ON MAKING SENSE OF SCIENCE DISCOURSE: THE ROLE OF THE FOUNDATION PROGRAMME IN A SOUTH AFRICAN UNIVERSITY

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Mrs V Padayachee
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Dear Mrs Padayachee

PROTOCOL: On making Sense of Science Discourse: The Role of the Foundation Programme in a South African University
ETHICAL APPROVAL NUMBER: HSS/0890/2009 M: Faculty of Education

In response to your application dated 20 November 2009, Student Number: **200302448** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL.**

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Professor Steve Collings (Chair)
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE

SC/sn

cc: Dr E Mgqwashu (Supervisor)
cc: Mrs R Govender

DECLARATION

This study represents original work by the author and has not been submitted in any form to another university. Where use has been made of the work of others, this has been duly acknowledged in the text.

……………………...............
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ABSTRACT

The BSc4 (Foundation) programme offered at the University of KwaZulu-Natal (UKZN) caters for students from disadvantaged educational backgrounds, with lower matriculation points, offering them the opportunity to pursue studies in science. The students in the BSc4 (Foundation) programme are registered for foundation modules in science, viz. biology, chemistry, mathematics and physics as well as an academic literacy course. It is in the context of these foundation modules in science within the BSc4 (Foundation) programme that this study is undertaken. This study explores the discipline-specific literacies that the BSc4 (Foundation) students require in order to learn science and to acquire science discourse. The study uses case study as a research design, the interpretive research paradigm and the qualitative research approach to analyse data obtained from multiple research instruments. Research findings reveal that with the change in student profile, module changes within the BSc4 (Foundation) programme were implemented. In light of these, the study explores factors such as the 'articulation gap' between school and university; and disadvantaged educational experiences. The findings also suggest that students experience challenges with the use of the language of science and the use of discipline-specific literacies in science in the modules offered in the BSc4 (Foundation) programme. However, there exists the scope for stronger engagement between the academics who teach the foundation modules in science and the academic literacy specialists to assist students in the acquisition of the discipline-specific literacies required to learn science and for science discourse.

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LIST OF ACRONYMS USED IN THIS STUDY

ACE - Advanced Certificate in Education
AD - Academic Development
ADEA - Association for the Development of Education in Africa
ADPs - Academic Development Programmes
AL - Academic Literacy
ALS - Academic Literacy Specialist
ALSs - Academic Literacy Specialists
ASP - Academic Support Programme
ASPs - Academic Support Programmes
ASSA*f* - Academy of Science of South Africa Forum
BICS - Basic Interpersonal Communication Skills
BSc - Bachelor of Science
CALP - Cognitive Academic Language Proficiency
CHE - Council on Higher Education
CSA - Centre for Science Access
DET - Department of Education and Training
DoE - Department of Education
DS - Disciplinary Specialist
DSs - Disciplinary Specialists
DUT - Durban University of Technology
EAL - English as an Additional Language
EAP - English for Academic Purposes
EFAL - English First Additional Language
ESL - English as a Second Language
FHU - Fort Hare University
FP - Foundation Programme
GM - Grammatical Metaphor
HAIs - Historically Advantaged Universities
HBUs - Historically Black Universities
HE - Higher Education
HEIs - Higher Education Institutions
HESA - Higher Education South Africa
HOA - House of Assembly
HOD - House of Delegates

HOR - House of Representatives

HWIs - Historically White Institutions

HWUs - Historically White Universities

IEASA - International Education Association of South Africa

JMB - Joint Matriculation Board

LoLT - Language of Learning and Teaching

MCQ - Multiple Choice Question

MCQs - Multiple-Choice Questions

MUT - Mangosuthu University of Technology

NBTP - National Benchmark Test Project

NBTs - National Benchmark Tests

NCHE - National Commission for Higher Education

NLS - New Literacy Studies

NP - Nationalist Party

NPHE - National Plan for Higher Education

NQF - National Qualifications Framework

NSC - National Senior Certificate

NSE - Norms and Standards for Educators

QL – Quantitative Literacy

RPs - Research Participants

RP - Research Participant

SAAAD - South African Association for Academic Development

SATAP - the Standardised Assessment Test for Access and Placement

SCOM - Communication in Science

SF – Systemic Functional

SFL - Systemic Functional Linguistics

SFP - Science Foundation Programme

STEM - Science, Technology, Engineering and Mathematics

SWR – Scientific Writing and Reporting

TESOL - Teaching English to Speakers of Other Languages

TIMSS - Third International Mathematics and Science Study

TIMSS-R - Third International Mathematics and Science Study Repeat

UCT - University of Cape Town

UDW - University of Durban-Westville

UFS - University of Free State

UKZN - University of KwaZulu-Natal

UN - University of Natal

UNIN - University of the North

Unisa - University of South Africa

UniZulu - University of Zululand

UWC - University of the Western Cape

WC - Writing Centre

Wits - University of Witwatersrand

ZPD - Zone of Proximal Development

CHAPTER 1

BACKGROUND AND RATIONALE FOR STUDY

Introduction

> The term "transition" refers to changes in the political, social, economic, cultural and educational structures of a society ... In higher education the term "transition" is often employed to refer to a major structural conversion of a national system of higher education that generally takes place over an extended period of time, e.g. the transition from elite to mass higher education. Transition in a higher education system in most cases gives rise to the transformation of higher education institutions. This implies profound and dramatic changes in institutions, sometimes occurring as a result of turbulence inside institutions or, more frequently, resulting from changes in their external environment. Transformation is usually a process by which the form, shape and/or nature of institutions are completely altered ... Transformation of higher education institutions is therefore not only about changes in the composition of staff and students, or changes in governance structures or course content. Essentially, it is about the transformation of the organisational culture and the development and acceptance of new shared values. This can only be achieved through fundamental changes in the mindset ("cognitive transcendence") of all stakeholders and role-players amongst which academic staff requires particular attention (Fourie, 1999: 276).

The year 1994 heralded transformation in South Africa from minority rule to a democratically elected government. Accordingly, higher education needed to respond to the transformation agenda as well. This involved giving focussed attention to equity and redress in higher education, both of which are fundamental for effective higher education systems. As part of the process, the National Commission for Higher Education (NCHE) (1996), appointed by the democratic government of South Africa, was tasked with proposing policies for the transformation of Higher Education (HE). The NCHE (1996) envisaged that in order for a higher education system to embrace transformation, it should ensure "increased participation by all sectors of society; by greater institutional responsiveness to policy imperatives, and by a new set of co-operative relations and partnerships between higher education and society" (1).

The relevance of transformation is highlighted in The Green Paper on Higher Education Transformation (1996)[1] which endorsed the principles of the NCHE, and which asserts that:

[1] The Green Paper signals the policy intentions of the Department of Education (DoE) in regard to the reconstruction and development of Higher Education (HE) in South Africa.

> A major mechanism to attain equity in the higher education system is redress, which constitutes one of the most significant components of the transformation agenda. The inherited system of higher education is characterised by injustices, inequalities and imbalances, and opportunities and privileges are currently skewed as a result of racial and gender-based policies, structures and practices. Applying the principle of equity implies, on the one hand, a critical identification of existing inequalities, and on the other a programme of transformation with a view to redress. Such transformation includes not only abolishing all existing forms of unjust differentiation, but also measures of empowerment to bring about equal opportunity for individuals and institutions (Green Paper on Higher Education Transformation, 1996: 7).

In the above quote, equity is suggestive of fairness and equal opportunity. Bitzer (2010: 301) offers a comprehensive explanation of the concept of 'equity' which includes the following:

- Individuals who have the ability to attend university should be able to do so;
- Barriers to access a university should be at the minimum;
- Selection for university places should be on merit;
- Selection for university places should be without discrimination on the basis of variables such as social class, gender, religion or ethnicity; and,
- Individuals should have a fair opportunity to develop their talents.

Definitions of 'redress' range from "rectifying a wrong" to "reparation" to "restoring equality" to "empowerment" (Barnes: 2005: 210). Nkomo *et al.* (2007), furthermore, define 'redress' as "the need to ensure that some practical measures are instituted so that the inequalities resulting from the country's apartheid[2] past are corrected" (411). The Green Paper on Higher Education Transformation (1996) clearly outlines the role of higher education in South Africa. In its introductory comments, the former Minister of Education, Prof. S. M. E. Bengu (1996), stated that 'redress' must operate partly in terms of access:

> The system of higher education must be both expanded and transformed, within the reality of limited resources. In order for such expansion and transformation to be effective, and to deliver the required results, redress is a further imperative. Redress must operate partly in terms of access: it must ensure that no-one with the capacities to succeed in higher education is barred from doing so. And redress must also operate at the institutional level, in ensuring that inherited inequities and disparities are identified and addressed. The Department of Education is committed to a planned and targeted process of redress in the next few years, in order to ensure that in the longer term all

[2] Apartheid was derived from the Afrikaans word meaning 'apartness'. It was a system of racial segregation enforced as law in South Africa in 1948 by the former ruling party, the Nationalist Party (NP). The racial segregation involved political, legal, educational and economic discrimination against non-whites. Apartheid recognised four races: Black, Coloured, White and Asian. Through the policies of apartheid, the rights of the majority of non-whites were restricted while white supremacy and Afrikaner minority rule was maintained.

> students and institutions can contribute as fully as possible and on equal terms (Green Paper on Higher Education Transformation, 1996: 4).

Thus, the birth of democracy in South African politics meant that higher education transformation should allow for the "increased participation by a more diverse constituency of learners" (NCHE, 1996). In other words, university education is expected to be accessible to all South African students who qualify for admission, as determined by the criteria for entry. This is further encapsulated in a document[3] for the Association for the Development of Education in Africa (ADEA) and South African National Department of Education (DoE) prepared by Griesel (1999) which states that "in order to achieve the policy goals of redress and equity on the one hand, and of development on the other, access must entail dimensions of quality and capacity building" (3).

As outlined thus far, transformation at Higher Education Institutions (HEIs) in South Africa meant that the doors of learning in the Historically White Universities (HWUs)[4] had to be opened to the previously marginalised sector of the country, the black students. According to Mabokela (2000), the increased presence of black students at HWUs introduced a number of issues that these universities never had to contend with: student racial diversity, variations in students' academic preparation, increased need for financial assistance, institutional culture and curricular modifications.

All these new challenges emerged as a result of the entrance into university of victims of apartheid, the majority of whom were black students who were products of an inferior primary and secondary schooling system. It is not only the educational background that sets these students apart from the HEIs that they are entering, but also their different culture and language. Such students are often viewed within the HEIs as being 'disadvantaged' and

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[3] "The document is 'Access and Higher Education Sector: A South African case study on policy and programme achievement'. The study recognises the centrality of access in South Africa's recent higher education history, and locates its analysis of achievement within the context of sweeping socio-political change – late 1980s to the present" (Griesel, 1999: 3).

[4] The apartheid government was responsible for creating tertiary institutions of differentiation for whites and blacks. "The NP passed the Universities Amendment Act of 1959 that prohibited the admission of Blacks to Historically White Universities (HWUs)" (Mabokela, 1997: 423). During apartheid, the HWUs continued to service educational needs of white South Africans through two distinct sub-groupings. The first of these were universities whose primary medium of communication and instruction was in Afrikaans. These were the University of Orange Free State, Potchefstroom University, University of Pretoria, University of Stellenbosch, and Rand Afrikaans University. The second grouping offered communication and instruction using English and these universities were University of Natal, Rhodes University, University of Cape Town and University of Witwatersrand.

‘underprepared’ for university studies, resulting in their struggle to succeed academically. In actual fact, the education meted out to such students has rendered them ‘educationally disadvantaged’.

Novick (1978 cited in Zaaiman, 1998) defines ‘educational disadvantage’ as “the net effect of those characteristics of a student’s environment that provide less than normal exposure to factors that motivate and facilitate educational growth” (23). A disadvantaged student who thus enters a tertiary institution would have been exposed to a schooling system characterised by inadequate access to educational resources and services which had compromised his/her educational potential. He/she is thus underprepared for university studies. In the context of South Africa, the term ‘disadvantage’ is associated with the inferior education meted out to black children who attended the former Department of Education and Training (DET)[5] schools, a form of educational segregation dictated by apartheid. Eiselen and Geyser (2003 in de Klerk *et al.* 2006: 3) define the ‘underprepared’ student as being insufficiently prepared to:

- gain access to a university (based on school results);
- register for certain modules/subjects (because of lack of foreknowledge);
- be retained successfully in a degree programme until graduating (because of certain personal qualities and/or lack of abilities);
- play a meaningful role in society (not being fully equipped after graduating due to lack of appropriate knowledge, skills and attitudes); and/or,
- study successfully as a result of the nature of the higher educational institution (students’ negative experience due to university structures/policies).

The issue of using the concept of ‘disadvantage’ loosely has been criticized by researchers and educationists. Ndebele, the former vice chancellor of UNIN (University of the North, recently renamed the University of Limpopo) warns against using the word ‘disadvantage’,

[5] The organizational structures of the education system under apartheid reflected Nationalist theory that South Africa’s four ethnic groups should live and develop independently of each other. Thus separate education systems were established for each racial group. Further administrative changes followed in 1984, when the Tricameral Parliament was created to give Coloureds and Indians – but not Africans – a limited political voice. Each of the three chambers was empowered to run its own schools through its own department of education. Thus, in the final years of apartheid, white students attended schools under the control of the House of Assembly (HOA); Coloured students were in schools run by the House of Representatives (HOR); and Indian students attended those run by the House of Delegates (HOD). Education for Africans living in townships remained under the control of the Department of Education and Training (DET). Four additional departments of education ran schools in the “independent” homelands of Bophuthatswana, Ciskei, Transkei, and Venda, and separate departments were set up in the six “self-governing” territories that had resisted designation as independent states. A national department with no operating authority brought the total number of separate education departments to fifteen (Fiske and Ladd, 2004: 43).
“The former DET schools are still influenced by the problems experienced during apartheid” (Kapp, 2004: 246).

simply to classify a large group of people as being underprepared without taking into account the reasons for and implications of such disadvantage (Ndebele, 1995). Morrow (1994), furthermore, warns against a well-meaning but paternalistic sympathy entrenched in policies of affirmative action[6] and in the use of the words ‘deprived and disadvantaged’. Initially, black students who were unprepared for tertiary studies were tagged as being deficient. Other descriptions used for them were ‘handicapped’ or ‘developmentally deficient’ (Hofmeyr and Spence, 1989). These references were later changed to ‘disadvantaged’ or ‘underprepared’. Zaaiman (1998) even argues that it is inaccurate to equate blackness with being disadvantaged because it automatically suggests the need for remedial education.

