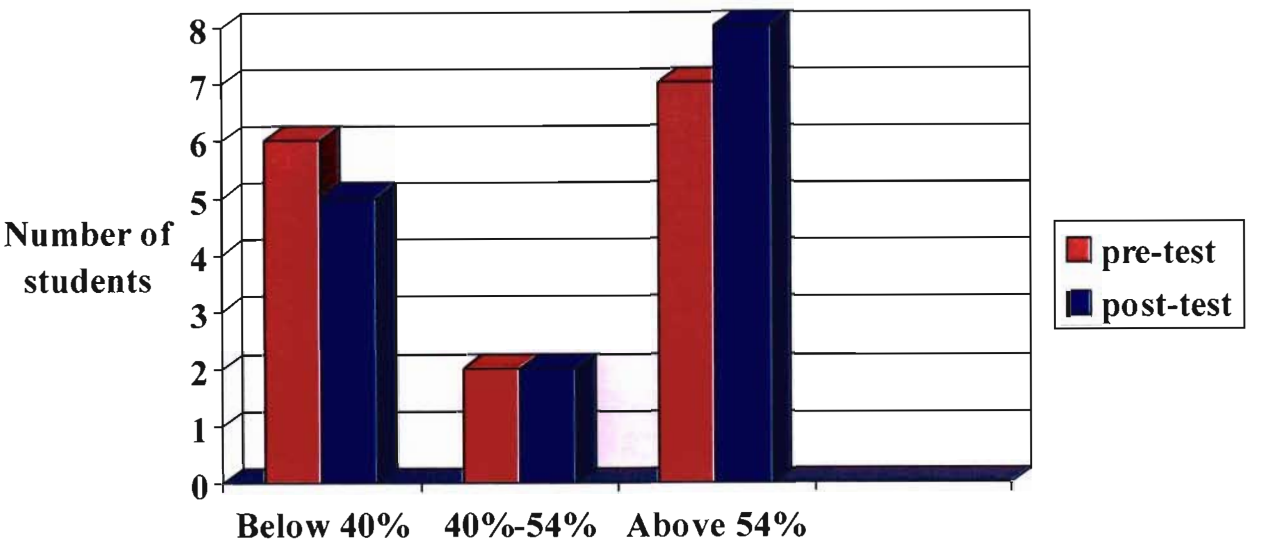
Table 16: Scores obtained for the Readability Exercise (Cloze Test) in the Pre-test and Post-test.

Student Number	Score in Pre-test	Score in Post-test	Average score
1*	22	24	23
2	9	12	11
3	4	11	8
4	20	21	21
5	22	23	23
6 *	22	22	22
7 *	22	22	22
8	9	13	11
9	7	11	9
10	17	21	19
11	6	10	8
12	15	18	17
13	9	5	7
14 *	22	22	22
15	15	8	12

* Denotes English First Language students

Ten students increased their scores in the post-test, with one substantial increase (+7). There were three students whose scores remained the same and only two students who decreased their scores, with one substantial decrease (-7). This suggests that overall, students' ability to read the materials improved between the pre-test and the post-test. The average readability score was calculated to determine the correlation between the average readability and performance in the multiple choice questions, short response questions and the comprehension exercise on "Plant breeding".

Figure 4: Comparison of Readability Estimates in the Pre-test and Post-test



4.3 Correlations

The researcher wished to test the following hypotheses:

a) The general scientific literacy of students improves as a result of studying a science module using a mixed mode of delivery.

b) The performance of students in the scientific literacy test is related to their language competence in English.

In order to assess overall language competence in English, the average language comprehension score and the average readability score was calculated for each student. As mentioned earlier, the multiple choice and short response scores were summed to give a measure of the scientific literacy of each student in the pre-test and post-test.

There was a significant positive correlation between:

- Average language comprehension scores and the scientific literacy scores in both the Pre-test and Post-test. (Pre-test Spearman's rho = 0,788, $p < 0{,}01$ and N =15, Post-test Spearman's rho = 0,820, $p < 0{,}01$ and N =15). Therefore, performance in the scientific literacy test is likely affected by language comprehension.

- Average readability scores and scientific literacy scores in both the Pre-test and Post-test. (Pre-test: Spearman's rho = 0,746, $p < 0{,}01$ and N =15). (Post-test: Spearman's rho = 0,782, $p < 0{,}01$ and N =15). Therefore, performance in the scientific literacy test is likely affected by ability to read.

Table 17 summarises the performance of students in the final module assessment, scientific literacy scores and biographical data.
Spearman's correlation coefficient for ranked data revealed that there was a positive correlation between:

- the pre-test and post-test ($r_s = 0{,}889$, $p < 0{,}05$)
- the pre-test and final examination score ($r_s = 0{,}889$, $p < 0{,}05$)
- the post-test and final examination score ($r_s = 0{,}859$, $p < 0{,}05$)

Thus, able students performed well in all testing situations, including language skills. Conversely, weak students performed poorly in all testing situations.

Table 17: Ranked Performance and Biographical data of students

Student	Final Exam %	Rank	Pre-test %	Rank	Post-test %	Rank	Home Language	Qualifications	Subjects / Grades taught
1	81	5th	56	3rd	63	1st	English	Junior Primary Diploma in Education	All Learning Areas Grade 5
2	72	7th	41	9th	46	8th	isiZulu	Secondary Teacher's Diploma	Nat.Sc. and Biology Gr.8,11,12
3	24	15th	24	15th	31	13th	isiZulu	B.A.Honours	Biology Grades 10-12
4	75	6th	56	4th	54	5th	isiZulu	Senior Teacher's Diploma	Biology Grades 10-12
5	82	4th	55	5th	56	3rd	isiZulu	Primary Teacher's Diploma	Natural Science Grades 8,9
6	94	1st	64	1st	57	2nd	English	Diploma in Education	All Learning Areas Grade 6
7	87	3rd	60	2nd	52	6th	English	Senior Primary Education Diploma	Nat.Sc. and Bio. Grades 8,11,12
8	54	11th	32	11th	44	9th	isiZulu	Senior Sec.Diploma, B.Paed.	Zulu Grade 10
9	59	10th	26	14th	29	14th	isiZulu	Senior Sec.Diploma, B.Paed.	LO, HSS, LLC Grade 8-12
10	43	13th	33	10th	44	10th	isiZulu	Secondary Teacher's Diploma	Maths, Phy.Sc. Grades 10-12
11	46	12th	26	13th	33	12th	isiZulu	Senior Primary Education Diploma	Not Available
12	63	9th	44	7th	48	7th	isiZulu	Secondary Teacher's Diploma	Maths, Biology Grades 10-12
13	34	14th	28	12th	18	15th	isiZulu	Senior Primary Education Diploma	NS/Tech, MLMMS Grade 4
14	88	2nd	48	6th	56	4th	English	Junior Sec.Diploma Further Diploma	Natural Science Grades 8,9
15	67	8th	43	8th	36	11th	isiZulu	B.A., B. Paed.	Geography Grades 8-12

4.4 Ranked Performance and Biographical data of students

Table 17 summarises the performance of students in the pre-test, post-test and the final examination, as well as biographical data of the students.

It is evident from the biographical data that only four students spoke English as their home language while eleven students spoke Zulu as their home language. The four students who spoke English as their home language performed well in the pre-test, post-test and final examination. This highlights that home language was a good predictor of student's performance and corresponds with the findings of the TIMSS-R study (Howie: 2001) and Feltham and Downs (2002) study.

The qualifications and subjects / grades taught by the students were also summarised in the table, since these factors could have impacted on students' content knowledge and therefore their performance in the test.

Students 9 and 13 both performed very poorly in the pre-test, post-test and final examination. Their qualifications included a Senior Secondary Diploma, B.Paed. and a Senior Primary Education Diploma respectively and they taught Life Orientation, Language Literacy and Communication and Human and Social Sciences Grades 8-12 and Natural Science/Technology, Mathematics Grade 4 respectively. In the case of the student who taught Life Orientation, Language Literacy and Communication and Human and Social Sciences Grades 8-12, his/her poor performance could be due to the fact that he/she was not teaching Natural Science or Biology. Although the other student taught Natural Science/Technology, Mathematics, his/her poor performance could be due to the fact that he/she only taught at Grade 4 level. However, even though student 3 had a B.A.Honours qualification and taught Biology Grades 10-12, he/she still performed very poorly in the pre-test, post-test and final examination.

Only four of the fifteen students had a university degree. The remaining eleven students had a three year diploma from a college of education. The poor performance of the students ranked twelfth to fifteenth in the achievement test suggests that they lack adequate preparation in terms of content knowledge.

4.5 Error Analysis of Multiple Choice Questions and Short Response Questions in the Pre-test and Post-test

Table 18 summarises students' performance in the multiple choice and short response questions. Each question is analysed as follows:

- Content category
- Performance expectation
- International Average %
- Average % in Pre-test and Post-test

It is evident from Table 18 that the students in this study scored above the international Grade 8 average in 19 questions in the Pre-test and 22 questions in the Post-test. The students scored below the international Grade 8 average in five questions in the Pre-test and three questions in the Post-test.

The questions marked with an * in Table 18 are questions in which students' performance was less than 67% and will be discussed in detail later in the chapter.

Table 18: Error Analysis of Multiple Choice and Short Response Questions

Question number	Content category	Performance expectation	International Average % Gr. 8	Average % in Pre-test	Average % in Post-test	Number of words
1	Life Science	Understanding simple information	69	87	93	8
2	Life Science	Understanding simple information	71	80	80	8
3	Life Science	Understanding simple information	70	67	73	21
4	Life Science	Understanding simple information	65	73	73	9
5	Life Science	Understanding simple information	70	87	80	9
6	Life Science	Understanding simple information	78	93	93	3
* 7	Life Science	Understanding simple information	49	33	60	7
* 8	Life Science	Understanding simple information	33	47	47	18
9	Life Science	Understanding complex information	72	80	73	16
*10	Life Science	Understanding complex information	37	40	47	23
*11	Life Science	Understanding simple information	60	27	40	17
12	Life Science	Understanding simple information	54	93	93	12
13	Life Science	Understanding simple information	41	87	80	13
*14	Life Science	Understanding complex information	40	47	73	19
*15	Life Science	Understanding complex information	48	53	60	20
*16	Sc. inquiry & nature of Sc.	Understanding simple information	40	40	27	16
*17	Sc. inquiry & nature of Sc.	Investigating the natural world	35	40	53	47
*18	Sc. inquiry & nature of Sc.	Investigating the natural world	48	53	60	42
19	Life Science	Understanding simple information	56	73	80	27
20	Life Science	Understanding complex information	87	80	93	23
*21	Sc. inquiry & nature of Sc.	Investigating the natural world	12	20	33	30
22	Life Science	Understanding complex information	41	67	80	12
23 (i) *23 (ii)	Life Science	Understanding complex information	40	46	53	24
*24	Life Science	Theorising, anal. & solving problems	41	7	13	39
*25	Life Science	Theorising, anal. & solving problems	26	53	47	33

4.5.1 Analysis of Multiple Choice Questions in the Pre-test and Post-test

A discussion of those multiple choice questions in which student performance was less than 67 % follows. The correct alternative is in bold print.

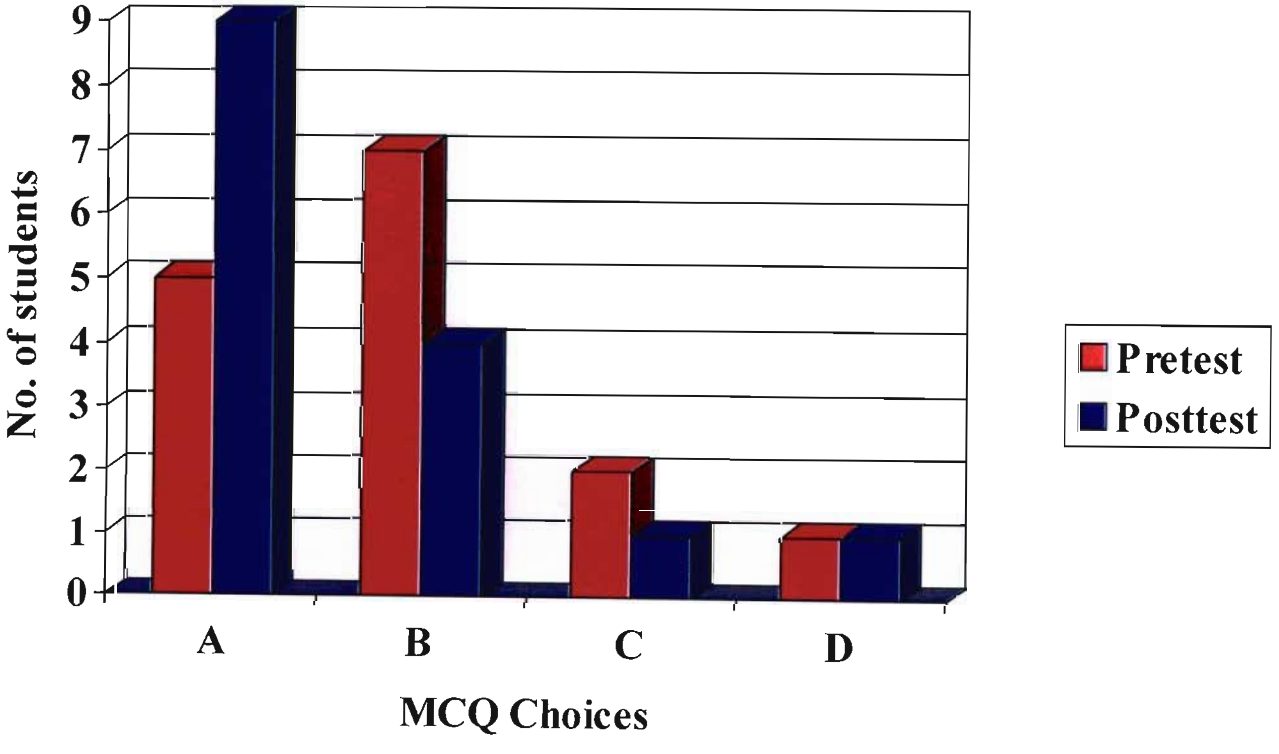
<u>**Question Seven**</u> What feature is shared by ALL insects?