What makes this view problematic is that being prepared to undertake tertiary studies does not, or need not necessarily be equated to race, especially where black is historically perceived as being equivalent to lack. MacKenzie (1993) describes the state of schools available to black learners during apartheid as “deficient”, with “limitations in curricular provision, resource allocation, pedagogical methodologies, and administrative purposes” (409). This implies that black students are not inherently weak or incapable of achieving success at tertiary institutions, but are victims of inferior schooling. “Many able black students fail to meet university requirements, not because they lack intellectual ability but because the school culture they have endured has failed to provide them with the academic tools necessary for academic success” (MacKenzie, 1993: 410).

Even after the introduction of democracy in South Africa, many black students are still exposed to disadvantaged schooling. They enter desegregated tertiary institutions in the country and are viewed as being deficient. They are tagged with one of the following deficiencies – educational, cultural, cognitive, linguistic, social or familial deficiencies. They are characterised as lacking the academic, cultural and moral resources to succeed in the higher education environment and are in need of academic support for success,

[6] Affirmative action, according to Moore (2005), seeks to “take proactive steps to reduce or address the impacts of discrimination with the ultimate goal of eliminating differences between genders, race and ethnicities, underrepresented and dominant groups” (80). Sikhosana (1993) highlights other definitions of affirmative action: “an active process that attempts to reduce (or more optimistically eliminate) the effects of discrimination, namely disadvantage”, and “preference, by way of special measures, for certain groups or members of such groups (typically defined by race, ethnic identity, or sex) for the purpose of securing adequate advancement of such groups or their individual members in order to ensure equal enjoyment of human rights and fundamental freedoms” (3-4).

retention, progression and to become part of the dominant university culture. One of the concepts used to discuss this issue of deficiency, and one which is often viewed from a racial point, is the model of deficit thinking based on the Deficit Theory. The Deficit Theory, perspective or model blames the victims of institutional oppression for their victimization by referring to negative stereotypes and assumptions regarding certain groups or communities (Irizarry, 2003).

This Deficit Theory has its roots in Cultural Deficit Theory which originated in the 1960s by Cultural Deficit theorists. Theorists such as Hess and Shipman (1965), for example, stated that most cultural deficit studies blamed the child's social, cultural and/or economic environment as being ‘depraved and deprived’ of the elements necessary to ‘achieve the behaviour rules (role requirements)’ needed to succeed academically. According to Tharp (1989), the Cultural Deficit Theory postulated that since the African American students’ educational backgrounds lacked cultural knowledge and competence that schools needed to build upon, teachers needed to change these students’ educational, behavioural and linguistic competencies to meet European American middle class expectations. Powell (1998) explains that the Deficit Theory emerged in the 1960s as an attempt to explain why disadvantaged students tended to experience high rates of failure in school. The theory suggests that as a result of students’ economic disadvantage, they lack verbal stimulation at home and thus enter the schooling system with minimal linguistics skills required for educational success.

Deficit Theory has been challenged from many angles by different researchers. The claim of Deficit Theory that children from disadvantaged populations are regarded as being intellectually disadvantaged as a result of their supposed inferior linguistic development has been dispelled by a number of researchers. Labov (1969 in Giglioli, 1985) debunks the notion suggested by proponents of Deficit Theory that children who come from lower socio-economic backgrounds “cannot speak in complete sentences and cannot form concepts or convey logical thoughts” (179) and he regards this view as problematic because “it diverts the attention from real defects of an educational system to imaginary defects of the child” (179). Furthermore, contrary to the Deficit Theory, research in the early 1970s indicated that children from lower class cultures were highly competent in their own vernacular in situations where they were able to maintain some degree of control (Labov, 1969). The relevance of this debate to this study is that black students who enrol to study at

HWUs in South Africa, where institutional instruction is through the medium of English, the dominant language of the global world, are forced to speak, read and write in a language (generally, English) that is not only foreign to them, but which may be their additional language. Ironically, the majority of the black students who were assumed to have inferior linguistic development are able to speak as many as three African indigenous languages, of which only one is their mother tongue. In some cases they succeeded in engaging with complex subject matter in an additional language used as the Language of Learning and Teaching (LoLT).

1.1 On Students' Underpreparedness for Higher Education (HE) Studies

The issue of black students' underpreparedness for higher education studies is often understood as a problem within the students themselves. Apart from the language issue that is associated with students' underpreparedness to cope at university causing them to fail, students' internal shortcomings or external weaknesses are also blamed. According to Valencia (1997), the internal shortcomings may be cognitive or emotional, while external weaknesses are either cultural or familial. Valencia (1997) is at odds with a perception that problematizes the students rather than the institutional system by stating that:

> The dominant discourse in higher education attempts to understand student difficulty by framing students and their families of origin as lacking the academic, cultural and moral resources necessary to succeed in what is presumed to be a fair and open society, and needing support from the dominant society or culture. It effectively blames the victim for lacking certain desirable characteristics that would promote academic success. Various terms are used in the educational literature to refer to this kind of approach: models of deficit thinking, cultural deprivation or inadequate socialization, and even the more recent construct of the 'at risk student'. They all have in common a focus on the inadequacies of the student, and 'fixing' this problem. In the process the impact of structural issues are often ignored or minimised. When applied to education policies it has been argued that deficit thinking amounts to a neo-liberal commitment to help those who cannot help themselves (Valencia, 1997 cited in Smit, 2010: 1).

One of the major criticisms put forth by Smit (2010) regarding Deficit Theory is that "it strengthens stereotypes in the minds and thought of educators, policy makers and students themselves. In essence, deficit thinking allows generalisations about student ability to be made, and supports a laziness to grapple with the complex issues around student difficulties. In the process, people who are already disenfranchised, are labelled and further stigmatised" (3). Swanson (2002) explains that it is Deficit thinking that gives rise to the concept of differences between students within the learning context. These points can be linked to that made by Labov (1969 in Giglioli, 1985) when he states that “in attempting to account for the poor performance of children attending ghetto schools, educational psychologists attempted to discover the kind of defect or disadvantage they are suffering from, and which is used as a basis for large scale intervention programmes” (179).

The Deficit labelling of students can create a sense of negativity, disillusionment and alienation. This is especially so when students from disadvantaged backgrounds have survived their inadequate schooling and have been able to enter the university territory, only to be viewed as deficient students who are not only separated from mainstream, but are forced to play catch-up with students from advantaged backgrounds (Tema, 1988).

There have been other counter arguments to the view of students being deficient. One such view on student underpreparedness is presented by Mphahlele (1994). He argues that disadvantaged students are in fact over-prepared in a study mode that is unsuitable for higher education. Thus, rather than laying blame on these students, the university should attempt to socialize them into the new higher education culture and help them to unlearn learning strategies that had been effective at school level . He also disagrees with labelling them as ‘deficient’. Having been the higher achievers at their schools, they were used to success, even if it was in a less than challenging learning environment. This view can be likened to that of Tema (1988), who sees such students in a positive light. He perceives them as survivors who have not only survived, but have beaten the system of an inferior schooling system. Although all students who enrol at tertiary institutions are expected to make intellectual, social, academic and emotional adjustments to university life, the perception exists that it is black students from disadvantaged backgrounds who experience difficulties adjusting to higher education studies and require more assistance than other students.

1.2 Addressing Student Underpreparedness

1.2.1 ‘Proposed’ Foundation Year for White Students in HWUs: The Early Apartheid Period

The issue of student underpreparedness for tertiary education and underpreparedness of black students, in particular, has not only surfaced since South Africa had achieved its democracy. On the contrary, the issue of the under-performance of first year students entering South African universities has been raised even during the period of apartheid in South Africa. There has been research conducted as early as the 1930s through to the 1970s in South Africa which indicates that the issues of first year students being underprepared for tertiary studies, low throughput and high attrition rates were also of concern for white students at Historically Advantaged Universities (HAIs)[7] in South Africa. This point is necessary for this study as it indicates that the issue of underpreparedness for higher education should not be only judged along racial lines.

According to Malherbe (1977), the first comprehensive investigation into the validity of matriculation[8] as a predictor of success or failure at university was conducted as early as 1936 by the National Bureau for Education and Social Research. This investigation took the form of a survey into how approximately 8 000 matriculants entering all South African universities had fared over a period of six years. The main finding of the study was that almost 47% of all first year students failed in at least one subject and 25% failed in more than one subject. The investigation which was prompted by the then Minister of Education, the Hon. Mr J. H. Hofmeyr, was initially intended to examine the alleged youthfulness of university students as the main cause of excessive failures in the first year but went beyond the initial purpose to probing deeply into the problem of the transition from school to university. Although the study did indicate correlation between matriculation results, school records and subsequent careers at university, the study proved no positive correlation whatsoever between entrance age of students and their failure in the first year of study. It did, however, show that the younger students performed better than the older ones.

In the 1950s the Transvaal Education Department in South Africa conducted investigations which corroborated the earlier findings of the National Bureau for Education and Social Research. The research by the Transvaal Education Department showed the performance of matriculants with the same matriculation aggregates at different universities. The research by the Transvaal Education Department drew attention to the fact that the highest

[7] The HWUs were also referred to as Historically Advantaged Universities (HAUs). Such institutions were described as being advantaged in respect of resources, financial assistance, funding, staffing and research.

[8] In South Africa, *matriculation* (usually shortened to *matric*) is a term commonly used to refer to the final year (Grade 12) of high school.

percentage of failures generally occurred in the biological sciences and in the exact sciences with the lowest percentage of failures being in the arts and social science faculties. The percentages indicating failings in the different fields of study were as follows: In the applied biological sciences required for entry into medical, agricultural and veterinary courses: 42%; Architecture and Quantity Surveying: 40%; Engineering and B.Sc.: 33%; Commerce and Business Administration: 22%; and Arts B.A.: 15% (Malherbe, 1977).

Stemming from the research into the link between matriculation and first-year university performance, the then Joint Matriculation Board (JMB), commissioned a statistical study of the transition from school to university. The research study was in 1963 delegated to Prof. H.S. Steyn of the University of South Africa (Unisa). The study was based on data of full-time first year students registered in 1954 to 1957 at the eight residential universities in South Africa. One of the conclusions of the study was the huge difference of success rate between, for example, students studying B.A and B.Sc., where the percentage of students eventually obtaining an Arts degree was 63% as opposed to the faculties of Science and Engineering, each of which was 48%. A further example of the difficulties experienced by white students in adjusting to higher education studies showed that only 55% of students admitted into the eight South African residential universities succeeded in obtaining a first degree however long they tried (Malherbe, 1977: 481).

The Steyn Report which was referred to the then National Advisory Education Council, recommended against more stringent admission criteria as the implication was that by raising the standards, "potentially good white university material might be excluded from a university training and that [might thereby limit] the much-needed trained manpower in the country" (Malherbe, 1977: 495). The recommendations to solve the problem of white attrition and contain the "staggering figures of first-year failures" in the universities included the call to improve school guidance and student counselling; a suggestion for a post-matriculation year in high schools; and the recommendation for the establishment of a foundation or basic year for all students (Malherbe, 1977: 491). This foundation year would serve as a preparatory year for university degree work. The rationale behind this foundation year was to expose students to the academic, intellectual and emotional experiences at university in order to be able to make informed choices regarding their direction of study. Each student would have been exposed to lectures and reading in the humanities (e.g. literature), the social sciences (to become familiar with the social and political context of the universities), the exact natural or physical sciences (to acquaint the student with deductive and inductive thinking) and communication (so that the student would be able to express himself in both the oral and written forms). As much as the foundation year was intended to operate at each of the eleven white universities in South Africa, the proposal was not implemented. Since the proposal was not put into practice, it was then proposed that the foundation year would have been more useful in the universities for "non-Whites where through circumstances their general education has been very limited" (Malherbe, 1977: 493). The foundation year or extra preliminary university year was actually made compulsory for all non-White matriculants[9] entering the Medical School at the former University of Natal (UN). According to Malherbe (1977), their "premedical science courses were thus spread over two years and, during this period they were obliged to take a course in language and literature (English), and a course in social science (history or sociology)" (493).

The suggestion to implement a foundation programme for white students at HWUs in South Africa approximately forty years ago is an important reference point for this study. The fact that a support programme was considered for students who had had the comfort of a superior schooling system (as dictated by the country's legislation at the time), and the privilege of attending well-funded and well-resourced HEIs that boasted well qualified faculty staff, informs that student ill-preparedness for tertiary studies cannot be viewed through the racial lenses. However, this is precisely the thinking that dominated HE at the time.

From the 1980s, the demography of the HWUs began to change. They had formally admitted non-traditional students, i.e. students of colour, viz. black students. As a result of having been exposed to a disadvantaged educational background, HWUs viewed such students as being underprepared for higher education academic studies. They were thus perceived to be in need of academic support programmes to bridge the huge divide between schooling and university and ensure that students adjusted to the university environment with self-confidence. To make academic support in HEIs accessible only to black students is suggestive of viewing them as being deficient, as implied in the Deficit Theory (which has already been outlined in the preceding pages of this Chapter) and to convey the view

[9] In South Africa, learners in their final year (Grade 12) at school are referred to as *matriculants*.

that academic support serves to remedy such deficiencies. At face value, the emphasis on academic support was based on educational disadvantage rather than on race. In South Africa, the majority of students who needed such support tended to be black, so it did become a race issue. However, despite its tag of negativity, the provision of academic support programmes also enjoyed favourable support.

1.3 Establishing Academic Support Programmes (ASPs) at HWUs

According to Lazarus (1987), the institutionalized Academic Support Programme (ASP) at the 'white' English speaking universities in South Africa started between 1980 and 1982. Almost all ASPs were voluntary, non-credit-bearing, add-on, adjunct courses, i.e. they were located outside mainstream teaching and learning. This new initiative at the time, in the view of Lazarus (1987), "started with no or little theoretical underpinnings"; and was a "response or reaction to an emerging problem" – which was "the poor academic performance of black students admitted to these institutions" (11). The explicit role and immediate challenge then of the ASP, according to Hunter (1985), was to help educationally disadvantaged entrants to succeed academically in existing courses. This form of support was offered to the small number of black students entering historically white liberal institutions in the early 1980s as a result of the relaxation of apartheid policy (Pavlich and Orkin, 1993) and "was aimed at equality and equity" (Boughey, 2010: 5).

ASPs, however, were not spared criticism, interrogation and resistance. Lazarus (1987: 11) interrogated the view of ASP as being established to help educationally disadvantaged entrants to succeed academically in existing courses; and in doing so, critiqued its underlying assumptions that:

i. the problem is located in the student;
ii the problem is manifest in communicative (e.g. English Language), cognitive (e.g. study, learning and conceptual), and subject specific (e.g. mathematics, physics etc.) deficiencies; and,
iii. the problem can be cured through Academic Support Programmes such as additional tutoring, language courses, foundation years and slow streams.

At the 1985 and 1986 ASP conferences, Tema (1985) and Vilakazi (1986) vehemently challenged assumptions that blamed the student rather than the institution. In other words, the belief was that the problem did not lie essentially with the student but within the social structure, the power structure, and collective personality of the university itself (Vilakazi and Tema, 1985).

ASPs were criticised for being narrow and patronising, with the inclusion of the word 'support' having connotations of remediation and inferiority' (Scott 2009). Furthermore, students in the ASP courses were seen in a deficit light and were described in harsh, racist and uncomplimentary terms. According to Moll (1987), some such descriptions were "disadvantaged, handicapped, culturally deprived, underprepared and suffering from developmental deficit" (30). The perception that ASPs would provide educationally disadvantaged students with essential communicative, cognitive and epistemological skills that they were deficient in, is primarily a Deficit view of ASPs that Slonimsky and Turton (1985) opposed. Slonimsky and Turton (1985) commented on the view among those involved in ASP that the DET fails to provide students with certain basic and essential learning skills. They critiqued the belief that the students therefore lacked learning and related cognitive skills. These researchers were clear that they did not perceive the students as deficient. Their belief was that the students do have these essential cognitive skills and do not need to be 'given' them. They preferred to view the education of the masses of oppressed students under the DET as being one that emphasized rote learning, regurgitation and surface processing to the detriment of students using their cognitive skills, which are in reality merely untapped skills (63).

In the 1980s, ASPs were viewed suspiciously and described as "a kind of academic group area, acting as a buffer between the university and the black community" (Mehl, 1988: 19). Similarly, Nzimande (1988) was critical of a programme that was started on the premise that it is mainly black students who are disadvantaged (118); a programme that looked at black students as the only disadvantaged sector of the white liberal universities" (114) therefore "the focus of the ASP was to change the black student to fit into the (unchanged) institution" (118).

Walker and Badsha (1993) viewed the ASP model as implying that 'the black students' deficiencies could be cured through ASPs such as pre-university bridging programmes, foundation courses, subject specific tutorials and language/academic skills courses. This view implies that black students have inherent deficiencies and need to be plied to fit the institution rather than the view that the institution needed to be transformed to accommodate its diverse student body.

The critique of enforcing change in black students to ‘fit in’ the institutions rather than the more important issue of institutional transformation to accommodate students from diverse educational backgrounds to achieve academic competence and success has also been expressed by others. Vilakazi (1986) shifts the blame from the racially-oppressed students being considered lacking in being able to learn and pass at university, to the elite universities which he believed are “linguistically, conceptually, culturally and psychologically ill-equipped to accommodate students who were deprived as a result of their class and race” (35). This argument indicates the divide between the elitists and the masses. Vilakazi and Tema (1985) state that the problem of academic deficiency did not lie essentially with the students, but within the social structure, the power structure and the collective personality of the university.

The provision of such support programmes meant that the university was providing a service for disadvantaged black students and could then continue its job as usual – attending to its traditional mainstream sector while remaining basically unchanged. Another major criticism of ASPs was the way in which they isolated and separated the university student body. This ties up with the fact that the ASPs were ‘adjunct’. They were located outside mainstream teaching and the learning community and these programmes took the form of tutorials, language development courses and skills courses. As outlined by Ndebele (1995), students allotted to the ASPs were black, with a DET background. These students were set apart from the rest of the mainly white student body and were made to join the rest of the student community once they had been prepared for higher education via the ASPs.

Another criticism against the ASPs was that they concentrated only on the weaknesses of black students. A concern of Nzimande (1988) was that the ASPs were not able to prepare the liberal universities to incorporate some of the strengths of the black students, one of which at the time was the students’ knowledge of the struggle for democracy.

Despite airing the negatives associated with ASPs, Nzimande (1988) ended his presentation at the 9th ASP Conference reiterating the purpose of the programme/s: “I think South Africa is going to need academic support services for a long time to come, probably even more so in the immediate post-liberation phase. The damage done by apartheid will stay with us long after apartheid is gone" (119). He was also of the opinion that there should be the call for fundamental restructuring and change of focus within the ASPs. One such point in this regard was one made by Muller (1988) that ASP is enjoined by insiders and outsiders to 'develop' more and 'support' less (120). Although ASPs did address many of the problems that students face, an important point raised at the 1988 ASP Conference was ASP should not take sole responsibility for equipping students with learning and study skills. Real change is only likely when such skills are part of the mainstream teaching process, making it the responsibility of mainstream lecturers too.

Even though the universities were critiqued for the establishment of ASP specifically targeted at black students, a significant point is that the implementation of placing support structures in place in the HE sector at the time was an indication of the shift in the intentions of the English-speaking HWUs to accommodate change. One such example of the commitment to change then was reflected in the Mission Statement of University of Cape Town (UCT):

> The university encourages each faculty, department and the administration to plan forward and establish specific strategies for the years ahead so that the University of Cape Town of the future will not merely be a projection of its past but will be in tune with and reflect the changing environment in which it functions (Saunders, 1985 cited in Lazarus, 1987: 12).

At the time, the above statement of intent provided ASPs with a mandate to assist faculties, departments, and the university administration to plan forward and establish specific strategies so that such an institution would reflect the changing environment in which they function.

ASPs at universities in the late 1980s were also a form of redress. The following extract from the Mission Statement (1989) of the former UN clearly explains the commitment to use ASPs as a redress mechanism to account for educational gaps as a result of poor schooling:

> In circumstances where students enter the University without the necessary educational background to benefit immediately from the experience ... it is necessary for special academic support programmes to be developed so that these students can make good their educational deficiencies and so be given the best possible opportunity of realising their potential for success (1989: 15, cited in SAAAD, 1992).

Despite criticisms levelled against ASPs, there were proponents who voiced favourable support for ASPs. One such view was expressed by John (1988) who conceptualised the role of ASPs:

> As ASP teaching staff, we are no longer seeing ourselves as 'preparing' 'underprepared' students to meet the demands of the university, but rather as facilitating personal growth and independence in students as individuals and learners, breaking down their alienation from the university environment, empowering them to take control over their own lives and to act upon their environment in their own way. In other words, we see ourselves as having a very definite social and political role far beyond that conventionally assumed by the teacher (168).

When the white English-speaking universities were interpreting the demands of the broader educational movement as a demand for equal educational opportunities for all, the ASP at the time was assisting black students to cope with the system in an attempt to provide them with an equal tertiary education. ASP satisfied the call for support to students whose educational experiences rendered them underprepared for tertiary studies. Scott (1986), for example, stated that students from disadvantaged communities should be provided with conditions that foster real development of their academic potential – opportunities to develop true intellectual strength, independence, critical ability, and an understanding of their social context – to enable them to take charge of their own experiences (21). This ties with the earlier assertion of Slonimsky and Turton (1985) that the ASP could be of use to assist students to mobilise their cognitive skills in the university context, "to infuse their own life experiences into their academic world" (64).

As much as there was support for ASPs established in the tertiary sector, one of the concerns was about the way in which ASPs were offered – as an adjunct (a-contextual) model of instruction. The thinking behind this was it that implied that the content/mainstream class retains its traditional format and curriculum while the language class is "adapted to the demands of the content course" (Benesch, 1992: 1).

Agar (1988b), in a discussion on evaluation of ASP (in the context of its offering in University of Witwatersrand (Wits)) distinguishes between ASP as a-contextual and contextual. The a-contextual ASP is where the students are made to fit into an already established institutional context, a type of 'band-aid' approach which defines the problem as the students' and consequently situates the problem in the students – which was the way in which ASP functioned. Although Agar (1988b) did not deny the merit of giving students the skills and habits to cope, survive academically and realize their potential, he believed that this was not sufficient. Agar (1988b) suggested that the evaluators of ASPs must explore and explain the influences of the institutional and broader socio-economic contexts – how these contexts influence the academic progress of the students and explore mechanisms of change. What Agar (1988b) was suggesting was that the status quo needed to change.

There were calls to a change in the provision of ASP from that of an appendage in the HE sector to one that was integrated into the mainstream departments. "ASPs are perceived as a support service within which academic skills conveyed are largely viewed as neutral, abstract, decontextualised, discrete, technical skills, such as English, time management and writing. These skills are assumed products of teaching and learning which simply can be added on to the content-based curriculum in an extracurricular manner or within the curriculum itself, rather than being seen as an integral part of learning within the mainstream curriculum" (Luckett, 1996: 31). The advantage of the integration of ASPs, according to Carter (1991), would in the long term, be:

> a major step towards ensuring the survival of academic development within South African universities as a critical element in the success of all students in achieving their goals within the tertiary education structure of the country ... integrating ASP into mainstream departments will assist the universities in adjusting to the new conditions which they face both now and in the new South Africa (33).

Lazarus (1987) had grave concerns about the teacher/tutor function of staff and with the ASPs assuming functions with which the academic departments should have been dealing. He could not see the logic in increasing the number of ASP staff as the number of black students increased. The argument put forth by Lazarus (1987) was that ASP was "providing a mechanism for keeping the realities of black students and the realities of the university apart" (12). One of the flaws of the ASP he highlighted was that it created the perception of difference between the ASP staff and the mainstream staff, with the implication that the former had the monopoly on skills and attitudes to deal with black disadvantaged students, or put simply, to cater for the educational deficiencies of black students in a white institution. The consequence of this was a schism between the mainstream and ASP staff.

There were calls for mobilising change by re-visiting the provision of ASP, redefining the role of the ASP. One of the focal changes to ASP was, according to Lazarus (1987), to change its role from one that helped students to cope with the system to one where the students and the system (the institution) coped with each other. One of the suggestions in 1987 was that the functions of the ASP staff be changed from teachers and tutors of educational content to catalysts, mediators and facilitators of institutional policies and processes within the broader academic context. This would mean working through a wide, diverse and ever-expanding network of students, mainstream academics, administrators and community colleagues (Lazarus, 1987: 13).

It was suggested that ASPs be integrated into the mainstream university system. This integration meant shedding the perception of ASP as a "band-aid service" (Agar, 1988b: 293) that was in place for the underprepared students. This integration also meant that ASPs were no longer seen as 'a-contextual' (Agar, 1988b: 293). Integration then allowed for mainstream departments to also be responsible in assisting students. There were several united voices at that time for integration and a change in the function of the ASP. In this regard, Lazarus (1987), the former director of academic support at the then UN, maintained in the 1987 ASP conference that:

> The English Second Language teacher, the learning skills specialist, and the subject tutor's responsibility changes from running separate courses and tutorials for students to assisting students and academic staff to explore their teaching and learning difficulties within their particular context. The object of this approach is simple: to assist the students and the system to cope with each other (12)

Similarly, Scott (1986), the director of ASP at UCT at the time, indicated that one of the major challenges facing ASPs was to find really effective means of positively influencing the regular academic departments in the university. Tema (1988), too, interrogated the merit of ASP as a separate offering from the point of a student who questions the provision of a support programme that has no link to the academic subjects in which he/she is weak. Tema (1988) then suggested that the ideal way forward was for each department to have its [own] support programme or a representative in ASP. The suggestion of placing ASPs "within their particular context" (Lazarus, 1987: 13) was supported by Mehl (1988) who stated that "university development centres would lead to interdisciplinary degrees between the subject department and the centre. In this way, ownership of ASP type activities will be placed within the university's departmental fabric – where, of course it belongs" (17).

Likewise, Hunter (1989) advocated ASP involvement in the improvement of mainstream teaching and structured teaching arrangements which were supplementary to mainstream departmental provision of lectures, tutorials and practicals, or which constituted enriched forms of mainstream courses. Hofmeyr and Spence (1989) saw the answer to "integrate ASPs into the regular work of departments in the hope of persuading government that ASP is an integral part of their work and should be part of the subsidy formulation" (44). The type of integrated model of ASP articulated by the proponents of ASP was, in the words of Carter (1991), "a giant step in making university education in South Africa responsive to the multi-racial and multi-cultural environment within [the] society" (39). Scott (1986) articulated that "universities should provide an environment in which the intellectual and social development of <u>all</u> [author's emphasis] their students can flourish" (16).

In the 1980s, ASP was limited entirely to disadvantaged [black] students. However, there were concerns that support of this kind be given to all the entrants who needed it, and even students of later years who were in need of it. The rationale for the shift was "partly the need to provide support wherever it was required, and partly an avoidance of any suggestion of a special 'black' programme" (Hunter, 1986: 27). Aware of the fact that the transition from school to university is not an easy adjustment, especially for students from disadvantaged backgrounds, Scott (1986) was of the opinion that virtually all students, even those from the best white schools, experience some difficulty in adjusting to a university environment (Scott, 1986: 16).