A. **external skeleton**
B. two pairs of wings
C. jumping legs
D. stinging mechanism

International Average Percentage responding correctly: 49%

Average Percentage responding correctly in this study: 33%

Figure 5: Students' responses in the Pre-test and Post-test for Question Seven



Discussion of question and results:

In the pre-test only 33% of the students answered correctly. Given that this question was short and simple, language and interpretation of the question should not have been problematic. All students attempted this question in both the pre-test and post-test. Students had studied insects and their characteristics during the semester. This could account for the improvement in the post-test.

Nevertheless, although students' performance improved, it is clearly evident that many students have misconceptions about features of insects. Five students chose the correct answer (A) in the pre-test, while seven students chose B ("two pairs of wings"). The misconception persisted in the post-test, where four students still chose alternative B.

<u>**Question Eight**</u> The BEST reason for including protein in a healthy diet is because it is the main source of:

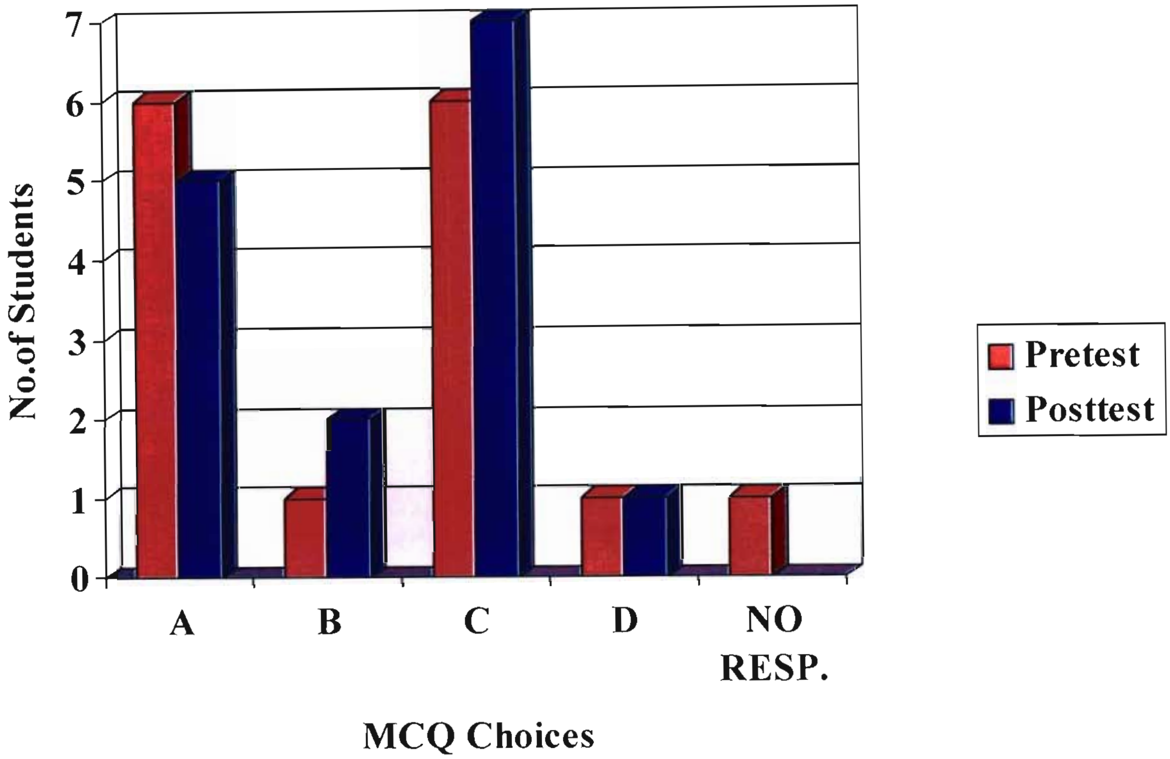
A. energy for the body
B. fibre for digestion
C. raw materials for cell growth and repair
D. vitamins for fighting disease

International Average Percentage responding correctly: 33 %

Average Percentage responding correctly in this study: 47%

Discussion of question and results:

Figure 6: Students' responses in the Pre-test and Post-test for Question Eight



This was a short question using simple language, therefore language and interpretation should not have been problematic. Figure 6 highlights the possibility of misconceptions among students. Six students chose the correct answer (C) in the pre-test, but six students also chose alternative A. Students have misconceptions about the role of protein in the body. Tutors confirmed that biochemistry and the role of proteins were not covered in the study material. This could account for the poor results in both the pre-test and post-test, with little improvement.

<u>**Question Ten**</u> Which one of the following characteristics is most likely to be found in mammals that are preyed on by other mammals for food?

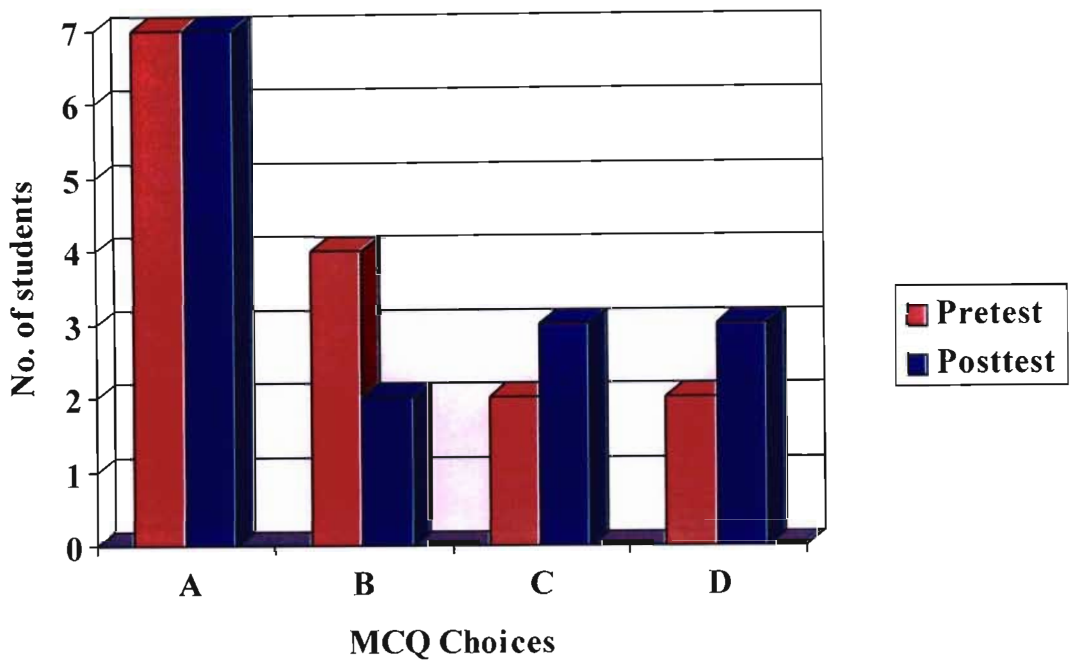
A. **eyes on the sides of the head**
B. teeth that are long and pointed
C. claws on the feet
D. ears that cannot move

International Average Percentage responding correctly: 37 %

Average Percentage responding correctly in this study: 40%

Discussion of question and results:

Figure 7: Students' Responses for Question Ten



Eight students experienced difficulty in answering this question. It is possible that students had difficulty with the use of two prepositional phrases in succession and the passive voice. All students attempted this question in both the pre-test and post-test. Although the tutors confirmed that adaptations and characteristics of prey were discussed during tutorials, Figure 7 reveals that students still had difficulty answering this question in the post-test. Seven students chose the correct alternative (A) in the pre-test. Also, four students chose alternative B while two students each chose alternative C and alternative D as answers in the pre-test. However, in the post-test, seven students chose alternative A, two students chose alternative B, while three students each chose alternatives C and D. It is therefore likely that students either had difficulty deciphering the question or misconceptions about characteristics of prey.

<u>Question Eleven</u> When male jackals place their scent on trees, they most likely are doing this in order to :

A. attract female jackals
B. attract prey
C. **mark their territory against other jackals**
D. mark the location of food supplies

International Average Percentage responding correctly: 60 %

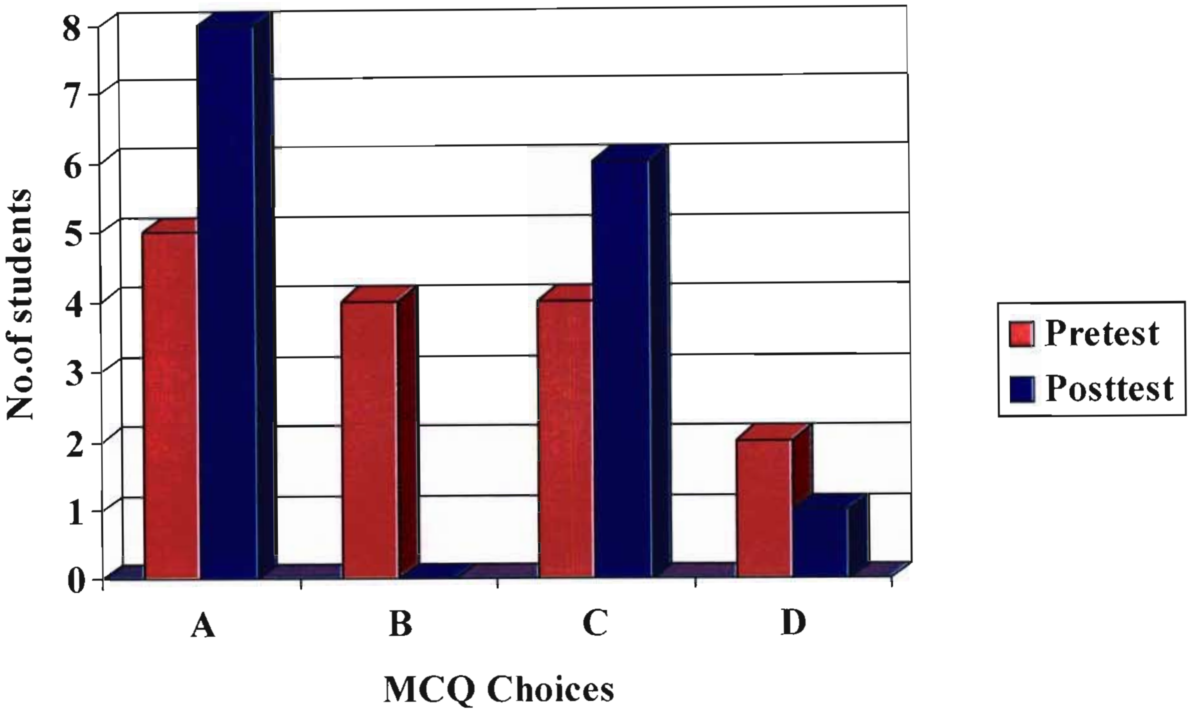
Average Percentage responding correctly in this study: 27%

Discussion of question and results:

In the TIMSS-R achievement test this question referred to male wolves. However, in the achievement test used in this research study, the word "wolves" was changed to "jackals".

This change or adaptation was made because the researcher believed that it would be more relevant to South African students since they should be more familiar with jackals than wolves. This was the most poorly answered question in the pre-test, much more poorly answered than the average Grade 8 learner internationally.

Figure 8: Students' responses in the Pre-test and Post-test to Question Eleven



Responses of students to this question indicate possible misconceptions regarding territoriality. In the pre-test, four students chose the correct alternative C while five students chose alternative A, four students chose alternative B and two students chose alternative D. However, in the post-test, although six students chose the correct alternative C, eight students chose alternative A, which seemed a strong distracter, and two students chose alternative D. Given that eight students still chose alternative A in the post-test, the researcher believes that these misconceptions persisted.

All students attempted this question in both the pre-test and the post-test. The improvement in performance could be attributed to the fact that "territoriality" was included in the study material and discussed during tutorials.

Question Fourteen Which statement best explains why mammals are found in very cold regions of the world but lizards are not?

A. both mammals and lizards are cold-blooded, but mammals have fur to keep them warm.

B. both mammals and lizards are warm-blooded, but lizards get too cold when they shed their skin.

C. since mammals, but not lizards, are warm-blooded, their body temperature will adjust to match the external temperature.

D. since mammals, but not lizards, are warm-blooded, they will maintain their body temperature using heat from metabolic processes.

International Average Percentage responding correctly: 40 %

Average Percentage responding correctly in this study: 47%

Discussion of question and results:

This question and the responses to choose from were longer than most others. In the pre-test, six students answered correctly, one did not attempt the question and one chose two alternatives. In the post-test, 11 students answered correctly. This was a complex question, yet most students got it right in the post-test, so the complexity of the language was not a factor.

Figure 9: Students' responses in the Pre-test and Post-test for Question Fourteen

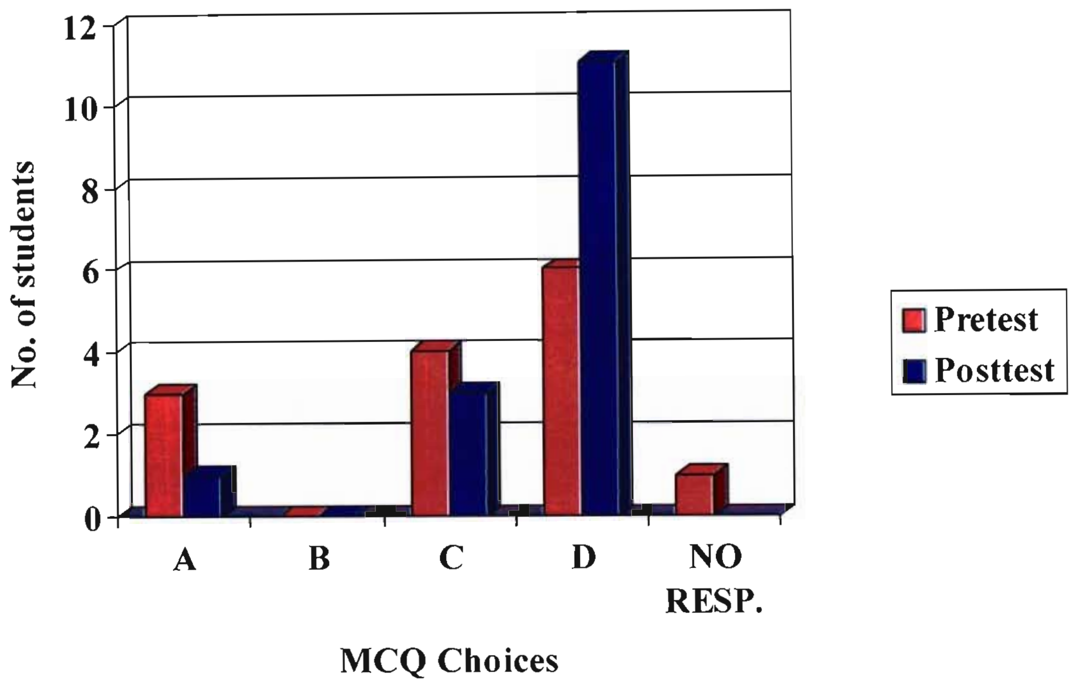


Figure 9 reveals that although five more students chose the correct alternative D in the post-test, three students still chose alternative C and one student chose alternative A. Discussion with the tutors revealed that poikilothermy and homeothermy were discussed at length during tutorial sessions. This could account for the improvement in the post-test.

<u>**Question Fifteen**</u> Animals hibernate to survive cold weather and poor food supplies. Which of the following occurs in animals when they hibernate?

A. their blood stops circulating.
B. their body temperature increases.
C. their body fat remains constant.
D. their rate of metabolism decreases.

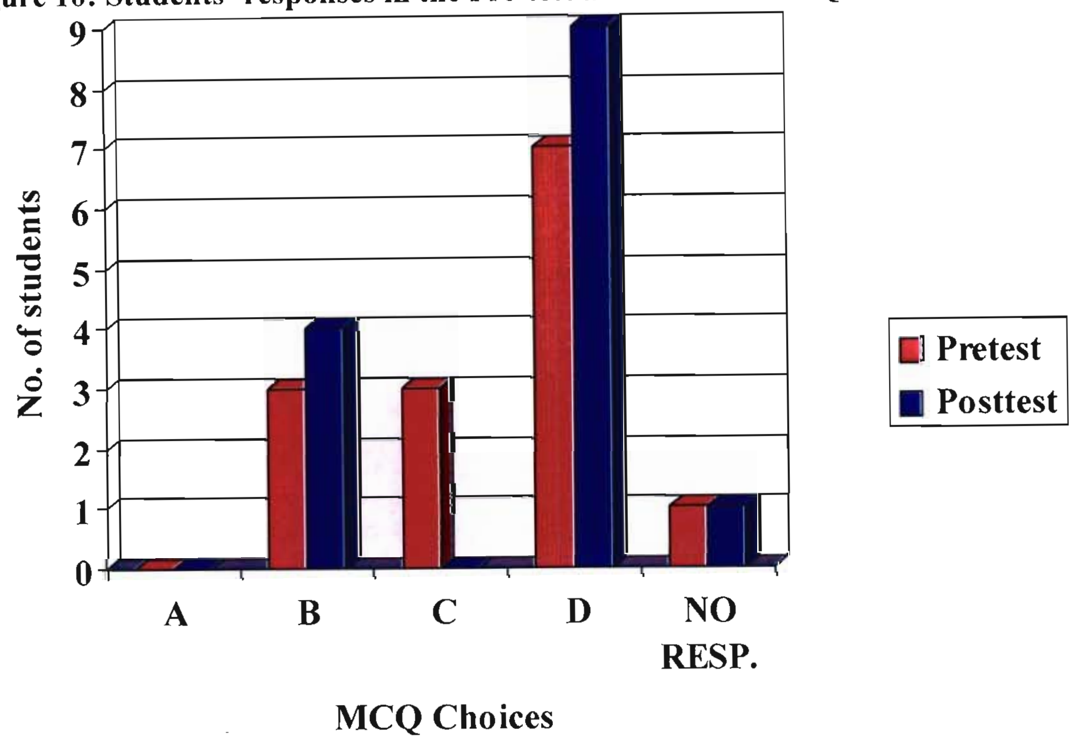
International Average Percentage responding correctly: 48 %

Average Percentage responding correctly in this study: 53%

Discussion of question and results:

The alternatives to choose from were short, simple sentences, so language and interpretation should not have been problematic. It is possible that some students did not know the meaning of 'hibernating'.

Figure 10: Students' responses in the Pre-test and Post-test for Question 15



Analysis of responses in Figure 10 suggests that there may be misconceptions amongst students. Although seven students chose the correct alternative D, three students each chose the alternatives B and C in the pre-test. Even though nine students chose the correct alternative D in the post-test, four students still chose alternative B. This implies that alternative B was a significant distractor.

One student did not attempt this question in both the pre-test and post-test. Percentage of students responding correctly increased from 47% to 60%.

Question Sixteen The primary reason scientists repeat the measurements they take during experiments is so that they can:

A. check that the equipment is working
B. list all the results in a table
C. estimate experimental error
D. change the experimental conditions

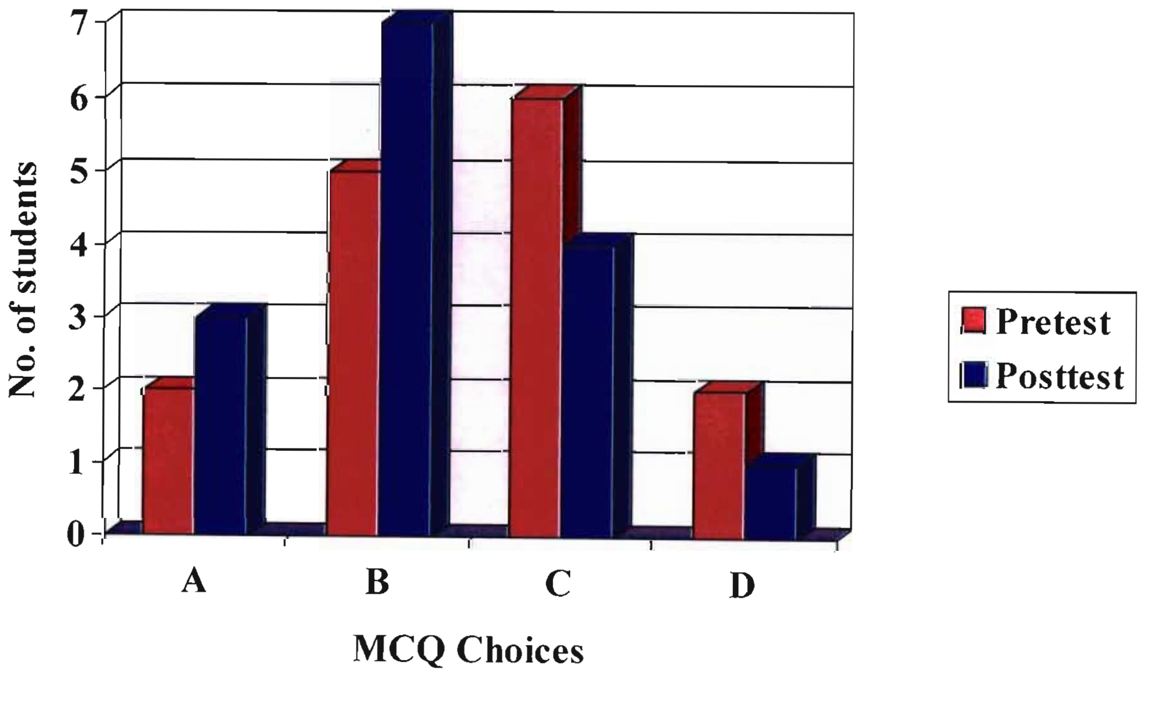
International Average Percentage responding correctly: 40 %

Average Percentage responding correctly in this study: 40%

Discussion of question and results:

This was the first question testing experimental work and it was clearly evident from the results obtained that students had great difficulty answering it. This was the only question in which the performance decreased substantially in the post-test.

Figure 11: Students' responses in the Pre-test and Post-test for Question 16



It is evident from Figure 11 that students were either confused or had misconceptions that persisted in the post-test. Although six students chose the correct alternative (C) in the pre-test, this decreased to four students in the post-test. Given that five and seven students chose the incorrect alternative B in the pre-test and post-test respectively, alternative B seemed to be a strong distracter. All students attempted this question in both the pre-test and post-test. The results confirmed the tutors' observation that "students' practical knowledge was almost non-existent". Given that tutors indicated that the concept of "experimental error" was adequately covered during the practical week, the researcher expected an improvement in the performance in this question. However, it seems contradictory that performance decreased in the post-test.

<u>Question Seventeen</u> Alexander Fleming noticed that bacteria growing on a plate of agar did not grow next to a mould that was growing on the same plate. He wrote in his laboratory report: "The mould may be producing a substance that kills bacteria". This statement is best described as:

A. an observation
B. a hypothesis
C. a generalisation
D. a conclusion

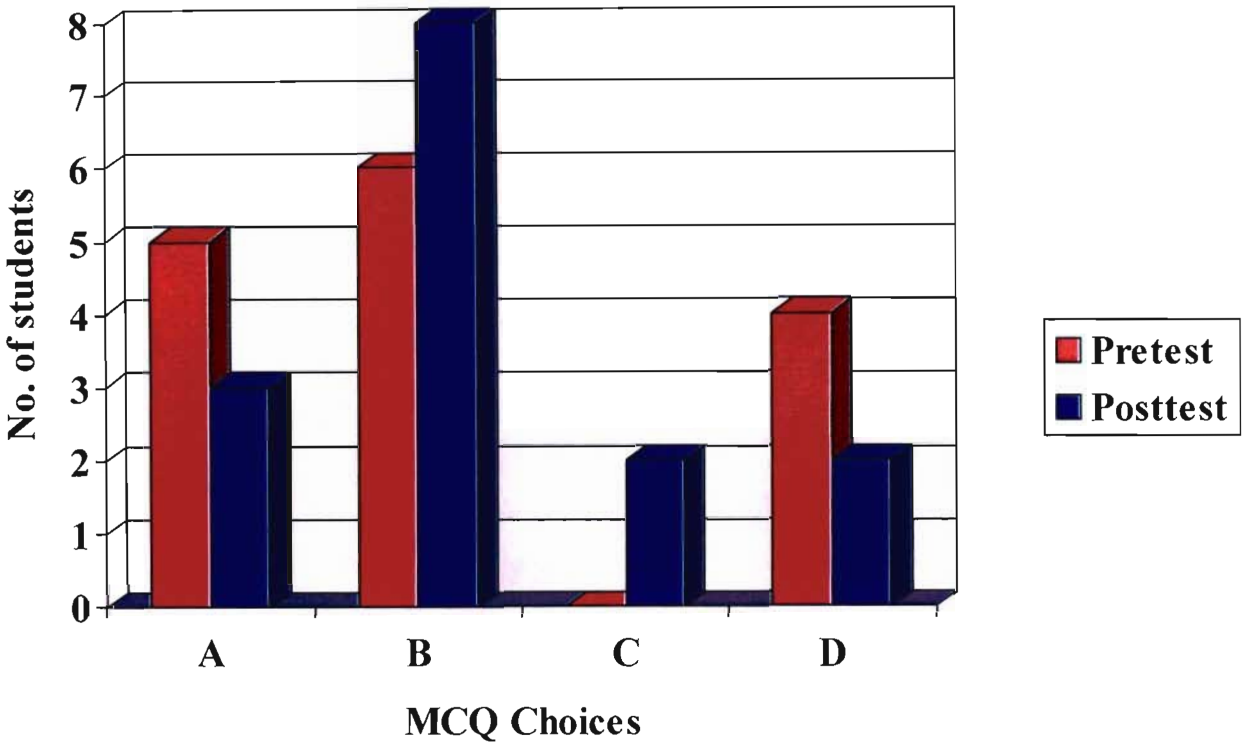
International Average Percentage responding correctly: 35 %

Average Percentage responding correctly in this study: 40%

Discussion of question and results:

Although the responses to choose from were short, this was the longest question, made up of forty seven words. It is possible that since students had more information to read in this question, language and interpretation were problematic.

Figure 12: Students' responses in the Pre-test and Post-test for Question 17



It is evident from Figure 12 that many students answered incorrectly. Six students chose the correct alternative (B) in the pre-test and eight students in the post-test. However, Figure 12 highlighted a misconception of students since five students chose alternative A and four students chose alternative D in the pre-test. This changed slightly in the post-test with three students choosing alternative A and two students each choosing alternatives C and D. All students attempted this question in both the pre-test and post-test. Discussion with the tutors revealed that the concept of formulating a hypothesis was adequately covered in the practical week. This could account for the improvement in performance in the post-test.

The post-test was written during the practical week in July and it is possible that students were still establishing concepts when they wrote the post-test. Therefore, although tutors mentioned that estimating experimental error and formulating a hypothesis were adequately covered in the practical week, it would be unrealistic to expect a drastic improvement in performance immediately. On the contrary, it could be argued that the concepts were well established during the recent practical week.

Question Eighteen Two open bottles, one filled with vinegar and the other with olive oil, were left on a window sill in the sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation?

A. vinegar evaporates faster than olive oil.
B. olive oil evaporates faster than vinegar.
C. both vinegar and olive oil evaporates.
D. only liquids containing water evaporate.
E. direct sunlight is needed for evaporation.