At the time, ASP was experimenting with a variety of methods such as peer group teaching, small group tutoring, supplemental instruction, mentoring, computer-based instruction to encourage students to engage actively with their disciplines. Students were encouraged to work at constructing their own meanings and knowledge activity rather than being receptive vessels (Searle, 1992: 558). Although staff was initially indifferent to ASPs as they believed it was not their job to teach students skills; provide background knowledge; or to deal with students who had trouble with reading; they were compelled to change. This, according to Searle (1992), was on account of the increasing numbers of students who found the methods and the content of traditional universities problematic; and the external pressure to produce good black graduates. Eventually, however, staff [those at UN, for example] had to be more receptive of ASP as it became faculty-based and was integrated into the university structure (Searle, 1992).

Besides being established at HWUs, academic support was also launched in the Historically Black Universities (HBUs)[10]. The great majority of students at these universities were from disadvantaged backgrounds. Thus, the ASPs at HBUs were primarily for students from DET schools who were underprepared for university studies and its focus was on "language and study skills" (Bulman, 1997: 7). Scott (1986) explains that academics at HBUs were concerned about the massive breakdown of the school systems (from where the bulk of their students came) and the high failure and dropout rates at university. This lead to them into taking the initiative to form [the] South African Association for Academic Development (SAAAD). SAAAD was primarily concerned with researching and implementing academic support and developmental measures that would be effective in meeting the very demanding circumstances that these academics were facing (10). Unlike the traditional ASP at HWUs, ASPs at the HBUs emphasized staff development which was aimed at encouraging mainstream academics at the HBUs to improve their teaching, leading to the birth of the term, 'Academic Development' (AD). Various other reasons were presented for the SAAAD being initiated at the HBUs. Lazarus (1987) presents the view that the SAAAD initiative at the HBUs was "a direct response to the limited appropriateness of traditional ASP to the problems that they were experiencing" (11). Mehl (1987) stated that the traditional role of the ASP was too narrow and did not address their particular problems on a broad enough front.

1.4 The Birth of Academic Development (AD)

Volbrecht and Boughey (2004) define Academic Development (AD) as "an open set of practices concerned with improving the quality of teaching and learning in higher education" (58). The definition of AD quoted by Gennrich (1997)[11] succinctly outlines the purpose of AD:

> all those areas of work at a tertiary institution that contribute to the transformation and ongoing development of the capacity of students, staff, curricula and organisational structures, to meet the ongoing demands of the

[10] The Historically Black Universities (HBUs) that that came into existence during apartheid were segregated: universities which admitted African students were Medunsa University, University of the North, Vista University, University of the Western Cape, North West University, University of Transkei, University of Fort Hare and University of Zululand. The University of Durban-Westville was demarcated for Indians; while the University of the Western Cape serviced the educational needs of the Coloured race group.

[11] "This definition of AD was in the Draft AD Proposals Document, University of the North West, October, 1997, p. 1" (cited by Gennrich, 1997: 2).

> changing scale of socio-political values of the society in which the institution is situated (2).

Forrest and Winberg (1993) spelt out the wide aims of academic development in a South African situation – to provide a learning environment and support mechanisms which:

> 1. actively attempt to counteract the limitations of the apartheid education;
> 2. play a role in enabling transition from the distortions, restrictions and fragmentation of the past towards the creation of a new order for the future; and,
> 3. facilitate academic study (347).

With the shift from ASP to AD, there has been the change from a peripheral marginalized endeavour to an integrated university activity that was more holistic. The offering of AD in the 1990s at tertiary institutions in South Africa involved a shift in focus from student to the institution "as the higher education system prepared to transform itself in anticipation of a new political order ... AD work came to centre on the development of teaching methodologies and curricula which would meet the needs of the anticipated black majority in the student body" (Boughey, 2007: 2). This shift initialized changes in learning environment, curricula; teaching practices; and student development as well as staff development. AD became an umbrella term which incorporated staff development, student development, curriculum development and organizational development (Troskie-de Bruin, 1999; Baijnath, 1997). "AD, through the infusion model, represents a shift from student to curriculum as a whole and hence to the university and is aimed at developing an appropriate learning and teaching environment" (Goodman, 1994: 257). "AD was not seen as a separate activity but part of the ongoing business of teaching and learning in tertiary education, concerned with the broader curriculum that encompasses the teacher and the learner as well as the content" (Bulman, 1997: 9).

In 1997, the greater call for change to AD involved staff, students, curriculum and research. According to Khabanyane (1997), all these aspects are interwoven, because to develop staff implies to develop the methods of imparting knowledge by the staff through making use of a better-developed curriculum that addresses the needs of the learner, which may result in better-developed students, since they will have been taught to gather knowledge in better way. It is an indication of a better-developed research if the staff can use the curriculum to address the needs of the students (1).

Gennrich (1997) comments on AD provision and transformation of a tertiary institution:

> AD potentially impacts on every aspect of an institution's planning and implementation. But for this to be a reality, institutional management has to not only support AD initiatives, but to own AD as an integral part of its ongoing transformation ... Transformation is regarded as an essential part of any educational process, in that it involves an ongoing sense of responding to the needs of different types of students within an ever-changing socio-political and economic environment. AD recognises that tertiary institutions are not immune to their situational contexts, and that it is in fact vital for their existence to respond appropriately to constantly changing external demands in an ongoing and proactive manner (2).

In light of transformation, the comment by Jacobs (1997) is valid: "Unless the academic contexts within which AD interventions occur and the policy frameworks which shape these contexts are seen to be part of the process of transformation and challenged to change, there will be no significant reshaping of the tertiary sector and AD initiatives will continue to have minimal impact (161).

The proponents of AD have seen it as a way of helping students. Shepherd and Karodia (1992) have made specific reference to the fact that on first entry into university, students – besides [those having] undergone the ravages of the apartheid education system in South Africa – might not have been exposed to conceptual, analytical and pedagogical skills to develop learning. Besides this, they are in an "unfamiliar academic environment, an alien culture" (168). To help students bridge this gap, these researchers have argued favourably for a holistic, integrated approach that emphasises development of staff and students. This leaning towards AD approaches the issue of student development as a learning experience, it integrates all the participants and is sensitive to the environment in which it takes place. The premise with this type of thinking is that if students are to develop, so must staff. Hence, staff development is central to the issue of student development. They suggested a closer integration between the management of coursework, teaching practice and the curricula. Their view of AD was that, rather than being "offered in a piece-meal fashion, it needed to be offered as a comprehensive, co-ordinated year long programme involving ALL [authors' emphasis] first year students" (Shepherd and Karodia, 1992: 170). AD's link with staff development meant that the AD staff member was making the shift from working only with the students to working with academic staff, i.e. the lecturer, tutors and module co-ordinators.

Researchers (Shepherd and Karodia, 1992; Baijnath, 1997 and Troskie-de Bruin, 1999) isolated curriculum development as being an important component in AD. In this regard, Forrest and Winberg (1993) state that:

> [t]he curriculum therefore would have to be developed in such a way as to centralise the development of systematic, independent and creative thought, while simultaneously promoting the subconscious acquisition and conscious mastery of the linguistic forms demanded by this, and understanding and mastery of the academic study skills appropriate to the learning environment. All of which has implications for syllabus and materials design and involves [our] conception of methodology (348)

AD was a strategy of institutional academic redress. The National Plan for Higher Education (NPHE) (2001) outlines that AD includes:

1. Extended curricula rather than supplementary support;
2. The need for students to be integrated into the mainstream; and,
3. The need to be responsive to all students (DoE, 2001: 31).

As with the opposition against ASP in the 1980s, AD, too, was contested. The provision of AD has been subjected to questioning by the likes of researchers such as Akoojee and Nkomo (2007), who state that Academic Development Programmes (ADPs) are marginal to institutional practices. They also stated that the fact that the student intake enrolled for ADPs are black draws attention to the issue of disadvantage and the issue of black students being categorised as deficient. Using the same argument that was used against ASPs by other opponents, these critics categorically state that "AD serves as a programme directed to ensure institutional fit, rather than enabling institutions to adapt to their new charges" (392) This point, like the Deficit Theory, problematizes the issue that institutions make very little change to accommodate diversity, but expect black students to be able to adapt to the institutional culture.

For Masenya (1994), ADPs are associated with black students' underpreparedness rather than the under-preparing socio-educational realities in our society which are indicative of power relations between the subordinate and dominant groups. Leaving the academic standards at HWUs unchanged means that the HWUs are maintaining their ideological hegemony which defines students' underpreparedness. The term 'hegemony', coined by Gramsci in the period from 1891 to 1937, signifies the way dominant ways of thinking and being may become common-sense to us, with the result that they are never questioned. If the intention of the introduction of ADPs at HWUs is to bring black students from disadvantaged backgrounds up to recognised academic standards, the question that needs to be asked is, "What standards and whose academic standards" are being protected (Mabokela, 1997: 431). Perhaps the answer to the question of standards had been prematurely answered by Nzimande (1988) who, at an earlier ASP Conference, commented that the decision not to sacrifice the dominant white liberal academic standards at the HWUs was a defense mechanism of those who were unable to relate to black students and were thus reluctant to sacrifice institutional "academic standards" (116).

On the issue of institutional standards, Hunter (1991) asserts that with the intake of underprepared students, HWUs need to understand the educational needs of the underprepared students and implement institutional change by restructuring course content and teaching strategies without altering their assessment standards. This point is linked to the issue of institutional accountability expressed by Akoojee (2002) who states that "institutions will have to develop ways to ensure that personnel will be appropriately skilled and re-skilled into new ways of engaging with the new community of students ... this will include novel ways of dealing with teaching and learning provision, including peer mentoring and other strategies" (7). However, with regard to the issue of access and academic standards, in embracing diversity in HEIs, the quality of higher education should not be compromised.

The issue of the deficiency apparent in black students and the resistance of the institutions to change are highlighted by Mabokela (2000), who argues that when black students were admitted to HWUs, some of these universities explored alternative admissions criteria. He explains that the philosophy underlying the structure of alternative admissions programme operated from the assumption that black students were the problem and remedial education was the answer. This philosophy assumes that the underdevelopment among the black students could be addressed by paying attention to their deficiencies rather than by altering organizational structures within the universities.

There were, however, more favourable views on the inclusion of mechanisms to assist students at tertiary institutions. Gasa *et al.* (1994: 49) offer commentary on the issue of the LoLT that African students from poor educational backgrounds experience. They state that language is a crucial means of gaining access to important knowledge and skills and this can determine academic achievement. They believe there is a link between language competency and conceptual understanding. They went on to state that at tertiary level the language problem cannot be dealt with in isolation; and that these students require a holistic approach of intervention. Their thinking was that if tertiary institutions were committed to opening access to students who would otherwise not gain entry, there was a need to ensure that the academic and intellectual skills of these students are enhanced to their full potential. This calls for the University to put into place mechanisms to support the alternative admissions policy and consolidate the potential academic ability of students.

An equally relevant point raised by Gasa *et al.* (1994) was that all students experience difficulties adjusting from secondary to tertiary education, an issue they expand on by commenting that:

> [u]niversity is a unique learning experience with new demands and expectations. Coping with these demands involves learning how to learn, modifying existing study strategies, abandoning others and developing new, more effective strategies, as well as monitoring one's learning. What has been observed is that the successful students, of whatever race, are students who are active learners who think about and react to course content and use a variety of thinking skills to fit different academic situations" (48).

1.5 Current discussion on AD in the HE in South Africa

Higher education in South Africa has undergone major transformation. Higher education transformation in South Africa has necessitated that all students regardless of racial differences access higher education in increased numbers. The increased student access to higher education has been part and parcel of the massification of higher education (Higgs 2010). With massification, which Reddy (2004) simply defines as "changing the higher education system from an elitist to a 'mass' system" (35), "the traditional client base of the university has changed" (Gibbons, 1998) and the university lecture rooms are now characterised by a heterogeneous group of students whose language, culture and schooling differ. According to Carrim and Wangenge-Ouma (2011), the need to integrate education and training; the centrality of a high skills- and knowledge-based workforce, the need for an integrated curriculum; the importance of ICT [Information Communications Technology] use in teaching and learning as well as the concomitant skills to use them; the link between a global economy and knowledge production; and, the need for human capital growth and development all appear intricately linked with the characteristics and features of globalisation (12).

Higher education has now become a more marketable commodity and students would have to apply their knowledge and communicate in various contexts outside the environment of the university. One of the specific goals HE in South Africa was called upon to advance was "to improve the quality of teaching and learning throughout the system and, in particular to ensure that curricula are responsive to the national and regional context" (Department of Education (DoE), 1997: 1.27).

The DoE Education White Paper (1997b) also hoped that the programme-based approach to higher education would improve the responsiveness of the system to "[the] present and future social and economic needs, including labour market trends and opportunities, the new relations between education and work, and in particular, the curricular and methodological changes that flow from the information revolution, the implications for knowledge production and the types of skills and capabilities required to apply or develop the new technologies" (2.6).

One of the gaols in implementing the transformation strategy in HE in the Education White Paper (DoE, 1997b) is "to produce graduates with the skills and competencies that build the foundations for lifelong learning, including, critical, analytical, problem-solving and communication skills, as well as the ability to deal with change and diversity" (1.27)

Academic development in the higher education sector has also featured in the National Plan for Higher Education in South Africa (DoE, 2001: 21) in which the commitment to the promotion of AD in HE and its expectations of AD in HE is reflected below:

> The Ministry remains committed to the funding of academic development programmes as part of the new funding formula. However, it should be made clear that higher education institutions have a moral and educational responsibility to ensure that they have effective programmes in place to meet the teaching and learning needs of the students they admit. This requires that institutions should integrate academic development programmes into their overall academic and financial planning (21)

In addition, the Ministry of Education in South Africa considers the role of academic development programmes in improving the efficiency of the higher education system in terms of graduate outputs as being critical (DoE, 2001: 22). The value of AD in the HE sector cannot be undervalued. In 2008, the 'Report of the Ministerial Committee on Transformation and Social Cohesion and the Elimination of Discrimination in Public Higher Education Institutions' supported a review of the undergraduate qualification structure in terms of its appropriateness and efficacy in dealing with the learning needs of students. The review of the undergraduate qualification structure would be considered in light of the context of schooling in South Africa, and given the acknowledged gap between school and higher education. In addition to considering the 'desirability and feasibility' of the introduction of a four-year undergraduate degree, the review would include the role of academic development programmes and their integration into a new four-year formative degree (DoE, 2008: 73).