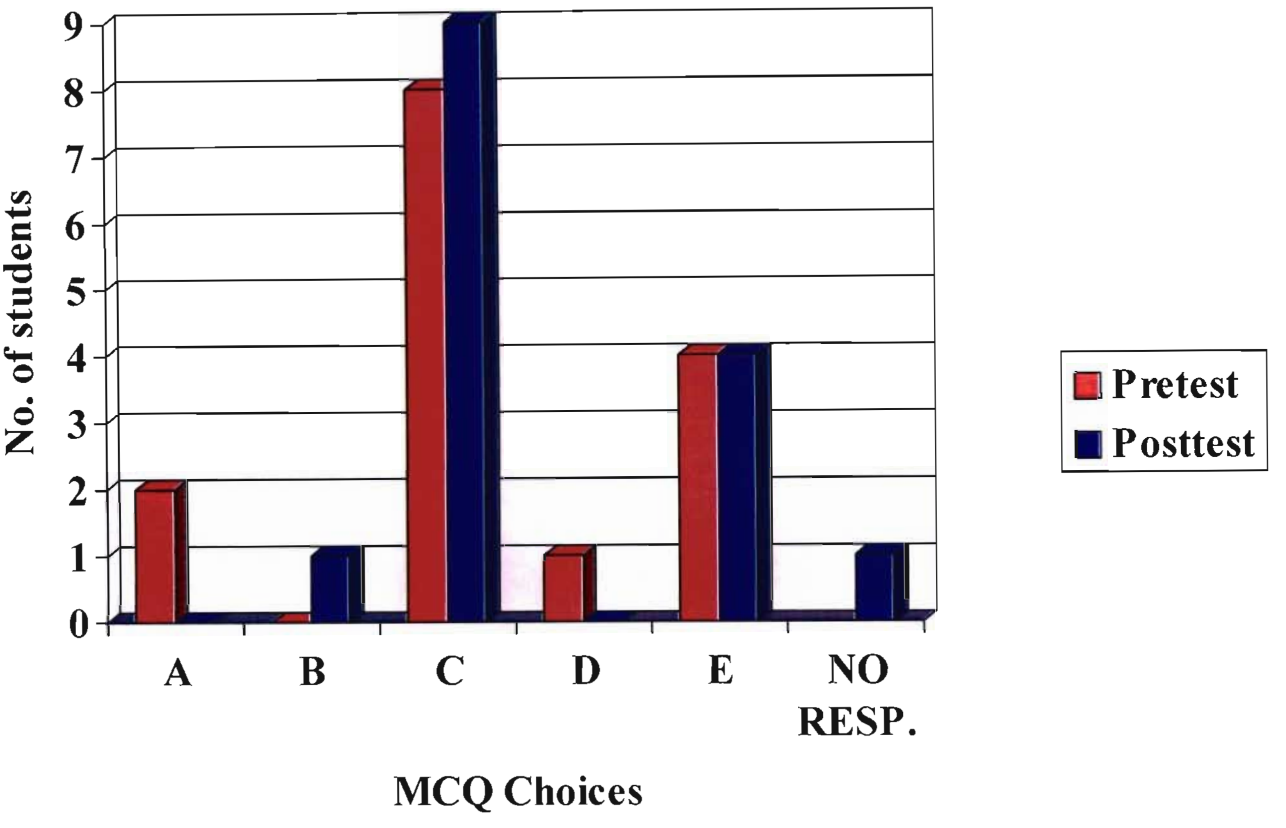
International Average Percentage responding correctly: 48 %

Average Percentage responding correctly in this study: 53%

Discussion of question and results:

This question tested students' knowledge that liquids evaporate at the same rate. It was also a long question, made up of forty two words, so language and interpretation could have been problematic. Although eight students chose the correct alternative in the pre-test and nine students in the post-test, the sunlight involvement is a distractor, therefore alternative E was chosen by four students in both the pre-test and post-test. All students attempted this question in the pre-test, while one student did not attempt it in the post-test. Discussion with tutors revealed that evaporation was not covered during tutorial sessions.

Figure 13: Students' responses in the Pre-test and Post-test for Question 18



4.5.2 Analysis of Short Response Questions in the Pre-test and Post-test

<u>Question Twenty One</u> Suppose you want to investigate how long it takes for the heart rate to return to normal after exercising. What materials would you use and what procedures would you follow?

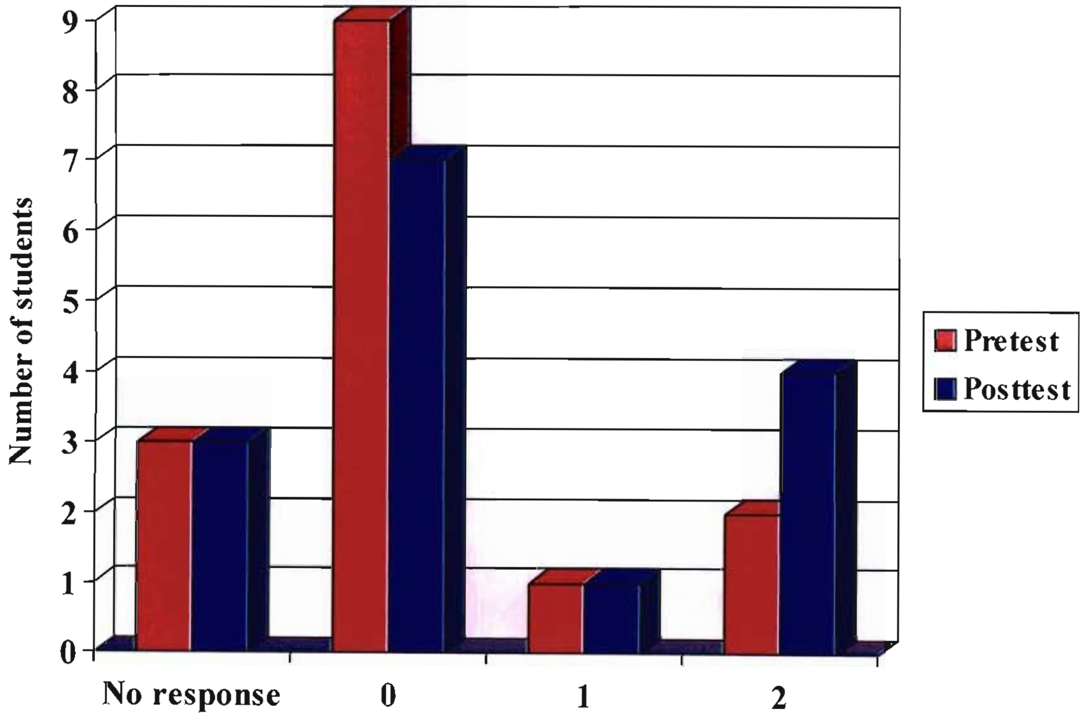
International Average Percentage responding correctly: 12%

Average Percentage responding correctly in this study: 20%

Discussion of question and results:

Students scored slightly higher than average international Grade 8 learners. It is evident from Figure 14 that this question was very poorly answered with three students not responding to the question at all in both the pre-test and post-test. This seems to confirm the findings of the TIMSS-R study that South African students "did not have the language and comprehension skills to convey their answers in writing" (Howie: 2001, p 150).

Figure 14: Students' responses in the Pre-test and Post-test for Question 21



Nine students provided incorrect responses and scored 0 points in the pre-test, however, in the post-test seven students provided incorrect responses and scored 0 points.

The following responses (actual words) of students highlights the misconceptions and misunderstanding among students:

- *"I will take two people. The other one walk and the run about 10 m long. After than I will take the thermometer and measure their temperature"*

- *"I will use two ballons, two plastic straws, two cut 2 litre transparent plastic bottle, a string, a plastic bag which is transparent. I will cut two bottles (plastic) at the bottom, sealed them by covering with a plastic bag. I will tie both balloons and insert straws"*

An analysis of the above responses indicated that students confused the use of the thermometer for measuring the pulse rate. The above responses also indicated that students confused an experiment for measuring pulse rate with a model of the thorax and lungs, that they likely made during the vacation school practicals.

This question consisted of two parts, namely, to first discuss the materials they would use and then discuss the procedure they would follow. Both in the pre-test and post-test one student did not answer the second part of the question and therefore scored one point only. This suggests that the student either did not read the entire question or did not know how to respond to the second part of the question. The number of students scoring two points increased from two in the pre-test to four in the post-test.

Question Twenty Two What digestive substance is found in the stomach? What does it do?

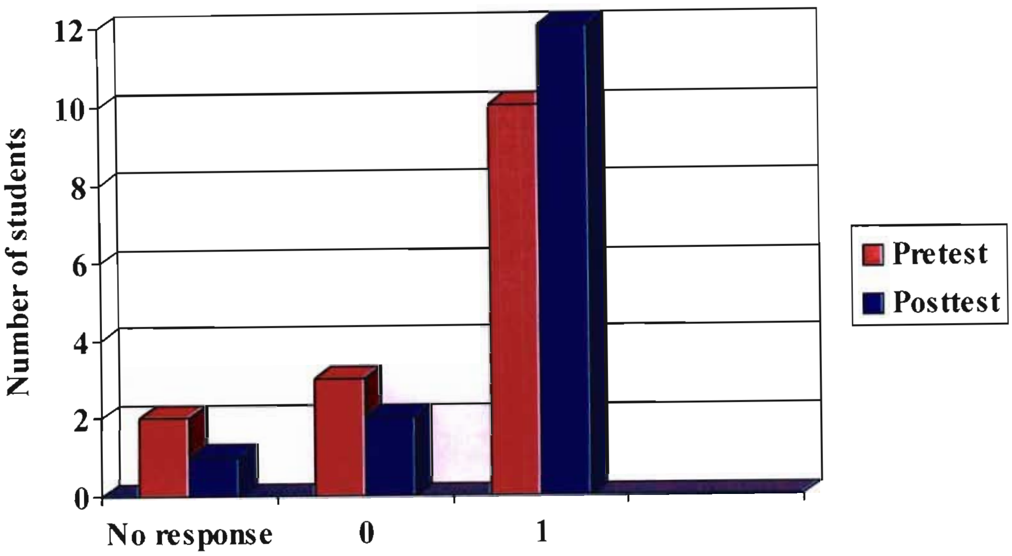
International Average Percentage responding correctly: 41 %

Average Percentage responding correctly in this study: 67%

Discussion of question and results:

This question consisted of two parts that were not numbered separately. However, the number of students not responding and providing incorrect answers is lower than in the previous question. This could be possibly due to the fact that students were more familiar with the content tested in this question, compared to practical application tested in the previous question. Two students did not respond to this question in the pre-test, while only one student did not respond in the post-test.

Figure 15: Students' responses in the Pre-test and Post-test for Question 22



The following are actual responses of students to this question:

- *"Enzymes which is called salivary amylase. The function of these enzymes they break protein into smaller parts"*
- *"Small intestine are use for digestion food such as protein, fats and vitamin. After digestion it dissolve and taken by blood"*
- *"Bile - to convert food from its normal way into the suitable substance for being transported"*

Analysis of the above responses indicated that although these students were able to link this question to digestion, they were unable to list the specific digestive juice in the stomach and its function. Students' performance in this question improved since twelve students scored one point in the post-test compared to ten students in the pre-test.

Question Twenty Three A new species of fish was released into a lake. State two unwanted outcomes that could arise from the introduction of this new species.

International Average Percentage responding correctly: 40 %

Average Percentage responding correctly in this study: 46%

Discussion of question and results:

Each outcome was scored separately with a score point of one. In Figures 16 (a) and (b) this question is analysed separately as Question 23(i) and Question 23(ii).

Figure 16 (a): Students' responses in the Pre-test and Post-test for Question 23(i)

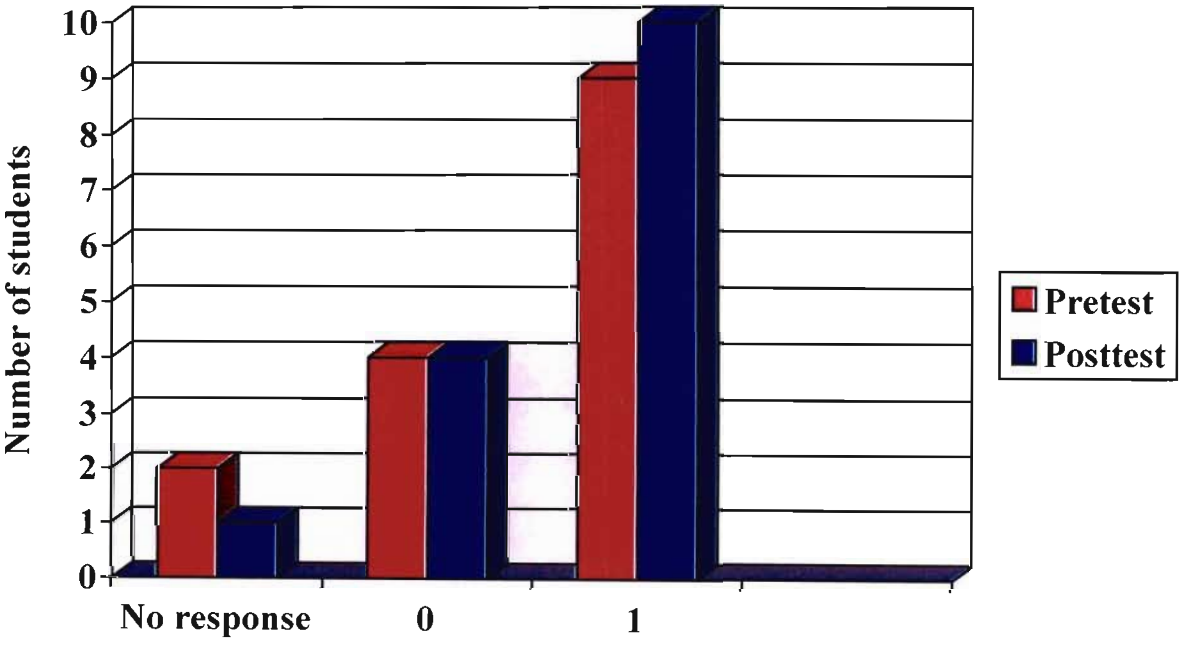
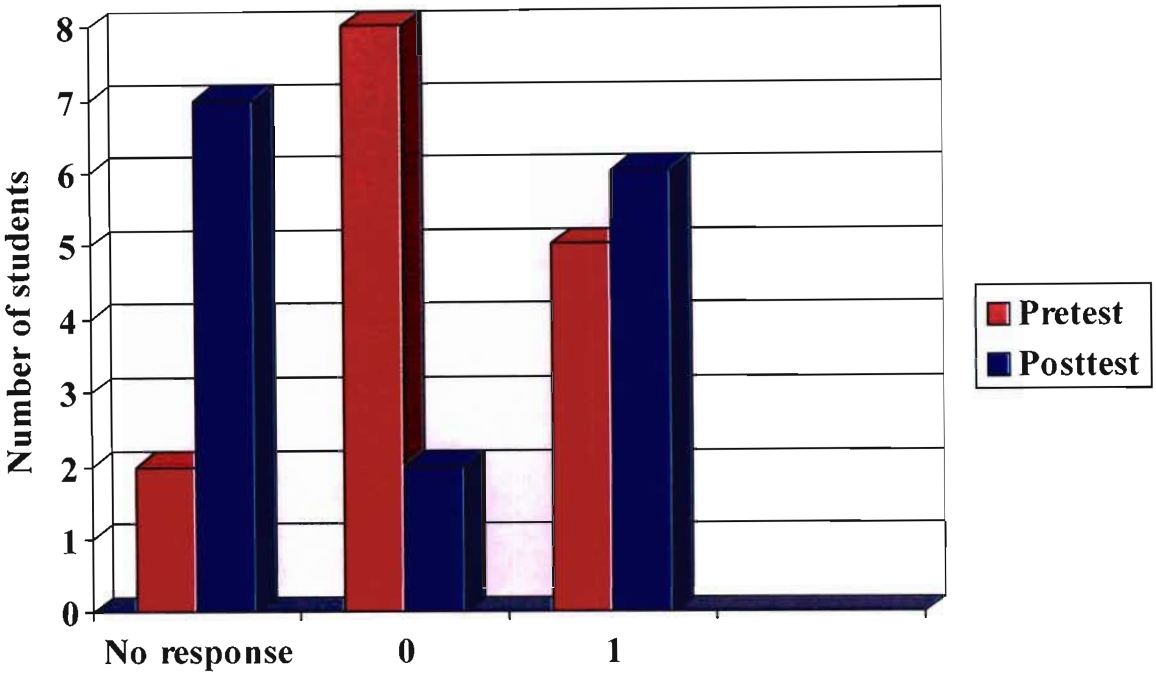


Figure 16 (b): Students' responses in the Pre-test and Post-test for Question 23(ii)



It is evident from these graphs that the number of students who did not respond at all or provided incorrect answers is much higher for Question 23(ii). This confirms the suggestion that either students did not read the entire question and only answered the first part or were unable to answer the second part of the question.

In question 23(i), the number of students not responding at all decreased from two in the pre-test to one in the post-test. Four students provided incorrect responses in both the pre-test and post-test. However, the number of students scoring one point increased from nine in the pre-test to ten in the post-test. Different trends were observed in question 23(ii). The number of students providing incorrect responses decreased from eight in the pre-test to two in the post-test. It is apparent that some students chose not to respond to this question at all, since the number that did not respond increased from two in the pre-test to seven in the post-test. Also, the number of students scoring one point increased from five to six.

The following are actual responses of students to this question:

- *"It could end up dominating the population of the lake"*
- *"It will spread the poisonous when it bite people"*
- *"The condition of the lake (dirty), gases eg. breathing process"*
- *"It can happen that this species has disabilities"*

Analysis of the above responses indicated that these students were very confused about the effect the new species of fish would have on the other organisms in the lake. These students seem to lack basic knowledge about food chains and its effects on the ecosystem. This corresponds with the findings of Driver *et al* (1994) which highlighted that only 50% of a sample of undergraduate students was able to relate their knowledge about feeding and energy to the interactions among organisms in an ecosystem.

<u>Question Twenty Four</u> Ethan hammered a nail into the trunk of a young tree. Explain why the nail was still at the same height from the ground twenty years later even though the tree had grown to a height of 22 metres.

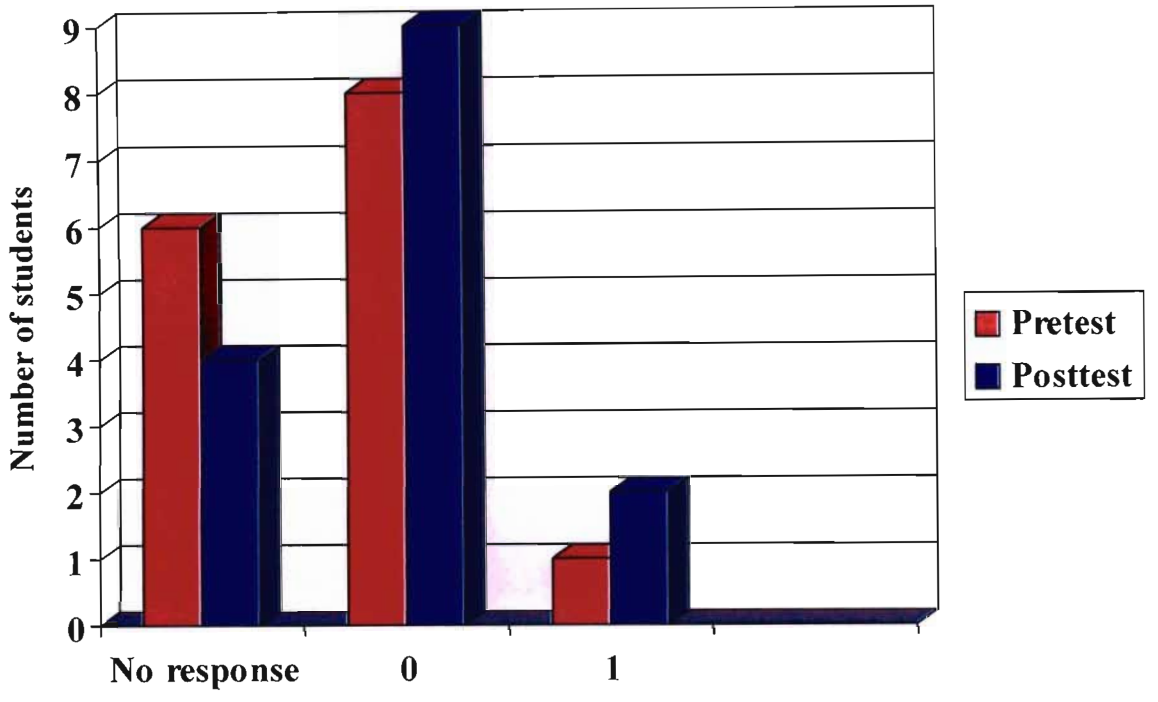
International Average Percentage responding correctly: 41%

Average Percentage responding correctly in this study: 7%

Discussion of question and results:

This was the most poorly answered short response question.

Figure 17: Students' responses in the Pre-test and Post-test for Question 24



Six students did not respond to this question in the pre-test. This decreased to four in the post-test. However, the number of students answering this question incorrectly increased from eight in the pre-test to nine in the post-test.

The following are actual responses of students to this question:

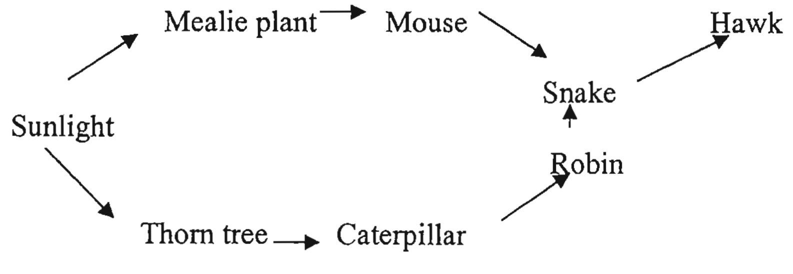
- *"The nail has no living substance that can help it to grow it would remain on the same spot but the tree will grow"*
- *"The growth of the tree has no link with the nail"*

- *"Hammering the nail into the tree interfered with its growth at that particular spot, hence no growth took place so the nail remained the distance from the ground"*
- *"The nail is a non-living thing so it does not have characteristics of living organisms like growth etc."*

An analysis of the above responses suggested that students were confused and had misconceptions regarding secondary thickening, which persisted throughout the semester. Some students believed that the hard cuticle or bark or lignin or cellulose caused the nail to stick in the same place. Also, students believed that since the nail was non-living is remained in the same place since it does not have living characteristics.

From her experience as a biology teacher, the researcher confirmed that this was a section in which most students experienced great difficulty at school. Students may also have performed poorly since this question required application and analysis. It is also evident that only one student answered correctly in the pre-test compared to two students in the post-test.

Question Twenty Five



Look at the food web. If the mealie crop failed one year what would most likely happen to the robin population ? Explain your answer.

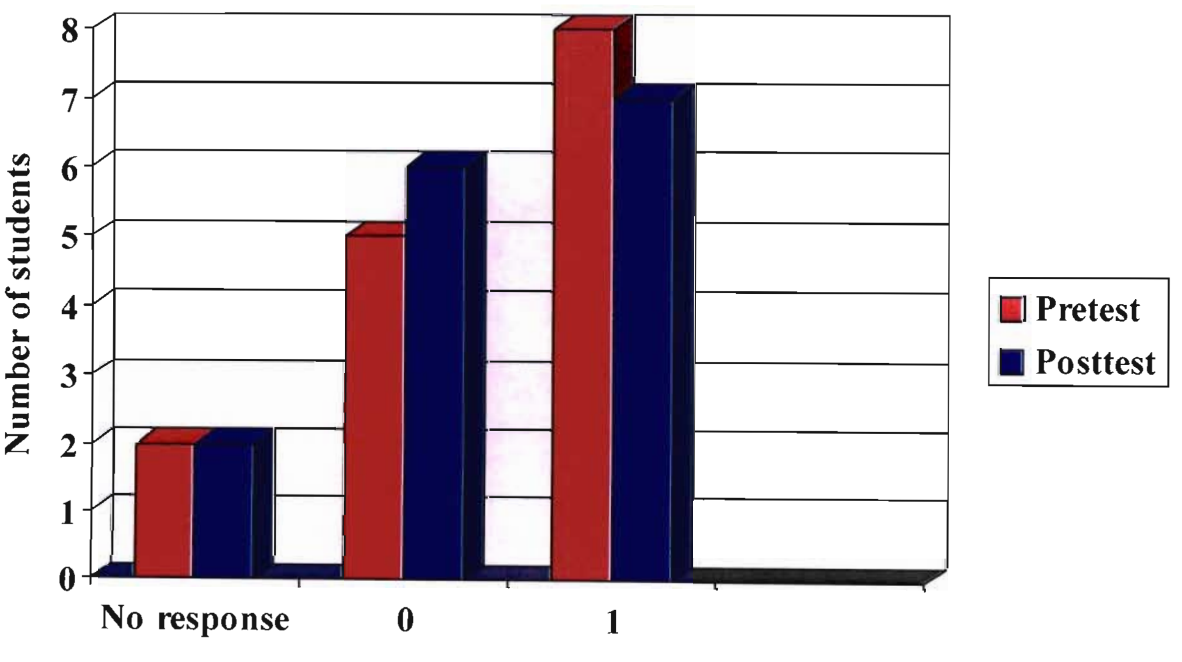
International Average Percentage responding correctly: 26%

Average Percentage responding correctly in this study: 53%

Discussion of question and results:

Two terms were adjusted from the TIMSS-R achievement instrument: "corn" was changed to "mealie plant" and "oak tree" was changed to "thorn tree". The researcher also assumed that students would know that the robin is a bird.

Figure 18: Students' responses in the Pre-test and Post-test for Question 25



Three students did not respond to this question in both the pre-test and post-test. It is evident from the graph that five and six students answered this question incorrectly in the pre-test and post-test respectively.

Misunderstandings and misconceptions about food webs are revealed in the following actual responses of students:

- *"If the mealie crop failed, the mouse would'nt be survive. Mealies depend on sunlight. Thorn tree protect plant from animals"*
- *"The robin population will be greatly affected because no food will be available for them and end up in death"*
- *"Nothing. The robin is not dependent on the mealie plant because the link from the robin to the sun (primary energy source) has not been affected"*

with regard to the first and third response of students quoted above, it is also possible that these students did not know what a robin is. Similar misunderstandings and misconceptions were revealed in responses to Question 23 that also tested knowledge and understanding of food chains and their effect on the ecosystem. The concepts of producers, consumers and energy flow were introduced in Biological Science 610 only. However, food chains and food webs were discussed in later modules. This could account for poor performance in questions 23 and 25.

The international average score of Grade 8 learners in the TIMSS-R (2001) study was 68% and the average score of Grade 8 South African learners was 35%. The average score of educators in this study was 63%. This study therefore supports Verspoor and Leno's (1986) findings that sub-Saharan teachers are inadequately trained for the subject they are teaching and have not mastered the subject content.

The researcher analysed the number of words in each question to determine whether this impacted on student's performance. Student's performance in Questions17, 18, 21 and 24 was very poor. This could be attributed to the fact that these questions consisted of 47, 42, 30 and 39 words respectively. It is possible that students experienced difficulty reading, understanding and interpreting these questions because they comprised many words. However, although questions 19 and 20 consisted of 27 and 23 words respectively, students' performance was 73 and 80 percent respectively. Students' also performed very poorly in questions seven, eight and 11 that consisted of seven, 18 and 17 words respectively. In the case of these three questions, it seems that misconceptions in students' understanding of the scientific concepts tested in these questions resulted in their poor performance. It is also possible that the type of words used, grammatical structure of the sentences as well as whether the question required recall, application or analysis influenced students performance.

4.6 Analysis of Language Comprehension Exercise on "Plant Breeding" in the Pre-test and Post-test

Students were required to answer seven questions based on an extract on "Plant Breeding" from the Natural Science "Life and Living module" module.

The following four questions tested recall from the extract and could therefore be classified as low-order questions:

Question 1: Name two plants that are self-pollinators.

Question 2: Name two plants that are cross-pollinators.

Question 3: List two differences between self-pollinating and cross-pollination plants.

Question 4: Name one difficulty faced by plant breeders in respect of cross-pollination.

Students did not experience great difficulty answering questions 1 and 2 as the majority were able to select the correct answers from the extract. However, a few students experienced some difficulty answering questions 3 and 4. Although the answers were in the extract, students were required to read and select relevant information instead of selecting correct names. The following are actual responses of students that indicated poor comprehension of the extract:

Question 3:

- *"Self pollinating plants produce their own pollen and produce seeds. Cross pollination plants rely on other plants for growth and do not produce seeds"*
- *"Self-pollinating – pollen can fertilise the eggs of the same flower or of different flowers"*

Question 4:

- *"Cross-pollinating plants are too much demanding for manpower"*
- *"The breeder have to remove the tassles before they start producing pollen"*
- *"Plants are not fertilise the eggs of the same flowers"*
- *"Feld fires"*

The above responses revealed that some students could not answer simple questions based on the extract.