According to Boughey (2007), AD in South Africa has gone through a number of shifts, seeing it move from a focus on equity to a focus on efficiency (1). This has included the shift from the provision of ASPs as a form of support for the small number of black students entering historically white liberal institutions in the early 1980s. Then, in the early 1990s, there was the change in focus from the student to the institution as the higher education system prepared to transform itself in anticipation of a new political order. This involved the development of teaching methodologies and curricula which would meet the needs of the anticipated black majority in the student body (Boughey, 2007: 2).

Volbrecht and Boughey (2004) comment on Higher Education Development as a phase in AD. According to these researchers, critical to this phase is the construction of the work of the AD movement as a resource for institutional efficiency in relation to teaching and learning. This satisfies the goal identified in the The Department of Education's (1997b) White Paper. What Boughey (2007) argues for is the need for:

> AD practices to become more nuanced and more contextualised in order to contribute to differentiated learning needs at programme level within a differentiated system. The location of Academic Development within a quality framing would allow this to happen since the practices would need to be contextualised at programme level in order to ensure that those programmes were, indeed, fit for purpose and able to bring about the transformation of learning (8).

With institutional efficiency, institutions were not only required to become more effective in using the resources at their disposal but also to recurriculate in order to meet the demands of globalisation and to attract students who were looking for work-oriented qualifications. As a result, AD practitioners began to be perceived as a resource to be drawn on in the quest for overall institutional efficiency (Boughey, 2007:3).

1.6 The Provision of Foundation Programmes

Many prospective students in South Africa come from schools that have not equipped them for admission to university. They do not obtain the required matriculation points for admission to specific undergraduate degrees. A number of universities in the country have developed alternative access programmes to identify candidates who have the potential to succeed at University which serve as alternative routes into university admission. One example of an alternative access route is the provision of the foundation programme. An understanding of the nature of the foundation programme is necessary for this study.

Boughey (2010) differentiates between a bridging course and a foundation course. The former is "a course which looks back into the school curriculum and attempts to upgrade students' performance on the school-leaving examination, while the latter looks forward into the university in the acknowledgement that academic knowledge and academic learning are qualitatively different to school based practice" (6). The Department of Education (2001) describes foundation programmes as state subsidised programmes of learning that are intended to assist underprepared students to cope with the demands of a mainstream academic programme. "Foundation programmes maybe defined as special programmes for students whose prior learning has been adversely affected by educational and social inequalities" (Kloot *et al.* 2008: 800).

The provision of these bridging or foundation programmes meant that some measure of progressive change was being adopted by HEIs to make a university qualification accessible to all sectors of the population. Volbrecht and Boughey (2004) describe the provision of these programmes – the foundation programme, in particular – as a consequence of a "shift in the attitude of the HWUs to take ownership of the phenomena of disadvantage and underpreparedness" (62). Such intervention programmes were also necessary to fill the articulation gap[12] between secondary schooling and higher education sectors, giving the educationally disadvantaged students the opportunity to realize their academic potential at university. However, this move created anxiety that institutional standards would be compromised to accommodate students whose inadequate schooling

[12] The "articulation gap" is the gap between "students' capabilities and universities' expectations" (Marshall, 2009: 65).

would have rendered them underprepared for tertiary studies and were thus in need of support.

Like the earlier issues of viewing educationally disadvantaged students as being deficient and in need of remediation to ‘fit in’ the higher education sector, foundation programmes offered at HWUs were criticized for being separate units (i.e. add-ons) created to support or remedy black students’ underpreparedness. This is aptly summed up by Nzimande (2010) in the Stakeholder Summit on Higher Education Transformation report which reads:

> The ability of foundation programmes to successfully bridge the academic divide is often hindered by a failure to integrate these programmes into the core curriculum of the institution as such programmes are simply seen as add-ons. Moreover, the remedial nature of foundation programmes often means that the students who take these courses are marked negatively at a social level as their apparent shortcomings are exposed (20).

The provision of the foundation programmes had racial undertones of marginalising the educationally disadvantaged black students from the greater mainstream university culture and environment.

Despite the negativity associated with foundation programmes, they were necessary in allowing educationally disadvantaged students access into higher education studies. Besides the point of being able to enter through the doors of higher education learning institutions, these students, especially those in foundation programmes, needed to be able to achieve some measure of success in their studies. Cele and Menon (2006) refer to this balance as "‘equity of access and equity of outcomes" (40) and they argue that neglect of this balance results in the continued participatory exclusion of historically marginalised groups in the broader economic and social spheres of life. For universities to rectify this, they need to ensure that students from previously disadvantaged backgrounds, upon access into university, are able to achieve academic success by not only graduating, but by doing so within an appropriate time frame.

1.7 The Establishment of Foundation Programmes in Science at Higher Education Institutions (HEIs)

The critical shortage of black graduates in the fields of science, technology and engineering in South Africa resulted in the establishment of the foundation programmes in science at HWUs and HBUs in South Africa. These programmes have enabled students from disadvantaged backgrounds, with lower matriculation points, to study science or science-related degrees. If successful in the foundation programme, these students can qualify for entry into underrepresented fields of study such as engineering, health and natural sciences, information technology, geology and medicine, thereby fulfilling the needs for black graduates in science from disadvantaged backgrounds, and also, simultaneously, allowing for social mobility. The twofold purpose of the foundation programmes in science at HEIs is summarized by Rollnick (2010) as the need "to meet the requirements of diversity, access and redress on the one hand, yet maintain a level of quality output of success, on the other hand" (16). This then highlights the two conceptions of foundation programmes which are 'access as participation' and 'access with success'. The definition of each is outlined by Akoojee (2002):

> 'Access as participation' is concerned with strategies directed at inclusion or involvement of students from groups excluded in the past. 'Access with success' is concerned with strategies that focus on the success of participatory initiatives i.e. to ensure that those who participate are provided adequate opportunity to succeed in these programmes (2).

In an attempt to ensure access for success and to address student underpreparedness for tertiary studies, foundation measures were initiated at both HWUs and HBUs.

Prior to the institutional merger[13] of higher education in South Africa between 2004 and 2007 (which was intended to increase access into higher education studies and bridge the urban/rural divide) Fort Hare University, North West University, Walter Sisulu University for Technology and Science (previously known as University of Transkei), University of Limpopo (previously known as University of the North), University of the Western Cape and Zululand University were described as HBUs.

[13] Under apartheid, there were separate Higher Education Institutions (HEIs) for different race groups, Historically 'White' Institutions (HWIs) were most favourably located and resourced and conducted almost all research and there was a binary system featuring academic universities and vocational technikons. The new government drove a radical restructuring of higher education aimed at making it stronger and more focused and more efficient, within a framework of policies and regulations, including the 1996 NCHE, 1997 Higher Education Act, and the 2001 National Plan for Higher Education (NPHE). The binary divide was dismantled, and the number of institutions was cut from 36 to 23 through mergers and campus incorporations involving most institutions (International Education Association of South Africa (IEASA), 2012: 14).

An *institutional merger* may be defined as an amalgamation in which two or more component institutions give up their legally independent identities in favour of a joint identity. The mergers are aimed at creating a new reality of sharing resources while maintaining academic standards (Humphrey, 2003).

This historical fact pertaining to the institutional merger is pertinent to this study as it indicates the institutional racial divide that was entrenched as policy in South Africa. Earlier references in this Chapter regarding the purpose of foundation programmes at HWUs during apartheid education pointed out the articulation gap between secondary schooling and higher education. The admission of black students into the HWUs during the period of apartheid in South Africa heralded intervention programmes, such as the foundation programmes, as being essential to fill in the gaps created by educational and social inequalities based on race. Post-apartheid, HEIs were no longer classified according to race and students were able to enrol for higher education studies as long as they satisfied specific faculty entrance criteria. However, both HWUs and HBUs have introduced foundation programmes as access strategies; and to ways to fulfil the demand for science graduates.

As a result of this institutional desegregation, "historically white institutions benefited from the expansion of enrolments and the movement of African students from historically black institutions to historically white institutions; while historically black universities did not benefit from the expansion of enrolments to the same extent as historically white universities" (Council on Higher Education (CHE) Profile, 2010: 16). Despite the transformation to HEIs, the University of Zululand (UniZulu), an HBU, has been unable to attract a diverse student population; "it has an overwhelmingly 97% African student enrolment, 1% White students, 0% Coloured students and 1% Indian students and 1% are classified unknown" (Council on Higher Education (CHE) Profile, 2010: 17).

Besides being unable to attract students from diverse race groups, HBUs have had to compete with HWUs for students who qualified for university admission. According to Jansen (2010), "the end of university segregation meant high achieving middle-class black students could now more easily enter former white institutions ... leaving the HBUs to attract only those students who passed poorly, and in most cases without the university-entrance pass ... resulting in [HBUs] registering poor and academically weak students" (130). This point is further emphasized by Makura *et al.* (2011) who state that "the urban (former white) universities attract crème de la crème, while the predominantly rural campuses like Fort Hare University (FHU) have had to content themselves with low quality students from surrounding areas whose second language challenges and a shaky secondary education foundation rendered students unable to cope with higher education demands" (2-3).

The establishment of foundation programmes at HWUs has satisfied the principles of access, redress and equity. As explained earlier in this Chapter, intervention programmes, such as the provision of foundation programmes, have been subject to criticism as they were primarily offered to black students who were perceived as being deficient. However, apart from being offered at HWUs, which are now integrated institutions, foundation programmes are also offered at the currently integrated HBUs, as a means of addressing student underpreparedness for tertiary studies and assisting with the transition from school to university by offering academic support to achieve academic success.

An example of a Foundation Programme in Science at a former HBU is the one offered at UniZulu which is aimed at "enabling under-prepared learners to graduate in science by providing them with academic support for the first year curriculum" (University of Zululand, reportal.uzulu.ac.za/.../UniZulu). The other which is offered at FHU is intended to "help students develop attitudes to learning and learning behaviours that will help them succeed in tertiary studies" (University of Fort Hare, ufh.ac.za›Academic›Departments).

The Science Foundation Programme offered at the University of the Western Cape (UWC) which has been in operation since 2002 was a way of dealing with the problem of student underpreparedness for tertiary studies. "In 1993, the University of Limpopo introduced a mathematics and science foundation year to address the low numbers and high failure rates in its science-based faculties. The foundation year was aimed at preparing disadvantaged South African students for admission to science-based faculties, and enhancing their chances of successfully completing a BSc [Bachelor of Science] degree programme" (van der Flier *et al.* 2003: 400). The foundation programme in science started in 1999 at the North-West University and students in the programme are equipped with adequate skills and competencies necessary for them to excel in their chosen degree programmes (www.sciencefoundation.org.za/index.php).

As explained earlier, foundation programmes initiated post-apartheid at HWUs were, like those established at HBUs, a result of the articulation gap between the school system and higher education and the problem of students being underprepared to take on the rigours of academic study in order to achieve academic success. Foundation programmes were thus a strategic mechanism to not only address inequities and imbalances but a way of assisting students whose disadvantage educational backgrounds had compromised their preparedness for studies at tertiary level.

1.8 The Establishment of the Access Programme in Science at the University of KwaZulu-Natal (UKZN)[14]

At the University of KwaZulu-Natal (UKZN), access programmes in science were located within the Centre for Science Access (CSA)[15], a unit within the former Faculty of Science and Agriculture (which, through institutional restructuring is now the College of Agriculture, Engineering and Science). The CSA arose from the 2004 merger of the Science Foundation Programme (SFP) located on the Pietermaritzburg campus of the former University of Natal (UN) (where it was launched in 1991)[16]; and in the former University of Durban-Westville (UDW) (where it was launched in 1999) (Grayson, 1997; Kioko, 2009; Kloot *et al.* 2008). The CSA offered three streams of science access which were the BSc4 (Augmented)[17]; BSc4 (Foundation) and the Science Foundation Programme[18].

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[14] The University of KwaZulu-Natal (UKZN) arose from the institutional merger on 1 January 2004 between University of Natal (UN) and University of Durban-Westville (UDW). UKZN is located in the province of KwaZulu-Natal, South Africa.

[15] For UKZN, the CSA is a strategic mechanism for redressing inequities among students in the natural and applied sciences by catering for students from disadvantaged educational backgrounds. However, the CSA dissolved in 2011 but the provision of the two streams of BSc4: the BSc4 (Augmented) and the BSc4 (Foundation) continues.

[16] "The Science Foundation Programme (SFP) offered was a year-long pre-degree programme designed to identify academically talented but underprepared black students who wished to pursue tertiary studies in science or applied science, and help them develop their potential in order to achieve this aim" (Grayson, 1997: 107). "Its goal was to enable Black students to cope with, and do well in, their undergraduate courses in the Faculties of Science and Agriculture and so increase the number of Black students graduating with science degrees" (Inglis, 1991: 19).

[17] "Admission to the BSc4 (Augmented): Applicants who have had a disadvantaged school background (as defined by Senate) who satisfy the University-wide requirements and who have (i) a full NSC with at least 22 points excluding Life Orientation, and (ii) have obtained a Level 3 (40%) in Mathematics and a Level 3 (40%) in Physical Science or Life Science or Agricultural Science" (UKZN, *College of Agriculture, Engineering and Science Handbook*, 2012: 63). "Students are given extra tuition in the first one or two years. They attend the regular lectures and practicals with other first year students, but in addition the courses are 'augmented' by additional lectures, practical sessions and small group tutorials" (UKZN, *College of Agriculture, Engineering and Science Handbook,* 2012: 78).

[18] The Science Foundation Programme is for students from disadvantaged schools who do not have a full matric endorsement nor a NSC (Deg) and hence do not meet the formal entrance requirements of the Faculties of Science and Agriculture, Engineering and Health Sciences, but who are judged to have potential

This study has as its focus the BSc4 (Foundation) stream. The BSc4 (Foundation) is offered on both the Pietermaritzburg and Westville campuses of UKZN. It is offered to "applicants who have had a disadvantaged school background (as defined by Senate) who satisfy the University-wide entrance requirements and who (i) have a full National Senior Certificate (NSC)[19] with at least 16 points (excluding Life Orientation) and (ii) have obtained a Level 2 (30%) in Mathematics and a Level 2 (30%) in Physical Science or Life Science or Agricultural Science. This leads to the completion of a degree in not less than four years. Students who have attended the University or any other university, whether in a degree or access programme of any kind, for a complete semester will not be admitted into the BSc4 (Foundation) stream". (UKZN *College of Agriculture, Engineering and Science Handbook*, 2012: 63).