The following three questions tested application, understanding and analysis and could therefore be classified as higher order questions:

Question 5: How does self-pollination take place?

Question 6: What is the advantage of self-pollinators to plant breeders?

Question 7: Explain what is meant by plant breeding.

An examination of the above questions indicated that students would have to read, understand and analyse the extract. Many students experienced great difficulty in answering these questions, since the answers could not be directly lifted from the extract. It was also noticed that several students could not express themselves adequately, once again highlighting the problem with language.

The following are actual responses of students to **Questions 5**:

- *"When the pollen grain the yellow powder its self into the stigma of other plant"*
- *"It inbreeding for many generations so they have less genetic variability"*
- *"By means of a wind. When wind is blowing the pollen is blown to different parts"*
- *"Self pollination take place during the cross pollination"*

The above responses to Question 5 revealed that students were confused about how self-pollination takes place. This highlights the poor comprehension skills of these students since the explanation for self-pollination was given in the second paragraph of the extract.

The following are actual responses of students to **Question 6**:

- *"it able to produce itself"*
- *"If the generation is the good and healthy one. It is then promoted or increased in numbers"*
- *"Pollen can fertilise the eggs of the same flower"*
- *"It is guaranteed to happened and it is indipendent"*

These responses of students to question 6 indicated that they did not understand the advantage of self-pollinators to plant breeders. This was explained in the third paragraph of the extract and once again highlights the poor comprehension skills of these students.

The following actual responses of students to **Question 7** illustrated that these students were confused or had misconceptions about plant breeding:

- *"It is to look after a plant by giving it water and its food"*
- *"Plant reproduction- reproducing seeds"*
- *"It is when plant or animal fertilise the egg of another species or the same species to give rise to new-born plant or animal"*
- *"A person who carries the work of fertilising the plants so that they can generate others"*

Tutors revealed that although the topic "Plant breeding" was included in the study material for Natural Science 610, it had not been discussed in the Natural Sciences tutorials when the pre-test and post-test was given. The topic "Plant breeding" was not included in the study material for Biological Science 610. This could be one of the reasons why there was no improvement in students' performance in this section of the test. It is also possible that students had misconceptions in this section that were not addressed in these modules.

The TIMSS-R (Howie: 2001) study as well as the findings of the Feltham and Downs (2002) study revealed that second language students experienced great difficulty when required to express their answers in writing.

Since 73% of these students wrote this test in their second language, this could have contributed to their poor performance in this comprehension exercise. Students' poor performance in this Language Comprehension Exercise also supports one of van der Laans' (1994: cited in de Feiter, Vonk and van den Akker: 1995) reasons for poor science education in Southern Africa that language is problematic for both teachers and learners, English being their second or even third language.

4.7 Qualitative Data

The researcher conducted semi-structured interviews with the Natural Science and Biological Science tutors in order to supplement the quantitative data obtained from the achievement tests. It was also envisaged that the Student Evaluation Questionnaires would provide a more holistic overview of student's perceptions about the modules and the course.

4.7.1 Semi-Structured Interviews with Tutors

The researcher included questions about the knowledge and skills that students possessed at the beginning of the modules, knowledge and skills that students lacked, participation of students during tutorials, English language competence of students and students' performance in assignments. Questions were also included relating to those aspects or topics in which students performed very poorly. Tutors were also asked to comment on the accessibility of the learning material and their impressions of whether scientific literacy of students had improved.

Both tutors mentioned that theoretical and practical knowledge of majority of the students was very weak at the commencement of the modules. They also mentioned that a few good students seemed to dominate the tutorial discussions, while most of the students did not participate much during discussions, possibly because of limited knowledge or their cultural beliefs.

Tutors also mentioned that students performed better in multiple choice tests than in tests that required them to explain their answers. Both tutors also mentioned that competence in English could have inhibited students during discussions since they could not express themselves adequately.

According to the tutors, student's performance in assignments improved throughout the semester, with some students obtaining 80 – 90% in their assignments. Students did not experience any difficulty with the learning material. According to both tutors, scientific literacy of students improved by the end of the semester.

The responses of tutors to questions relating to whether specific content or topics were covered or not, were discussed earlier in this chapter when individual questions were analysed.

4.7.2 Student Evaluation Questionnaires

An open-ended questionnaire was drawn up by the Quality Promotion Unit (QPU) evaluators in conjunction with the tutors of these modules.

(Refer to Appendix 3 and Appendix 4 attached)

The following are student's responses quoted verbatim to some of the questions asked in the Natural Science evaluation questionnaire:

State whether this module taught you how to teach Life and Living concepts and information.

"This module has helped me a lot in the understanding of Life and Living and I'm sure I can be a good teacher now"

"At first I had no idea about Life and Living content but now I can teach it easily to the learners according to their level of understanding"

The above responses indicated that the impressions of these students were that they have improved their knowledge and understanding of the Life and Living content which resulted in them becoming better teachers.

State whether you are now capable of applying Life and Living skills to practical situations.

"Yes I feel more confident that I will be able to apply Life and Living skills to practical situation"

"Very confident"

The above responses indicated that students felt more confident after studying the content to apply skills to practical situations.

Write down any other issue you want to raise.

"Tutors must try and accommodate all pupils in the same level. I did'nt did science at school so I was having no basics, tutors should be aware of that they are people who does not know anything about the subject they must not assume that we have done it and we know what its all about"

"This module has given me more confidence in teaching this learning area"

The first response corresponds with the perceptions of the tutors that the theoretical and practical knowledge of many students were very weak at the commencement of the course. The second r esponse highlighted that some students gained confidence studying these modules.

The Biological Science 610 student evaluation questionnaire had a slightly different layout. Students were presented with mostly positively phrased statements to which they could respond on a five- point scale. Their responses were categorised as positive, neutral and negative.

All students responded positively to the statements below:

- *At the end of this semester, I believe that I have developed intellectually beyond the point I was at when I started the module*
- *I found that the prescribed readings for the module were understandable*
- *I found that the reading material was beneficial in helping to understand the module*

- *I think that I have gained a clear understanding of the concepts and principles of this subject*

The first and last responses above once again highlighted the impression of students that they have improved intellectually and gained a clearer understanding of the concepts and principles of this subject after studying this module. However, this seems contradictory to the results obtained, with the weak students still performing very poorly in the post-test and the examination. The second and third responses indicated that students did not experience great difficulty with the reading material. However, this does not correspond with the results of the readability exercise that showed that the reading material was still at the frustration level for five students in the post-test.

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction

One of the aims of this research study was to determine whether scientific literacy in Life Sciences and general scientific skills of teachers improved as a result of studying one module covering basic biological concepts in a mixed-mode programme. It was also intended to determine the extent to which language and comprehension skills improved and whether students' performance was related to language skills. In this chapter the key findings that emerged from this research will be highlighted, conclusions will be drawn based on the analysis and recommendations will be made for future research.

5.2 Summary of major findings

The findings in this section have been divided into achievement test, comparison between pre-test and post-test, biographical data, tutors' and students' perceptions.

5.2.1 Achievement test

Students performed better in the multiple choice questions than in the short response questions and comprehension exercise in both the pre-test and post-test. From the responses of the short response questions, it appeared that students experienced difficulty in expressing their answers in writing.

Great difficulties were also noted in the language comprehension exercise on "Plant breeding". These findings highlighted that students lacked language competence in English to convey their answers in writing and correspond with those of the TIMSS-R study (Howie:2001). However, a major distinction between the TIMSS-R study and this research study is that in the TIMSS-R study the sample included Grade 8 learners whereas in this research study the sample included practising educators. This is a matter of great concern.

Multiple choice and Short response questions were categorized into two content areas, namely, Life Sciences and Scientific Inquiry and the Nature of Science. Of the 21 questions in the Life Sciences category, less than 67% of students answered correctly in nine questions. However, less than 67% of the students answered correctly in all four questions in the Scientific Inquiry and the Nature of Science category.

There were 13 questions in the Performance Category: Understanding simple information. More than 80% of students answered correctly in both the pre-test and post-test in questions 1, 2, 5, 6, 12, and 13. More than 67% answered correctly in questions 3, and 4. Less than 47% answered correctly in questions 8,11 and 16. Clearly, students had little difficulty in understanding simple information. There were seven questions in the Performance Category: Understanding complex information. 80% of students answered correctly in questions 9 and 20. 60% of students answered correctly in questions 15 and 22. Students performed poorly in questions, namely, 10, 14 and 23. Students seemed to experience more difficulty in understanding complex information.

Students' performance was very poor in the Performance Category: Investigating the Natural World. There were three questions in this category and students' performance was below 67% in all three questions, namely, 17, 18 and 21. It is therefore evident that students lack content knowledge and skills in this category and could not answer these questions correctly. There were two questions in the Performance Category: Theorising, analyzing and solving problems. Students also experienced much difficulty in this category since their performance was below 67% in both questions, namely, 24 and 25.

The content areas in which students clearly had misconceptions were:

- Role of proteins in the body (Multiple choice question 8)
- Characteristics of mammals that are preyed on by other mammals (Multiple choice question 10)
- Territoriality (Multiple choice question 11)
- Estimating experimental error (Multiple choice question 16)
- Formulating a hypothesis (Multiple choice question 17)
- Evaporation (Multiple choice question 18)
- Materials and procedure for measuring heart rate (Short response question 21)
- Secondary thickening (Short response question 24)
- Food webs (Short response question 25)

The international average score of Grade 8 learners in the TIMSS-R (2001) study was 68%, the average score of educators in this study was 63% and the average score of Grade 8 South African learners was 35%. Therefore, students assessed in this study performed at the level of the international average Grade 8 learner, but considerably better than the average South African Grade 8 learner. This supports the findings of the TIMSS-R study which emphasized that:

"about half of the science teachers did not feel prepared to teach science to Grade 8 pupils. They did not feel prepared to teach the various science topics".

(Howie: 2001,p153).

Similar findings emerged in the Feltham and Downs (2002) study which revealed that although students performed better in the items that were not as language dependent as the open-ended questionnaire, generally the student's background knowledge bases were very poor.

According to Rutherford and Watson (1990) and Miller (1998) cited in Feltham and Downs (2002, p175):

"academic achievement in the sciences is partly a function of the students' initial level of competence in terms of proficiency in English and Mathematics; commitment and diligence are an essential component of academic achievement"

This study supports this statement, in that competence in English is clearly positively correlated with performance on the achievement test.

Improvement in students' scores in the following content topics highlights the impact of the mixed-mode module on scientific literacy:

- Sensory messages to brain (Multiple choice question 1)
- Characteristics of mammals (Multiple choice question 3)
- Characteristics of insects (Multiple choice question 7)
- Poikilothermy and homeothermy (Multiple choice question 14)
- Changes in hibernating animals (Multiple choice question 15)
- Plant nutrition (Multiple choice question 19)
- Changes in pulse and breathing rate (Multiple choice question 20)

Scores improved slightly in Questions 10, 11, 17 and 18. Differences, however, were not statistically significant.

Questions 21, 22 and 23 of the Short response questions included two parts to be answered. Many students did not answer the second part of the question highlighting that they did not read the entire question. Analysis of the number of words in each question revealed that students performed better in questions with fewer words. Those questions that consisted of more than thirty words (Questions 17, 18, 21 and 24) were answered very poorly. This highlighted the problem with reading and language skills of students and corresponds with the findings of Feltham and Downs (2002) which revealed significantly poorer performance in the open-ended questionnaire than in the multiple choice or drawing questions.

The Readability exercise/Cloze test revealed that the material was at the "independent level" for one more student in the post-test than in the pre-test. Since one less student found the material at the "frustration level", this suggests that students' ability to read the material improved between the pre-test and post-test. However, five students still found the material at their "frustration level" in the post-test.

Therefore this research study confirmed empirically some of the reasons given for poor Science education in South Africa:

- Poor subject knowledge of teachers (Verspoor and Leno:1996 cited in de Feiter, Vonk and van den Akker: 1995)
- Language competence in English interferes with teaching and learning Science (MaNaught:1994, van der Laan:1994 cited in de Feiter, Vonk and van den Akker: 1995 , Damonse:1996, Osborne:2002)
- Poor knowledge of Nature of Science and Scientific Inquiry
- Impact of mixed-mode module on the above (Sokhela:1998, Bailey:2000, Feltham and Downs:2002)

The mixed-mode did not result in statistically significant improvement in language competence or scientific literacy. By contrast, Feltham and Downs (2002) study found significant improvement in all but open-ended questions in a full-time one-year science programme. The results raise questions about the efficiency of a mixed-mode programme at improving subject knowledge and English language competence of educators.

5.2.2 Comparison between Pre-test and Post-test

There was no statistically significant difference between the pre-test and post-test in any section of the test. The small sample size of 15 could have contributed to the non-significance of results. Nevertheless, a number of students improved in each section of the test and in the pre-test and post-test overall.

Eight students improved their scores in the multiple choice questions, six students improved their scores in the short response questions, ten students improved their percentages in the readability exercise / cloze test and eleven students increased their overall percentages from the pre-test to the post-test. This suggests that the basic Biology module is achieving a level of success in equipping students with knowledge and skills in these areas, although the results are not statistically significant. The perceptions of both the tutors and students were that scientific literacy of students improved.

The only section in which students' performance decreased was the Language Comprehension exercise on "Plant breeding". Knowledge that the test did not "count" for assessment and boredom when students recognized the post-test as being the same as the pre-test, are possible reasons for the decrease in some students' scores.

5.2.3 Biographical data

The following are important findings that emerged from the Biographical data of students:

- The four students who spoke English as their home language scored in the top six in scientific literacy, language competence and final examination. The researcher therefore concluded that one of the reasons for students' poor achievement in the test is the lack of competence in English second language learners. However, Miller (1997) as cited in Feltham and Downs (2002: p175) opposes this view and states that the extent of academic preparedness of students is the critical factor underlying performance and not whether students are first or second English language speakers.

- Since all educators in this sample had a post-schooling diploma or degree as a qualification, the researcher expected them to perform reasonably well in the achievement test given that the multiple choice and short response questions were taken from the TIMSS-R Grade 8 achievement test. However, ten students obtained below 50% in the pre-test and nine students obtained below 50% in the post-test. This raises questions about the subject matter / content knowledge of these educators and the curricula of the colleges of Education or universities where they obtained their qualifications.

- It was evident that not all educators were teaching Natural Science or Biology. Only eight educators taught Natural Science, Biology, Physical Science or Mathematics in Grades 8 -12.

- The remaining seven educators taught one or more subjects including Zulu, Life Orientation, Language, Literacy and Communication, Human and Social Sciences and Geography in Grades 8 -12 or all learning areas at intermediate phase. The researcher expected the eight educators who are teaching Natural Science, Biology, Physical Science or Mathematics in Grades 8 -12 to perform better in the achievement test than those educators not teaching Science. However, it was cause for great concern that the student whose performance was ranked 15th in the pre-test, 13th in the post-test and 15th in the examination had a B.A Honours degree and taught Biology Grades 10-12.

It is possible that this student did not study Science in his/her qualification and therefore had insufficient subject matter/content knowledge in Science to answer the achievement test adequately. It is evident from this students' results that he/she possessed very limited subject matter/content knowledge in Biology, which would have impacted on his/her learners' performance in Biology.

Cochran and Jones (1998) highlight comparisons of how subject matter knowledge is cognitively organized between experienced and less experienced teachers. They suggest that even though novice teachers complete baccalaureate degrees, they still have "unorganized, superficial and partly inaccurate knowledge". This is evident in this research study with many of the teachers possessing diplomas and degrees, but still performing poorly in the scientific literacy test, but these are experienced teachers.

5.2.4 Tutors' and students' perceptions

Both tutors confirmed that theoretical and practical knowledge of students was very poor at the beginning of the semester. They also found that student's knowledge and understanding improved gradually during the semester. They confirmed that students performed better in multiple choice questions than in questions requiring an explanation.

They did not perceive that students had a problem with the learning material. The tutors also mentioned that student's performance in some of the questions did not improve in the post-test since those content topics were not discussed. Both tutors asserted that the scientific literacy of students improved by the end of the semester.

Students' Evaluation Questionnaire responses revealed that most students provided positive comments about the course and their tutors. It was the impression of all the students that their knowledge and understanding of certain science topics improved as a result of studying the Natural Sciences or Biological Sciences module. They did not mention any problems with the learning material. This danger of unfounded confidence was also evident in South African learners who participated in the TIMSS-R study (2001). South African learners, more than any other country, thought Mathematics and Science were not difficult, although scoring 25% on TIMSS. Also, more learners want to become engineers or doctors, despite very poor Mathematics and Science scores.

5.3 Strengths and Limitations of the Study

A major strength of this research study is its possible contribution to further research on scientific literacy and the relationship between teacher knowledge and student knowledge. It is hoped that more research on science teachers' content knowledge and pedagogical content knowledge will have a positive impact on students' knowledge and learning in science.

Another strength is that the researcher used the TIMSS-R achievement test as a question bank to compile the achievement test for the present research study. The TIMSS-R achievement test was drawn up by an international team of researchers and represented the only international test of scientific literacy at the time of this research study. The instrument used in this study assessed a range of knowledge and skills since it consisted of multiple choice questions, short response questions, a comprehension exercise on "plant breeding" and a readability exercise/cloze test.

The information obtained from the readability exercise/cloze test would be very useful to material developers in order to adjust the language, use relevant examples and improve interactivity of the study materials. The results and findings could also be taken into consideration when planning the curriculum, content and skills to be taught, mode of delivery, learning material and type of assessment for future modules in this Programme. Therefore, the effectiveness and efficiency of this Programme can be improved.

This research study included analysis of both quantitative and qualitative data, to provide a more comprehensive, overall picture of the research hypotheses.

The major limitation of this research study was the small sample size. However, the researcher must once again acknowledge that this was beyond her control, as students registered late, dropped the course or wrote incorrect student numbers. The small sample size makes generalization to all South African science teachers invalid.

The small sample size also impacted on the statistical significance of the difference between the pre-test, post-test and the examination. According to the Wilcoxon's matched-pairs, signed-ranked test, the difference between pre-test and post-test scores was not statistically significant. Since eleven students improved their performance in the post-test, the modules must have had a positive impact on their scientific literacy. A comparison between this research study and Feltham and Downs (2002) study highlighted that the mixed-mode module did not result in statistically significant improvement in scientific literacy but the one-year full-time science programme did.

5.4 Recommendations for future research

Since the small sample size impacted on the significance of results, a similar research study needs to be repeated with a larger sample.

This study has highlighted a strong positive correlation between English language competence and performance in scientific literacy. This suggests that an obvious direction for future research is further investigation of the issue of the language of instruction and how to overcome it as a barrier to learning science concepts. It is also recommended that the course material and all assessment tools be translated into isiZulu, and then evaluate the impact of the module on scientific literacy. There is ongoing debate on the language of instruction in South Africa: does it make a difference to learning in Science?

The analysis of the results obtained in the multiple choice and short response questions highlighted misconceptions of students in specific topics or areas. Further research should be conducted to investigate the nature of teacher misconceptions in these specific topics or areas.

The report on Mathematics and Science teaching in South Africa in 1997 highlighted that 58% of science educators and 50% of mathematics educators had not specialized in Science or Mathematics in their teacher training. The report also revealed that 2 850 and 2 830 educators required re-training in Mathematics and Science respectively. (Mathematics and Science Teachers: Demand, Utilisation, Supply and Training in South Africa. Arnot *et al* 1997). There is an urgent need to conduct research investigating the number of mathematics and science educators that have been re-trained, the extent to which this re-training has met the targets set by the 1997 Edusource report and the impact that this re-training has had on the teaching and learning of Mathematics and Science.

Evaluation of the impact of mixed-mode programmes on the improvement of learner performance is also an area that can also be investigated further.

5.5 Conclusion

The researcher had two main purposes for conducting this research study: to examine the improvement in scientific literacy as a result of studying a basic Biology module and to assess the influence of English language competence on performance in the scientific literacy test.

The results reported in this research study revealed that although eleven students improved their performance in the scientific literacy test, this improvement was not statistically significant. However, the perceptions of both tutors from their semi-structured interviews and of students' gained from their evaluation questionnaire, was that students' knowledge and skills had improved as a result of studying the ACE Natural Science and Biological Science module.

The results also provide strong evidence that there are significant positive correlations between average language comprehension scores and performance in scientific literacy, as well as between average readability and performance in scientific literacy. This corresponds with Damonse's (1996) conclusion in which she stated: "The acquisition of knowledge is also hampered when pupils receive instruction in a language that is not their mother tongue". (p131)

Since the ACE Programme is concerned with professional upgrading and retraining of teachers, it is important to heed the advice of Borko and Putnam (1995: p58 cited in Anderson and Mitchener:1994)

"the central goal of professional development should be the elaboration and expansion of a teacher's knowledge base and that in reforming their educational practice, teachers must acquire a richer knowledge of subject matter, pedagogy and subject-specific pedagogy, and they must come to hold new beliefs in these domain"

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APPENDICES

APPENDIX 1

ADVANCED CERTIFICATE OF EDUCATION

Dear Student

The University of Natal is introducing an ACE retraining and upgrading Programme for science teachers this year. We would like to conduct research on the ACE Natural Science Programme and the materials developed for this course in order to find out how much student's understanding of science and language improves during the course. It is envisaged that the data collected will yield useful information that will assist us in the improvement and modification of the course content, materials developed and the delivery of such programmes offered by the School of Education in the future.

We appeal to all ACE Natural Science students to assist us in conducting this research. It would be greatly appreciated if you would complete a questionnaire and language exercise after registration .We will also be very grateful if you could also complete an evaluation form on the completion of the course in July.

It must be emphasised that your participation would remain anonymous and strictly confidential. We would like to reassure you that the results will only be used for research purposes and would not influence your assessment for this course.

Thank you for your time and participation.

Yours sincerely

Dr. Edith Dempster

Mrs Jackie Naidoo

APPENDIX 2

ESTIONNAIRE

UDENT NUMBER : __________

s test consists of 25 questions. Questions 1 to 20 are Multiple Choice questions requires you to circle the LETTER corresponding to the correct answer on the wer sheet provided. Questions 21 to 25 are short response questions and requires to write a short response on the answer sheet provided.

Sensory messages are taken to the brain by:

arteries and veins
arteries and hormones
nerves and hormones
muscles and veins

Seeds develop from which part of a plant ?

Flower
Leaf
Root
Stem

A small animal called the duckbilled platypus lives in Australia. Which characteristic of this animal shows that it is a mammal ?

It eats other animals.
It feeds its young milk.
It makes a nest and lays eggs.
It has webbed feet.

Humans interpret seeing , hearing , tasting and smelling in the :

brain
spinal cord
receptors
skin

Which of these is not a function of blood ?

Digesting food
Protecting against diseases
Carrying waste materials away from the cells
Carrying oxygen to different parts of the body

6. What are vitamins ?

A. Substances that break down food
B. Bacteria that people get when they eat some foods
C. Substances that people make from proteins
D. Substances that people need in small amounts in order for their bodies to function normally

7. What feature is shared by ALL insects?

A. External skeleton
B. Two pairs of wings
C. Jumping legs
D. Stinging mechanism

8. The BEST reason for including protein in a healthy diet is because it is the main source of :

A. energy for the body
B. fibre for digestion
C. raw materials for cell growth and repair
D. vitamins for fighting disease

9. What is the primary function of the large leaves found on seedlings growing in a forest ?

A. To provide shade for the root systems
B. To get rid of excess water that is entering the roots
C. To allow for leaf damage by insects
D. To gather as much light as possible for photosynthesis

10. Which one of the following characteristics is most likely to be found in mammals that are preyed on by other mammals for food ?

A. Eyes on the sides of the head
B. Teeth that are long and pointed
C. Claws on the feet
D. Ears that cannot move

11. When male jackals place their scent on trees , they most likely are doing this in order to :

A. attract female jackals
B. attract prey
C. mark their territory against other jackals
D. mark the location of food supplies

12. Which of the following organisms are used to convert milk to yogurt ?

A. Bacteria
B. Protozoa
C. Viruses
D. Algae

13. Tissues are found in living things. What is the definition of a tissue ?

A. A group of cells with similar structure and function.
B. A group of cells with different structure and function.
C. A group of organelles contained inside a cell.
D. A group of substances that make up the walls of a cell.

14. Which statement best explains why mammals are found in very cold regions of the world but lizards are not ?

A. Both mammals and lizards are cold-blooded , but mammals have fur to keep them warm.
B. Both mammals and lizards are warm-blooded, but lizards get too cold when they shed their skin.
C. Since mammals , but not lizards , are warm-blooded , their body temperature will adjust to match the external temperature.
D. Since mammals , but not lizards, are warm-blooded , they will maintain their body temperature using heat from metabolic processes.

15. Animals hibernate to survive cold weather and poor food supplies. Which of the following occurs in animals when they hibernate ?

A. Their blood stops circulating.
B. Their body temperature increases.
C. Their body fat remains constant.
D. Their rate of metabolism decreases.

16. The primary reason scientists repeat the measurements they take during experiments is so that they can :

A. check that the equipment is working
B. list all the results in a table
C. estimate experimental error
D. change the experimental conditions

17. Alexander Fleming noticed that bacteria growing on a plate of agar did not grow next to a mould that was growing on the same plate. He wrote in his laboratory report : " The mould may be producing a substance that kills bacteria." This statement is best described as :

A. an observation
B. a hypothesis
C. a generalisation
D. a conclusion

18. Two open bottles , one filled with vinegar and the other with olive oil, were left on a window sill in the Sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation ?

A. Vinegar evaporates faster than olive oil.
B. Olive oil evaporates faster than vinegar.
C. Both vinegar and olive oil evaporate.
D. Only liquids containing water evaporate.
E. Direct sunlight is needed for evaporation.

19. Some plants grow better if bone meal (ground -up bones) is spread around their roots. What does bone meal supply to plants that makes them grow better ?

A. Energy
B. Minerals
C. Vitamins
D. Carbon dioxide
E. Water

20. Immediately before and after running a 50 metre race , your pulse and breathing rates are taken. What changes would you expect to find ?

A. No change in pulse but a decrease in breathing rate.
B. An increase in pulse but no change in breathing rate.
C. An increase in pulse and breathing rate.
D. A decrease in pulse and breathing rate.
E. No change in either.

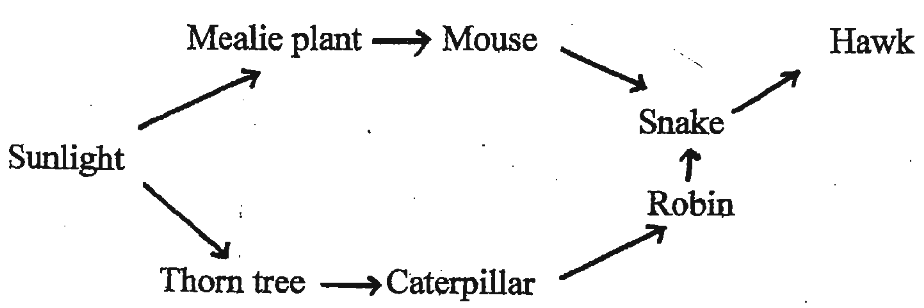
21. Suppose you want to investigate how long it takes for the heart rate to return to normal after exercising . What materials would you use and what procedures would you follow ?

22. What digestive substance is found in the stomach ? What does it do ?

23. A new species of fish was released into a lake. State two unwanted outcomes that could arise from the introduction of this new species.

24. Ethan hammered a nail into the trunk of a young tree. Explain why the nail was still at the same height from the ground twenty years later even though the tree had grown to a height of 22 metres.

25.



Look at the food web above. If the mealie crop failed one year what would most likely happen to the robin population ?. Explain your answer.