The BSc4 (Foundation) is a year-long programme. Students registered in the programme take credit-bearing[20] foundation modules[21] in biology, chemistry, mathematics, physics and Communication in Science (SCOM). The modules must be completed in two semesters. Students are not permitted to repeat any of the modules. The foundation modules are generally taught by academics, some of whom are qualified teachers, researchers, pure science or science education graduates. In addition to the foundation modules, students have to attend at least 80% of the timetabled non credit-bearing life skills workshops.

According to Snyders (2003), an effective foundation programme should be based on sound educational principles and should adopt an integrated, holistic, forward-looking

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to succeed in these faculties. (UKZN *Faculty of Science and Agriculture Handbook*, 2011: 46). This programme is no longer offered as an option in BSc4. It ceased at the end of 2011.

[19] In 2008, a new South African qualification, the National Senior Certificate (NSC) replaced the Senior Certificate, commonly known as 'the matric'. The NSC is a registered qualification on National Qualifications Framework (NQF) level 4 and it provides the requirements for promotion at the end of Grades 10 and 11 and the awarding of the NSC at the end of grade 12 (DoE, 2005). The NSC is an exit-level qualification at the end of grade 12.

[20]"Communication in Science (SCOM103) carries 16 degree credits. The foundation modules of biology (BIOL199), chemistry (CHEM199) and physics (PHYS199) carry 4 degree credits and 20 foundation credits each. The foundation module of mathematics (MATH199) carries 4 degree credits and 36 foundation credits. However, students will be awarded the degree credits only if they pass all four of these modules. In order to be eligible to continue studying in an undergraduate programme in the College, a student must pass every module of the curriculum" (UKZN *College of Agriculture, Engineering and Science Handbook*, 2012: 80).

[21] "A module means any separate course of study for which credits may be obtained" (UKZN *College of Agriculture, Engineering and Science Handbook*, 2011: 13).

approach. The BSc4 (Foundation) programme offered at UKZN appears to satisfy these principles. As an intervention model, its educational principles ensure teaching and learning is offered in small class groups (no more than 40 students) and student progress and performance are evaluated using the system of continuous assessment. Students write mid- and final year examinations in the foundation modules in science while SCOM has no examinations. SCOM is a course based on continuous assessment. Students enrolled in the programme are taught using a holistic approach which ensures that they acquire specific discipline knowledge. Attention is also given to their emotional well-being through the provision of a Life Skills course and counselling services. This programme enables students to gain the skills, literacies, competencies and knowledge required for their future mainstream studies, basically laying the foundation for subsequent learning, rather than offering a revision of the high school curriculum. This educational philosophy of the BSc4 (Foundation) programme is modelled along the lines of the former SFP which is:

> ... the focus of the resulting curriculum is on issues such as cognitive skills, practical skills, effective study attitudes and strategies, peer learning, articulation and communication of understandings, positive coping skills, self-reliance, confidence-building and awareness of how each individual student learns best (Grayson, 1997: 107).

Two theoretical perspectives, namely Constructivism and Social Development Theory, underlie the teaching and learning approach in the foundation programme. The first, the Constructivist Theory of Learning, acknowledges that new information is passed through the filter of a learner's prior knowledge and experience. The learning process can be significantly affected by the extent of learners' metacognitive skills, or ability to monitor and regulate their own learning. The second theory, Social Development Theory of Vygotsky (1978b) proposes that learning is a product of social interaction. In other words, "a university can be viewed as a culture into which students must be initiated through participating in relevant cultural activities and learning the social language of academia" (Grayson, 1996). "This cultural context is informed by culturally constructed norms, values, assumptions and dialects" (Rule, 1994: 101). Becoming initiated into the university culture is the process of acculturation which is "learning to read and write the culture" (Ballard and Clanchy, 1988:19). To succeed in university, first year students have to acquire both cognitive and linguistic competence. To achieve this, students need to acquire the academic discourse and the literacies needed to read, write, do and speak science.

1.9 The Purpose of the Academic Literacy (AL) module in the BSc4 (Foundation) Programme

In the BSc4 (Foundation), one of the mechanisms for students to acquire the academic discourse and the literacies (in science) has been through the inclusion of an Academic Literacy (AL) course called Communication in Science (SCOM)[22]. In discussing the reasons for the design of SCOM, Parkinson *et al.* (2007) [23] state:

> Our choice was for a module that was science-based; gave greatest stress to reading and comprehension; used a genre-based approach to the teaching of writing; placed only minor emphasis on formal grammar instruction ... We based the course on science content because we wanted the skills learnt to be applicable to their other science subjects ... The course thus uses science content to improve the reading strategies of students, to familiarise them with the pedagogical genres of science study (446).

SCOM offers students explicit development of proficiency in academic English and scientific literacy that are applied to the science disciplines in the programme. The fundamental purpose of such a course is conveyed by Kioko[24] (2009):

> Notably, the language course, rather than focus on the surface features of the English language uses the texts of appropriate scientific genres to teach literacy ... the language [course] [is] also designed to address Academic Literacy (author's emphasis) in the broadest sense, including the 'induction' of students into the scientific writing community of practice (23).

The SCOM module provides students with the relevant literacies they would require for science discourse in the foundation modules in science. Introducing this model here helps position the objectives of an AL module within science. In order to be able to acquire and construct knowledge at tertiary level, students need to apprentice themselves in various disciplines, learn and demonstrate the use of the conventions and discourses of such disciplines, and to comprehend, interact and engage with academic texts. They should be able to acquire the necessary reading and writing literacies to eventually produce their own texts. In other words, students should be able to acquire the academic literacies required for the discourse applicable to specific disciplines. In the context of this study, students

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[22] SCOM is a mandatory, year-long module, weighted 16 credits towards a science or science-related degree. "Assessment is 100% Continuous – written assignments (60%), tests (25%), oral presentations (15%). In order to pass, students must attend 80% of classes and complete all assignments (UKZN *College of Agriculture, Engineering and Science Handbook,* 2012: 352).

[23] Dr Jean Parkinson, a former senior lecturer at UKZN, was instrumental in the design, development and implementation of the SCOM course upon its inception in the access programme in science at UKZN in 2005.

[24] Dr. Joseph Kioko occupied the position as Head of the former CSA from 2006-2008.

need not only become academically literate, but academically literate in science, and SCOM was designed to serve this purpose.

SCOM is a content-based language course where authentic science content is used as a medium to teach and impart literacies for reading, writing and speaking science. Brinton *et al*. (1989) argue that in a content-based approach, "the activities of the language class are specific to the subject matter being taught, and are geared to stimulate students to think and learn through the use of the target language" (2). In this regard, Mohan (1986) states that language should not be taught in isolation from content, a point accentuated by Brinton and Holten (2001) who state that "authentic content provided the richest and most natural context for language teaching to occur" (239). The link between language and content has been adequately summed by Crandall (1994) who states that "[s]tudents cannot develop academic knowledge and skills without access to the language in which that knowledge is embedded, discussed, constructed, or evaluated. Nor can they acquire academic language skills in a context devoid of content" (256).

Advocating content-based instruction, Grabe and Stoller (1997) explain that in content-based classrooms:

> students are exposed to a considerable amount of language while learning content. This incidental language should be comprehensible, linked to their immediate prior learning, and relevant to their needs; learning is contextualized, students are taught useful language that is embedded within relevant discourse contexts rather than as isolated language fragments and; students have many opportunities to attend to language, to use language, and to negotiate content through language in natural discourse contexts (19).

In SCOM, grammar relevant for reading, writing and speaking science is specialized and is integrated into the course content, depending on the stylistic conventions necessary for the varying science genres.

1.10 Framing the Role of SCOM in the BSc4 (Foundation) Programme

Describing SCOM first is relevant in this study because it places it in perspective within the field of science. This study in no way seeks to mirror the way in which the teaching of the foundation modules in science (offered in the foundation programme) should occur against how SCOM is taught. However, the acquisition of the conventions associated with academic discourse is crucial for academic success and students studying science face the academic demands of reading, writing and speaking in the sciences, in other words, the language of science, the acquisition of which is facilitated by SCOM. (The language of science is thoroughly outlined in Chapter 4 in this dissertation).

As stated earlier, SCOM is used as a vehicle in the BSc4 (Foundation) to promote literacies in and for science. In the SCOM classes, academic content is extracted from science journals and textbooks, and where necessary, are rewritten, revised and adapted to suit the needs of students for whom English is not their native language, as is the case of FP students (See Appendix 1 for an example of an original and revised text used in SCOM). In the SCOM class, reading and comprehension of the content of texts in science are taught through the approaches of "scaffolding" (Vygotsky, 1978a; 1978b) (Appendix 2 has a scaffolded text used in SCOM). Rose *et al.* (2003) define 'scaffolding' as the support that a teacher can give learners so that they can work at a much higher level than is possible on their own. Scaffolding support enables learners to successfully practise complex skills, and as they become independently competent, the scaffolding is gradually withdrawn. Scaffolding strategies for reading and writing are designed to focus learners' attention on patterns of language and to recognise the meanings they express. (The concept of scaffolding is further explored in Chapter 3 in this dissertation). The process of engaging students in the texts and consolidating their understanding of the reading texts so that they are aptly able to construct writing assignments using the texts, is facilitated by the inclusion of various reading comprehension questions at various stages of the teaching and learning process. The compilation of questions is guided by Bloom's Taxonomy (Bloom *et al.* 1956)[25] (which is discussed in Chapter 3) and is inclusive of tasks such as summary writing, paraphrasing and conceptual mapping, which is also referred to as cognitive mapping. (Appendix 2 has the types of comprehension questions, summary, paraphrasing and conceptual mapping tasks used in SCOM). Angélil-Carter (1994) describes cognitive mapping as:

> a meaningful learning strategy for those whose learning takes place in a medium that is not their mother tongue (125) as it allows the teacher to see

[25] Benjamin S. Bloom and a team of researchers classified learning into three domains: cognitive, affective, and psychomotor. These domains were then further divided into subcategories which represented a hierarchy of the simplest types of learning to the most complex types of learning. The categories of the cognitive domain are referred to as Bloom's Taxonomy of Learning and range from the simplest to the most complex. These are knowledge, comprehension, application, analysis, synthesis and evaluation. Each successive level in this hierarchy requires mastery of all lower-level categories (Bloom *et al.* 1956). This is further discussed in Chapter 3.

> what kind of conceptual categories and links the learner is generating, and thus helps [her] to ascertain the actual level of development so that [she] can work within the ZDP[26] to push that development: the map can act as a kind of 'window' into the learner's thinking (132).

SCOM uses authentic scientific texts to teach the scientific genres[27] of laboratory report writing, academic essays, scientific posters and oral presentations. One of the strategies used to teach students to write academically in science in SCOM is the process approach advocated by theorists such as Pica (1986) and Dixon (1986). The process approach emphasizes writing as a process rather than a written product. White and Arndt (1991) point out an important factor that differentiates a process-focused approach from a product-centred one: the outcome of writing – the product – is not pre-conceived. In process writing, "writing is not a linear process of gathering information, outlining, and writing, but that it involves many different stages – generating ideas, planning, writing, evaluating, and rewriting – which are not necessarily independent, clear-cut entities" (Johnstone, 1996: 348). With process writing, students are taken through a cycle of writing, rewriting (drafting), revising and editing with regard to their assignments. With this type of approach, the academic staff who teach SCOM, who, in this study are referred to as Academic Literacy Specialists (which has been abbreviated to ALSs in this study)[28] offer students extensive feedback on their writing tasks. This feedback enables them to achieve acceptable levels of competence in the mechanics of composition. The nature of feedback is corrective, instructive, developmental and critical. Process writing involves both task complexity and topic knowledge. On this point, Hyland's (2003) view of the nature of process writing is pertinent. He states that process approaches have had a major impact on the ways in which writing is both understood and taught, transforming narrowly-conceived product models and raising awareness of how complex writing actually is. Hyland (2003) proposes genre-based pedagogies (which are discussed in greater detail in Chapter 3) used

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[26] Vygotsky's (1978b) Zone of Proximal Development (ZPD) is commonly referred to as the theoretical underpinnings of the concept of scaffolding as a teaching and learning strategy. ZPD is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (86). This concept is further elaborated on in Chapter 3.

[27]"*Genre* refers to abstract, socially recognised ways of using language. It is based on the assumptions that the features of a similar group of texts depend on the social context of their creation and use, and that those features can be described in a way that relates a text to others like it and to the choices and constraints acting on text producers" (Hyland, 2003: 19). This concept is expanded on in Chapter 3.

[28] The tutors/senior tutors/lecturers who teach the Academic Literacy (AL) module are described as Academic Literacy Specialists in this study and are referred to as ALSs.

in conjunction with process writing as a means of offering students explicit and systematic explanations of the ways language functions in social contexts (18). From a genre perspective, people do not just write, they write to accomplish different purposes in different contexts and this involves variation in the ways they use language, not universal rules (Halliday, 1994).

I have been teaching SCOM since 2005 and have contributed to its content development; teaching methodology; and the assessment and evaluation practices since 2006. I view myself as an academic literacy facilitator whose role is to facilitate the understanding, acquisition and development of literacies required 'in' science and 'for' science, both within the boundaries of the university and beyond. Being able to fulfil this role has been eased by my experiences as a former educator and the teaching pedagogy acquired from my post-graduate studies in TESOL (Teaching English to Speakers of Other Languages) both of which assisted in the way/s in which literacies were taught to individuals for whom English is not their native language. Being fully aware of the philosophy of the foundation programme and the rationale of including an academic literacy course in a university science programme and knowing what happens 'with' literacies for science 'inside' SCOM, I was particularly interested in exploring the issue of discipline-specific literacies 'outside' SCOM, i.e. in the foundation science disciplines that were part of the compulsory modules in BSc4 (Foundation).