ANSWER SHEET

1.	A	B	C	D	
2.	A	B	C	D	
3.	A	B	C	D	
4.	A	B	C	D	
5.	A	B	C	D	
6.	A	B	C	D	
7.	A	B	C	D	
8.	A	B	C	D	
9.	A	B	C	D	
10.	A	B	C	D	
11.	A	B	C	D	
12.	A	B	C	D	
13.	A	B	C	D	
14.	A	B	C	D	
15.	A	B	C	D	
16.	A	B	C	D	
17.	A	B	C	D	
18.	A	B	C	D	E
19.	A	B	C	D	E
20.	A	B	C	D	E

21. ____

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22. ____

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23. ____

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4. ____________________

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5. ____________________

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B. Read the extract below and answer the questions that follow.

PLANT BREEDING

Plant breeding follows basically the same principles as animal breeding. Plant breeders follow several generations of inbreeding with a generation of outbreeding. However, the techniques of plant and animal breeding differ because the mechanism of fertilisation is so different in plants and animals.

Many plants can self - pollinate, that is, pollen can fertilize the eggs of the same flower, or of different flowers on the same plant. Some major agricultural plants are self- pollinators, eg. wheat, rice, barley, beans, peas and tomatoes.

Self- pollinating plants have been inbreeding for many generations, so they have less genetic variability than cross-pollinating plants. Plant breeders do not have to interfere in the process of pollination of self-pollinators, because they do the job of inbreeding themselves.

Cross-pollinating plants are more labour intensive for plant breeders. Examples of cross-pollinating plants are maize, carrots, date palms, asparagus, hops and cabbage. The plant breeder has to make sure that no stray pollen lands on the flowers.

The breeder carefully removes the stamens (pollen-bearing organs) from the flowers he has selected and gently brushes the pollen on to the receptive stigma of another selected flower. He then covers the flower with a bag to prevent any other pollen reaching the flower.

In plants like maize, where the male flowers form a tassle at the top of the plant and the female flowers (the cobs) are lower down, the breeder removes the tassles before they start producing pollen. Then he can ensure that only pollen from selected plants will fertilise the eggs.

1. Name two plants that are self-pollinators.

____

2. Name two plants that are cross-pollinators.

____

3. List two differences between self-pollinating and cross-pollination plants.

____

____

4. Name one difficulty faced by plant breeders in respect of cross-pollination.

5. How does self-pollination take place?

6. What is the advantage of self-pollinators to plant breeders?

7. Explain what is meant by plant breeding.

C. Read the passage below and write down the words that have been omitted in the blank spaces provided.

Many organisms feed by absorbing the body __________ of another organisms usually causing it harm. __________ that feed this way are called parasites, __________ the organism on which they feed is __________ the host.

Parasites can live on the ___________ of the host, like fleas, ticks, headlice ___________ bedbugs. All these organisms feed on the ___________. of their hosts. They have special hooks ___________ piercing mouth parts that enable them to cling __________ the hair and to break the skin ___________ their host. Other parasites live in the ___________ canal of their hosts. The parasites absorbs ___________ from the alimentary canal of the host. ___________ host loses food to the parasite, and ___________ even die. Intestinal parasites are very common ___________ children in parts of South Africa. Fortunately, ___________ are good remedies available to treat worms. ___________ untreated, children may become tired, listless and ___________ because the worms are absorbing too much ___________ the child's food. Cleanliness and good hygiene ___________ important in reducing worm infestation in children. ___________ should always defaecate in toilets, which should ___________ well away from drinking water. Children must ___________ their hands with soap and water each ___________ they use the toilet. Food should always __________ washed with clean water. Worms can be ___________ to people through domestic animals. Animals should ___________ kept away from toilets or areas where ___________ is prepared. Domestic animals that come into ___________ house should be dewormed regularly. Finally, worms ___________ be transmitted in meat.

THANK YOU FOR YOUR CO-OPERATION

APPENDIX 3

ANSWER SHEET

1.	A	B	**(C)**	D	
2.	**(A)**	B	C	D	
3.	A	**(B)**	C	D	
4.	**(A)**	B	C	D	
5.	**(A)**	B	C	D	
6.	A	B	C	**(D)**	
7.	**(A)**	B	C	D	
8.	A	B	**(C)**	D	
9.	A	B	C	**(D)**	
10.	**(A)**	B	C	D	
11.	A	B	**(C)**	D	
12.	**(A)**	B	C	D	
13.	**(A)**	B	C	D	
14.	A	B	C	**(D)**	
15.	A	B	C	**(D)**	
16.	A	B	**(C)**	D	
17.	A	**(B)**	C	D	
18.	A	B	**(C)**	D	E
19.	A	**(B)**	C	D	E
20.	A	B	**(C)**	D	E

21. Materials: Stop watch / timer

Procedure: Measure 'normal' pulse / heart rate at rest, Subject does an exercise / physical activity eg. riding an exercise bike, Time interval is measured from completion of exercise until pulse rate returns to 'normal'.

22. Enzymes, HCl / gastric juices - Enzymes in stomach dissolve food so it can be absorbed / HCl breaks down food / Gastric juices break the food into smaller pieces.

23. - Competition with native species eg. overpopulation, eating the limited food supply. - Introducing diseases (bacteria / parasite
- Predation - new species killing off existing species - virus
- Cannot survive in the lake - extinction due to inhospitable habitat. - Upsetting food web / ecological balance.
- Mating with existing species.

24. Trees increase in height as a result of growth at the tips of stems / branches (apical meristem) and trunk growth only results in increased diameter. Trees grow from the top of the branches → increased height was because the top of the tree grew – Trunks will expand / grow in width.

25. Robin population may decrease – predators like snake/hawks eating more robins if mice die – mice starve because meadow crops failed.
Robin population may increase – predators like snakes/hawks dying due to lack of food (mice).

Robin population could stay the same – if the mouse found other grain to eat, so the snake would be unaffected.

B. Read the extract below and answer the questions that follow.

PLANT BREEDING

Plant breeding follows basically the same principles as animal breeding. Plant breeders follow several generations of inbreeding with a generation of outbreeding. However, the techniques of plant and animal breeding differ because the mechanism of fertilisation is so different in plants and animals.

Many plants can self - pollinate, that is, pollen can fertilize the eggs of the same flower, or of different flowers on the same plant. Some major agricultural plants are self- pollinators, eg. wheat, rice, barley, beans, peas and tomatoes.

Self- pollinating plants have been inbreeding for many generations, so they have less genetic variability than cross-pollinating plants. Plant breeders do not have to interfere in the process of pollination of self-pollinators, because they do the job of inbreeding themselves.

Cross-pollinating plants are more labour intensive for plant breeders. Examples of cross-pollinating plants are maize, carrots, date palms, asparagus, hops and cabbage. The plant breeder has to make sure that no stray pollen lands on the flowers.

The breeder carefully removes the stamens (pollen-bearing organs) from the flowers he has selected and gently brushes the pollen on to the receptive stigma of another selected flower. He then covers the flower with a bag to prevent any other pollen reaching the flower.

In plants like maize, where the male flowers form a tassle at the top of the plant and the female flowers (the cobs) are lower down, the breeder removes the tassles before they start producing pollen. Then he can ensure that only pollen from selected plants will fertilise the eggs.

1. Name two plants that are self-pollinators.

wheat, rice, barley, beans, peas, tomatoes Any 2

2. Name two plants that are cross-pollinators.

Maize, carrots, date palms, asparagus, hops, cabbage. Any 2

3. List two differences between self-pollinating and cross-pollination plants.

Self-Pollinating Plants: less genetic variability,

do the job of inbreeding themselves, 2X2 4

Cross-pollinating plants: more genetic variability, more labour intensive for plant breeders,

4. Name one difficulty faced by plant breeders in respect of cross-pollination.

The plant breeder has to ensure that no stray pollen lands on the flowers. covers flowers with bags to prevent any other pollen reaching flower. 2

5. How does self-pollination take place?

Pollen grains from same flower/plant lands on the stigma of same flower/plant and fertilisation takes place. 3

6. What is the advantage of self-pollinators to plant breeders?

Plant breeders do not have to interfere in the process of self-pollination, because they do the job of inbreeding themselves. Controls genetic variability 3

7. Explain what is meant by plant breeding.

Plant breeding is the process of producing genetically distinct lines of plants that are suitable for particular conditions. 3

C. Read the passage below and write down the words that have been omitted in the blank spaces provided.

Many organisms feed by absorbing the body fluids of another organisms usually causing it harm. Organisms that feed this way are called parasites, and the organism on which they feed is called the host.

Parasites can live on the surface of the host, like fleas, ticks, headlice and bedbugs. All these organisms feed on the blood. of their hosts. They have special hooks and piercing mouth parts that enable them to cling to the hair and to break the skin of their host. Other parasites live in the alimentary canal of their hosts. The parasites absorbs food from the alimentary canal of the host. The host loses food to the parasite, and may even die. Intestinal parasites are very common in children in parts of South Africa. Fortunately, there are good remedies available to treat worms. If untreated, children may become tired, listless and thin because the worms are absorbing too much of the child's food. Cleanliness and good hygiene are important in reducing worm infestation in children. Children should always defaecate in toilets, which should be well away from drinking water. Children must wash their hands with soap and water each time they use the toilet. Food should always be washed with clean water. Worms can be transmitted to people through domestic animals. Animals should be kept away from toilets or areas where food is prepared. Domestic animals that come into the house should be dewormed regularly. Finally, worms can be transmitted in meat.

30

THANK YOU FOR YOUR CO-OPERATION

APPENDIX 4

Natural Science 610: Life and Living
Course Evaluation

Co-ordinator and tutor: Hallam F.P. Payne

Please comment as fully as possible on the following:

1. The clarity with which Mr. Payne outlined and explained the objectives of the module.

____
____
____

2. The thoroughness of Mr. Payne's knowledge of Life and Living.

____
____
____

3. The extent to which Mr. Payne stimulated your interest in Life and Living.

____
____
____

4. The extent to which Mr. Payne's relationship with the class facilitated the development of a productive learning environment.

____
____
____

5. Mr. Payne's preparedness for class.

____
____
____

6. Mr. Payne's accessibility outside coursework sessions.

____
____
____

7. The degree to which Mr. Payne encouraged your participation in class.

____
____
____

P.T.O

8. The appropriateness of the level of Mr. Payne's input on issues.

9. The effectiveness of the examples that Mr. Payne used.

10. The extent to which you could say that this module taught you how to teach Life and Living concepts and information.

11. The structure of the module.

12. The extent to which you would say that your assessment in this module helped to develop your skills.

13. Strengths of this module.

14. Aspects of the module that you would like to see changed, and how you would like these changes to be made.

P.T.O

15. Comment on this module's achievement of the following intended outcomes or objectives:

a. That by now you are able to analyse situations in Life and Living and apply the skills you have learned.

b. That by now you are able to organise your pupils to do basic research in Life and Living.

c. That by now you are able to compare theories, approaches and techniques of studying Life and Living.

d. That you are able to apply Life and Living skills to practical situations.

16. Any other issue.

APPENDIX 5

MODULE EVALUATION QUESTIONNAIRE FOR BIOLOGICAL SCIENCE 610, (SECOND SEMESTER), 2002

In this questionnaire you will be asked your opinion on various aspects of Biological Science 610 for purposes of evaluation. You do not need to sign your name.

In each question you are presented with a statement to which you should respond on the computerised answer sheet. Your possible answers are:
A = strongly disagree B = disagree C = neutral response D = agree E = strongly agree
Fill in your answer on the right hand side of the answer sheet, under answers 1 - 40. **Please use an HB pencil only.**

Thank you for your co-operation.

General

1. I understood from the module outlines what was expected of me this semester.
2. I think that this module was well organised.
3. It was made clear to me how different parts of the module fitted together.
4. I found that I could use things that I learned in this module in my other modules.
5. I feel enthusiastic about studying Biological Science 610.
6. I think in general that I have been given sufficient guidance in order to help me cope with this module.
7. This module encouraged me to work independently.
8. As a result of studying Biological Science 610, I have learned to think in new ways.
9. At the end of this semester, I believe that I have developed intellectually beyond the point I was at when I started the module.
10. I found the workload for Biological Science 610 was greater than for my other modules.
11. I would recommend this module to other students.

Tutorials run or taught by Mrs. Isabel Matten

12. The tutor encouraged me to think that I had something to contribute to the discussion in tutorials.
13. I felt comfortable enough to participate in tutorials.
14. I found that it was useful to discuss wider issues in tutorials than only the module material.
15. I found that we covered relevant areas in tutorials.
16. I found that it was useful to bring problems that I had in lectures to a tutorial.
17. I found that it was useful to work through the problems before the tutorials.
18. I found that the feedback on the tutorial work was useful.
19. I found that my tutorial group was well run.
20. I found that my tutor was well prepared for the tutorials.
21. I found that Mrs. Matten's relationship with the class facilitated the development of a positive learning environment.
22. I found that the tutor inspired enthusiasm for this module.

:3. I found that the tutor was approachable.
:4. I felt sure that the tutor would have been willing to help me solve difficulties in studying this module if I had gone to see her.
:5. I attended (almost) all the tutorials in this module.

\ny comments on Mrs. Matten's tutorials or teaching?
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\ssessment

:6. I think that there is a meaningful link between what we learn in Biological Science 610 and how we are assessed.
:7. As a result of writing the first assignment I feel more confident about the second assignment.
.8. I submitted (almost) all my assignments on time.
.9. I learned from the mistakes that I made in the assignments.
0. I found that feedback on the assignments was timeous.
1. I found that the feedback on the assignments was useful.
2. I understood why I got the marks that I did for the assignments.
3. I think that the way my progress is assessed gives a fair reflection of my understanding and ability.

Iodule Materials and Skills

4. I found that the prescribed readings for the module were understandable.
5. I found that the reading material was beneficial in helping to understand the module.
6. I found that the readings were usually of a manageable length.
7. I read (almost) all the recommended readings for this module.
3. I found that I developed my ability to solve real problems in this field.
). I think that I have gained a clear understanding of the concepts and principles of this subject.

itended learning outcomes

). I am now in a position to provide a clear rendering of a number of (selected) perspectives on biological science in which appropriate data collection methods and techniques, as well as data analysis techniques are included.

hat do you perceive are the strengths of this module?
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If you could ıke changes to this module, what would they be?
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Please, comment on the usefulness of Winter School

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