1.11 Rationale and Motivation for the Study

Having outlined the philosophy behind the AL course (SCOM) and having contextualized its role as well as my own within the BSc4 (Foundation), I will now explain the factors that initiated this research study. The first factor is the challenge of students' perceived underpreparedness for higher education studies in general and, particularly in science, which has been outlined by various researchers (Cox, 2000; Lowe and Cook, 2003; Hay and Marais, 2004; Nel *et al.* 2009; Volkwyn *et al*. 2010; Wilson-Strydom, 2010; Bradbury and Miller, 2011; Selvaratnam, 2011). Hay and Marais (2004) draw attention to the fact that South African higher institutions are finding it increasingly difficult to deal with school-leavers who are ill-prepared for higher education, justifying the need for access programmes which can be successful in producing graduates if they operate in an innovative way (59).

Acknowledging that the challenge of under-preparation for university level study is not a new phenomenon, Wilson-Strydom (2010) writes that it is critical for universities in South Africa to focus greater attention on what happens to students during their schooling and how they experience the transition from school to university. The central concern of that study was to explore how these students made sense of their new worlds at university, and how their schooling informed this sense making. In a study on responses to questions in a first-year psychology examination, Bradbury and Miller (2011) noted that factual questions present the lowest level of demand or difficulty for students compared to relational and conceptual questions. They had conceded that "[u]nderpreparedness, then, is not simply a failure, or lack of aptitude, on the part of individual students but rather reflects a systemic failure by the educational system to initiate these students into the world of academic study and its implicit rules of enquiry and knowledge construction**.** The potential to bridge this disjuncture, therefore, becomes the task of educational intervention" (113).

The second factor that initiated this study is the challenges of accomplishing academic tasks at university. In a study which focussed on the Science Foundation Programme (SFP)[29] students' performance in a range of tasks in biology, Downs (2005) found that they had greater difficulties with tasks that required higher cognitive skills and in constructing succinct scientific arguments, answering short questions or essays. Similarly, a study conducted by Selvaratnam (2011) which tested students' competence in problem solving in a course in BSc indicated poor performance in all of the associated skills, viz. information processing skills; skills concerning equations; graphical skills; three-dimensional visualization skills and inverse proportion reasoning skills. The study suggested the need to explicitly identify important cognitive skills and strategies and to train students in them and to integrate that training with the teaching of content knowledge (185).

1.12 The Problem Focussed

This study engages with the issue of discipline-specific literacies. Chapter 2 adequately discusses literacies and academic literacy; and offers a distinction between content area literacy and disciplinary literacy. At this juncture, I would like to clarify that as much as 'modules' refer to the courses offered in the BSc4 (Foundation) programme, it is often used

[29] Downs' (2005) study which assessed students' performance in biology across years 1995-2000 and was undertaken in the former SFP offered in the former UN.

interchangeably with ‘disciplines’, especially among the academics teaching in the BSc4 (Foundation) programme. As an academic literacy facilitator in the programme, my initial understandings of the literacies specific to the disciplines in the BSc4 (Foundation) were primarily the conventional – i.e. the ability to read science text books, journal articles and course-notes; and to be able to write science prose such as reports and scientific summaries. Fully aware that science modules included laboratory practicals, I was aware that students would conduct experiments and interact with their peers in the laboratory sessions. I was also acutely aware of the strong role of mathematical knowledge in science. Having taught SCOM within the BSc4 (Foundation) programme, I was also aware that science content had to be presented in particular ways; in other words, science had its own ‘language’; its own discourse.

It is from this angle of knowledge and understanding, that I embarked on this study to explore the discipline-specific literacies required for science and for science discourse in the respective foundation modules of science offered in the BSc4 (Foundation) programme – i.e. biology, chemistry, mathematics and physics. I also explored the presence of any perceived challenges in the discipline-specific literacies that emerge in the use of the language of science in these disciplines; and the ways in which the disciplinary specialists who teach the foundation modules in science offered in the BSc4 (Foundation) programme assist the students with the acquisition of these literacies in each of the respective modules.

1.13 Research Questions

In order to address the issues outlined above, the critical research questions below were formulated. ‘Academic literacy specialists’, as used in the critical research questions below and in the context of this study, refer to the academic teaching staff who teach the SCOM module to the students in the BSc4 (Foundation) programme. ‘Disciplinary specialists’, as used in the critical research questions below and in the context of this study, refer to the academic teaching staff who teach one of the following foundation modules in science offered in the BSc4 (Foundation) programme[30] (which later in this study is referred to as

[30] To ease the use of this lengthy phrase in this dissertation, reference to the BSc4 (Foundation) programme within which this study is undertaken, will later be referred to as FP, i.e. Foundation Programme.

FP): biology, chemistry, mathematics and physics to the students registered in the programme.

1. *What discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by the students to learn science*?

2. *What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation) programme?*

3. *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

1.14 Structure of the Dissertation

This Chapter commenced with a discussion on the education system in South Africa from the period of democracy, paying particular attention to the need for redress and inequity which existed because of the educational disparities rendered by the injustices of apartheid. Consequently, issues of ‘disadvantage’; ‘underpreparedness’ for higher education and perceptions of ‘deficit’ and ‘deficiency’ were outlined. In order to place current foundation programmes at HEIs in perspective, it was thus essential to trace the evolution and purpose of institutional support measures such as ASPs and ADPs. This Chapter offered a preamble on the philosophy of the foundation programme, the context of this study, and SCOM, the course where literacies needed for science discourse are introduced and reinforced. It concluded with a reference to the rationale for undertaking this study, outlining the critical research questions that are to be answered in this dissertation.

Chapter 2 serves as a literature review of academic literacy in this dissertation. It pays attention to the entry of students from educationally disadvantaged backgrounds into the tertiary environment and the barriers that they encounter in respect of the LoLT as well as the complex nature of academic reading and writing. I have considered it essential to outline concepts and studies relating to literacies, especially since it is the specific focus of each of the critical research questions devised for this study.

Chapter 3 deals with the theoretical and conceptual framework that guides this study. This Chapter provides the literature associated with the New Literacy Studies (NLS) (Street, 1984; Gee, 1990), paying particular attention to its role in the acquisition of academic discourse. This is followed by the discussion on Systemic Functional Linguistics (SFL) Halliday (1978; 1985a) and Grammatical Metaphor (GM) (Halliday and Martin, 1993), exploring the role of each in relation to the literacies required for science, thus necessitating a reference to appropriate pedagogic practices needed for science.

I then chose to use Chapter 4 as the arena to explore the subject matter of this dissertation which is the issue of the language of science needed at tertiary level. The rationale for the inclusion of this Chapter lies in the nature of the focus of this study which is the meaning of science discourse. This Chapter is presented in four parts. The first part of the Chapter explains the role of the higher education sector in satisfying the demand for science graduates in South Africa. This is followed by the way in which this sector can contribute to helping students to acquire an identity in science. Part three of the Chapter explores the literacies required by students to convey science knowledge in specific disciplines in science. It is on account of this that the final part of the Chapter offers a review of literature outlining students' underpreparedness for tertiary science by referring to studies at both secondary education and tertiary levels. Each of these parts in this Chapter is crucial in addressing the critical research questions that guide this study.

Then, in Chapter 5, I offer an outline of the research methodology that guided this study. I identify the research paradigm, the research approaches and the research instruments that were adopted to analyse and evaluate the data gathered in this study. I include the reliance on case study as a research strategy to help interpret the emerging data.

In order to effectively understand the discipline-specific literacies required by students engaged in studying science at the research site selected for this study, I considered it essential to understand the profile of the students and their preparedness for tertiary level. As a preliminary discussion to the critical research questions that frame this study and in order to contextualise the research problem more clearly, I begin Chapter 6 by enquiring from the research participants whether the modules of science isolated in this research had undergone any particular changes. I then set out to ascertain the reason for such changes and the way/s in which the change was accommodated and effected. In an effort to understand the perceived challenges in discipline-specific literacies that manifest in the foundation modules in science, I had to field responses from the research participants with regard to the possible contributory factors. This helped in the interpretation of the verbal data in respect of critical research question 1. Data for critical question 1 was gathered from the semi-structured interviews, documentary evidence and observations.

Chapter 7 is a continuation of the analysis of the data gathered in response to critical research questions 2 and 3. The data gathered with regard to these critical research questions had emerged from the semi-structured interviews, documentary evidence and observation. From these research instruments I was able to glean an understanding of the meaning of science discourse. This data is linked to the literature around the literacies required ‘in’ and ‘for’ science discussed in Chapter 4 of this study. The data in relation to critical research question 2 explored the perceived challenges that emerged in respect of the language of science and the discipline-specific literacies in the modules offered in the BSs4 (Foundation) programme. Critical research question 3 focuses on the way/s in which the disciplinary specialists assist the students in the BSc4 (Foundation) programme with the acquisition of the discipline-specific literacies needed for science discourse. A proper understanding of the responses to critical research question 3 is facilitated by the theoretical and conceptual framework explored in Chapter 3.

Chapter 8 brings this study to a close. The crux of this Chapter being the conclusions drawn from the data and the suggestions arising from this study. It also presents the possibility for further studies that may have arisen from this study.

CHAPTER 2

SCHOLARSHIP ON THE PHENOMENON UNDER STUDY

Introduction

Chapter 1 commenced with an overview of the system of higher education in South Africa drawing attention to several pertinent issues. Firstly, it offered a discussion on differentiation in HEIs. Apartheid dictated institutional segregation of higher education institutional structures, leading to the establishment of HWUs and HBUs. This historical fact was included in the introductory Chapter in this dissertation in order to understand how race determined the quality of education in the country. Secondly, it drew attention to the issue of student underpreparedness for higher education studies. Thirdly, it portrayed the provision of higher education academic support structures with specific attention to the establishment of mechanisms such as the ASPs and ADPs to address the issue of underpreparedness. Fourthly, it explored the objectives and the nature of the foundation programmes in science initiated at tertiary institutions, more especially foregrounding the philosophy of the foundation programme in science at UKZN as an institutional measure to help underprepared but academically capable, black students to pursue tertiary studies in science and to help students fit into the university culture and community. The Chapter also offered a discussion on SCOM, contextualising its role in the BSc4 (Foundation) programme. Chapter 1 was interspersed with an explanation of various terminology relevant to this study such as ‘transition’; ‘transformation’; ‘equity’; ‘redress’; ‘disadvantage’; ‘deficit’; ‘underpreparedness’; and, ‘remediation’ which guided its discourse.

This Chapter begins by first paying specific attention to the entry of mainly educationally disadvantaged students into the higher education sphere in South Africa where the LoLT is usually English which is not their native language. An explanation of the double barriers experienced by students in respect of the language of instruction and the complexities of academic reading and writing is then given. This, thus, necessitated the distinction between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Cummins, 1979). Included are the varying definitions of literacy and its role in negotiating academic texts. The second major issue portrayed in this Chapter is the reference to institutional support measures offered at higher education level, isolating the development of academic literacy as the area for discussion and paying specific attention to SCOM as a consequence of its inclusion in the BSc4 (Foundation). Academic Literacy (AL) is explored with specific reference to perceptions of it and the different models implemented to facilitate its acquisition and development. The third issue explained here is academic writing, a crucial domain in higher learning contexts. This is followed by a presentation of Bloom's Taxonomy (Bloom *et al.* 1956), a model frequently used in the learning contexts to formulate module objectives and direct assessment practices. The final issue clarified in this Chapter is discourse facilitation.

2.1 Students' Entry into the Higher Education (HE) Environment

With the advent of democracy in South Africa in 1994, HEIs underwent major transformation. One of the major changes to the HWUs was the provision of access to tertiary studies to students from previously disadvantaged sectors of the population, who, as a result of the country's then policies of apartheid, were subject to under-resourced and inadequate schooling. Many of these students enrol at universities where the LoLT is not their native language, but is more likely to be their additional language. The LoLT at most tertiary institutions in South Africa is English, as is the case at a South African university used as the research site of this study.

Upon entry into HEIs, students are expected to engage in extensive reading and writing. The texts available at most universities in South Africa, including the one isolated for this study, are in English which is the LoLT. Tasks at university are cognitively demanding and students need to have the necessary academic language proficiency to succeed. This can pose as a problem to students for whom English is an Additional Language (EAL) and who have had to endure disadvantaged schooling experiences. To succeed at university, students will need to cope with academic studies, which expect proficiency in reading and writing and the ability to use literacies effectively to make sense of academic reading and compose academic writing tasks.

Bernhardt *et al.* (1995 cited in Teemant *et al.* 1997: 315) observe that second language students are in 'double jeopardy' each time they are asked to demonstrate "knowledge in a language over which they have only partial control" (6). Students entering university for the first time need to adjust to the university environment and community. Bartholomae

(1985) takes this point further when he writes, "Every time a student sits down to write for us, he has to invent the university for the occasion ... he has to learn to speak our language ... to appropriate (or be appropriated by) a specialized discourse" (273)[31]. Shay *et al.* (1994) refer to this as "inviting students to join the academic conversation as equals, an act that is daunting for new students 'who are not yet insiders' of disciplines, and thus cannot converse so quickly or easily with authority" (27) on the subject matter. A relevant view in respect of the double-edged sword facing EAL students in respect of the LoLT and the complexities of academic writing is expressed in the following comment:

> [T]he language of instruction for many of those identified as being academically illiterate is a second, third or even fourth language, the roots of this illiteracy is often perceived to lie in a lack of knowledge of the additional language compounded by a lack of familiarity with the way in which academic text is structured rhetorically, syntactically and lexically (Boughey, 1994: 22).

Students often have adequate conversational skills, especially those from disadvantaged backgrounds who have had greater exposure to oral culture than print media (at home) but these skills are not adequate to cope with the language of academia. Goodier and Parkinson (2005) note that "the discourse features of a language in specialised disciplines, both at a macro and a micro level, differ significantly from the discourse features of everyday language" (67).

2.2 Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP)

Cummins (1979) distinguishes between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP). Cummins (1979; 1984b) argues that the language required for CALP is immensely different from BICS. BICS refer to conversational fluency in a language, the surface skills of listening and speaking which are typically acquired quickly by many students while CALP refers to students' ability to understand and express, in both oral and written modes, concepts and ideas that are relevant to success in school.

[31] Similarly, in respect of the dominance of English in English-speaking countries, Lankshear (1997) draws attention to a 'double loss' facing indigenous and migrant peoples: by having to go along with practices of formal education grounded in language, dialect and Discourses of dominant groups, they stand to lose their language(s) and cultures, the latter being a result of cultural assimilation; while at the same time failing to achieve educationally. Thus, spurring on the need for education to promote bilingual or multilingual competence; and languages other than English should feature as both a medium of instruction and as curriculum subjects (34-35). Although the 'double loss' has parallels with 'double jeopardy', it is neither the intention of the study to explore the viability of bilingualism/multilingualism in FP nor the understanding of the FP students' culture/cultural loss.

On a continuum devised by Cummins (1984a), he illustrates the range of contextual support available for expressing or receiving meaning. The extremes of this continuum are defined in terms of types of communication: context-embedded communication and context-reduced communication. BICS are context-embedded communication where "the participants can actively negotiate meaning and the language is supported by a wide range of paralinguistic and situational cues" (136). BICS involve face-to-face conversations and offer cues such as facial expressions and gestures and concrete objects of reference which assist in understanding and imparting information. "The opportunities for immediate feedback to clarify meaning in context are evident. Context-embedded communication derives from interpersonal involvement in a shared reality which does away with the need for explicit linguistic elaboration of the message" (Starfield, 1990: 84). BICS involve conversational skills and are grasped more easily.

"CALP is context-reduced communication which relies primarily on linguistic cues to meaning" (Cummins, 1984b: 136). In CALP there are fewer non-verbal cues and the language is more abstract. With CALP, a shared reality cannot be assumed and the language used must therefore be elaborated precisely and explicitly to minimize the risk of misinterpretation (Cummins 1984a). Within the continuum, is the degree of active cognitive involvement in a task or activity (Starfield, 1990: 84) which is either cognitively undemanding or cognitively demanding. Cummins (1984a) claims that context-embedded communication is cognitively undemanding (BICS), compared to cognitively demanding, context-reduced communication (CALP). While cognitively undemanding language has a simple language structure and is easy to understand as it deals with everyday language and social conversation, cognitively demanding language has a complex language structure, refers to abstract concepts and uses more specialized vocabulary. Cummins' (1984a) framework drew attention to the interplay between language and cognition.

Cummins (1984b) states that while many children develop native speaker fluency (i.e. BICS) within two years of immersion in the target language, it takes between five to seven years for a child to be working on a level with native speakers as far as academic language is concerned. Thus, students are more likely to gain control of BICS more easily than that of CALP.

CALP was introduced by Cummins (1979) in order to draw educators' attention to the timelines and challenges that second language learners encounter as they attempt to catch up to their peers in academic aspects of school language (Cummins, 1979 in Street and Hornberger, 2008). Cummins (2008) comments that the notion of CALP is specific to the social context of schooling, hence the term 'academic'. Academic language proficiency can thus be defined as the extent to which an individual has access to and command of the oral and written academic registers of schooling (Cummins 2000). Moore *et al.* (1998: 12) cite Cummins (1984a) who states that students who have English as a second or additional language often appear fluent at the interactive communicative level, which is the BICS but they may not have the more advanced language skills necessary for developing conceptual understanding in the academic context (CALP). Schlebusch (2002) states that "[students'] ability to participate meaningfully in [school] learning activities is intimately linked to their proficiency in the language of learning" (1). By the same token, Starfield (1990) claims that "linguistic competence cannot be separated from the cognitive demands of [a] [task]" (86). Moore *et al.* (1998) draw support from Cummins' (1984a) theory about students' language skills and illuminate the fact that linguistic competence cannot be separated from the cognitive demands of a task. As a result, an explicit focus on language needed to be embedded in the teaching of mainstream courses (12). This study, in determining the issue of the acquisition of discipline-specific literacies in the foundation modules offered in the BSc4 (Foundation) programme, sees the need for CALP to engage with science content in the FP.

2.3 Defining Literacy

Being able to read and write can contribute effectively to higher learning but in no way implies having achieved literacy. The varying connotations of literacy are especially valid for this study that seeks to understand the acquisition of discipline-specific literacies in science. Traditionally, literacy has been viewed as the ability to read and write. Roberts (1995) problematizes "the surface notion of literacy as 'the ability to read and write' as an incomplete statement simply because questions regarding what one reads and writes, and 'how much' ability in reading and/or writing is required in order to be considered literate, are left unanswered" (143). New understandings of literacy (Draper, 2002; Street, 2003; Lee, 2004) have extended its meaning to encompass more than the ability to read and write.

The concept of literacy has thus evolved from being viewed in this single, monolithic light to being a multi-faceted practice shaped by context, culture, participants and technology.

Draper (2002), for example, notes that narrower definitions of literacy, which give preference to reading and writing traditional print material, have been rejected by many literacy educators as not honoring the role of listening, speaking, and experiencing in the comprehension and understanding of texts … not convey[ing] the importance of context and the situatedness of the reader/writer and/or the text (359). Langer (1987) summarizes literacy as:

> an activity, a way of thinking, not a set of skills. And it is a purposeful activity – people read, write, talk and think about real ideas and information in order to ponder and extend what they know, to communicate with others, to present their points of view, and to understand and be understood" (4).

Likewise, the view put forward by Scribner and Cole (1981) is that "[l]iteracy is not simply knowing how to read and write a particular script but applying this knowledge for specific purposes in specific contexts of use" (236).

Lankshear (1999) draws attention to Green's (1988) three dimensional view of literacy where the components i.e. the operational, the cultural, and the critical interlock, bringing together language, meaning and context. The operational dimension of literacy points to the manner in which individuals use language in literacy tasks in order to operate effectively in specific contexts. Addressing literacy from this perspective, refers to the ability of individuals "to read and write in a range of contexts, in an appropriate and adequate manner", i.e. to focus on the language aspect of literacy. The cultural dimension involves the "meaning aspect of literacy", and "competency with the meaning system of social practices" (Green 1988: 160). This is to recognise that literacy acts and events are context specific and content specific. The cultural aspect of literacy is a matter of understanding texts in relation to contexts - to appreciate their meaning and the appropriateness of ways of reading and writing. The critical dimension of literacy has to do with the socially constructed nature of all human practices and meaning systems. In order to be able to participate effectively and productively in any social practice, humans must be socialised into it (Green 1988; Lankshear, 1999). According to Lankshear (1999), an integrated view of literacy in practice and in pedagogy addresses all three dimensions simultaneously.

Draper (2002) adds to the definition of literacy, the inclusion of multiple activities such as reading, writing, listening, speaking, viewing and symbolizing; with multiple associated texts like print, digital, video, symbolic, images, diagrams, graphs and conversations (359). The argument that literacy is constantly evolving is put forth by Colombi and Schleppegrell (2002) who explain that "continual changes in technology and society means that literacy tasks themselves are always changing" (2).

Cunningham *et al.* (2000) illustrate that most definitions of literacy share three commonalities which are "the ability to engage in some of the unique aspects of reading and writing; contextualisation to some extent within the broad demands of the society; and some minimal level of practical proficiency" (64). Gee (1989) defines literacy as the mastery of secondary or formal institutional, often academic discourses (Gee, 1989). These secondary discourses typically involve ways of describing, explaining, and questioning that differ from ordinary conversation. The discourses typical of academic disciplines may be regarded as literacies (Michaels and O'Connor, 1990).

Researchers have distinguished between content area literacy and disciplinary literacy. Bean *et al.* (2008) define content area literacy as the ability to use reading and writing effectively as tools for thinking about and learning from texts across different content subjects. Shanahan and Shanahan (2012) emphasize two presumptions of content area literacy: the cognitive requirements of learning and interpretation are essentially the same irrespective of the content; and, the major difference among the subjects is the content matter. Fang (2012) is of the view that content area literacy emphasizes the acquisition of skills and/or strategies such as basic reading skills(e.g. fluency), cognitive text processing strategies (e.g. predicting) and generic learning strategies (e.g. highlighting texts) which can assist students to extract information from any content area text, helping to promote learning and retention of content.

"Disciplinary literacy involves the use of reading, reasoning, investigating, speaking, and writing required to learn and form complex content knowledge appropriate to a particular discipline" (McConachie and Petrosky, 2010: 16). Disciplinary literacy is built on the premise that each subject area or discipline has a discourse community with its own language, texts, and ways of knowing, doing, and communicating within a discipline (O'Brien *et al.* 2001). Disciplinary literacy situates literacy as an integral part of content.

Students learn how disciplinary experts read and write texts in their field and “how the disciplines are different from one another, how acts of inquiry produce knowledge and multiple representational forms (such as texts written in particular ways or with different symbolic systems or semiotic tools), as well as how those disciplinary differences are socially constructed” (Moje, 2008: 103). In support of the focus on disciplinary literacy as a benefit to students, Rainey and Moje (2012) state that:

> [it is] what students need to usher them into the ways of thinking and knowing and communicating in the disciplines ... teachers can reveal for students what the underlying practices and values and assumptions are of [their] disciplines so that they [students] may fully engage in them (77).

Similarly, Shanahan and Shanahan (2012) agree that the aim of disciplinary literacy is to “find ways of teaching students to negotiate successfully the literacy aspects of the disciplines ... [a]s an effort, ultimately, to transform students into disciplinary insiders who are able to approach literacy tasks with some sense of agency and with a set of responses and moves that are appropriate to the specialized purposes, demands, and mores of the disciplines” (8). “Being literate in a discipline means both deep knowledge of disciplinary content and keen understanding of disciplinary ways of making meaning” (Fang, 2012: 20). Fang (2012: 20) goes on to state that “literacy development involves simultaneous engagement with disciplinary content (e.g. core concepts) and disciplinary habits of mind (e.g. reading–writing, viewing–representing, listening–speaking, thinking–reasoning, and problem-solving practices consistent with those of content experts)” (20). The concepts of literacy and disciplinary literacy are relevant in this study, which critical research question 1 seeks to answer.

2.4 Institutional Support Mechanisms

Students who are EAL speakers have to familiarize themselves with the LoLT and the language of academia, both of which can be alienating as has been discussed already. Many of these students “have to manoeuvre their way through the troubled waters of cross-cultural and linguistic misunderstandings” (Kramsch, 1998: 27). At university level, students who are not proficient in the LoLT and whose CALP is inadequate or underdeveloped, are likely to have difficulty with the epistemological access necessary to succeed academically. This is further compromised if students’ educational background has been characterised by underpreparedness which further widens the articulation gap[32]. It is for this reason that such students require institutional support that have manifested in many forms, including programmes and intervention structures aimed at the development of academic literacy.

Such mechanisms assist students to manage their transition from secondary schooling to university education so that they can acquire ways of thinking and learning aligned with the demands of academia and intellectual rigour. These mechanisms have taken the form of ASPs which, for example, provided extra tutorials and assistance alongside [students'] normal studies (NARSET, 1997); generic academic literacy courses and discipline-specific academic literacy courses (McKenna, 2003); writing centres (Leibowitz *et al.* 1997; Hutchings, 2006) and the subsequent inclusion of ADPs such as foundation or extended curriculum programmes (Cantrell, 2008: 44). For the purpose of this study, the support mechanism in focus is academic literacy (AL).

2.4.1 Defining Academic Literacy (AL)

Various researchers have proffered definitions of Academic Literacy (AL). Boughey (1994) explains that definitions of academic literacy most commonly offered at South African universities tend to revolve around the "ability to use and understand the language of instruction in a form and register appropriate to academic contexts" (22). Examples of this definition are conveyed by Amos (1999) who defines academic literacy as the student's ability to read and write effectively within the university context (178); or as teaching academic language skills to assist students in their studies or research (Jordan 2004 and Hyland, 2006). Lea and Street (2006) define academic literacies as the diverse and multiple literacies found in academic contexts such as disciplinary and subject matter courses. Short and Fitzsimmons (2007) offer a comprehensive definition of academic literacy as that which includes "reading, writing, and oral discourse; varies from subject to subject; requires knowledge of multiple genres of and purposes of text use and is influenced by students' personal, social, and cultural experiences" (2). Leibowitz (1994) takes this definition further in stating that this will imply the student's ability to read and write within the academic context with independence, understanding and a level of

[32] The "articulation gap" is the gap between "students' capabilities and universities' expectations" (Marshall, 2009: 65). This is discussed in Chapter 4.

engagement with the learning. Particularly pertinent to this study is the description of academic literacy practices by Lea and Street (1998) as "reading and writing – within disciplines [that] constitute central processes through which students learn new subjects and develop their knowledge about new areas of study" (160). Weideman (2006: 84) listed the components of academic literacy that students need to master to become academically literate:

- understand a range of academic vocabulary in context;
- interpret and use metaphor and idiom, and perceive connotation, word play and ambiguity;
- understand relations between different parts of a text, be aware of the logical development of (an academic) text, via introductions and conclusions, and know how to use language that serves to make the different parts of a text hang together;
- interpret different kinds of text type (genres), and show sensitivity for the meaning that they convey and the audience that they are aimed at;
- interpret, use and produce information presented in graphic or visual format;
- make distinctions between essential and non-essential information, fact and opinion, propositions and argument; distinguish between cause and effect, classify, categorise and handle data that make comparisons;
- see sequence and order, do simple numerical estimations and computations that are relevant to academic information, that allow comparisons to be made, and can be applied for the purposes of an argument;
- know what counts as evidence for an argument, extrapolate from information by making inferences, and apply the information or its implications to other cases than the one at hand;
- understand the communicative function of various ways of expression in academic language (such as defining, providing examples, arguing) and;
- make meaning (e.g. of an academic text) beyond the level of the sentence.

2.4.2 AL as a Support Mechanism

The early provision of academic literacy at HEIs needs to be understood in light of Boughey's (1994) definition of AL quoted in the preceding paragraph. According to Boughey (1994), since the language of instruction (at South African universities) for many of those [students] identified as being academically *illiterate* [author's emphasis] is a second, third or even fourth language, the roots of this illiteracy are often perceived to lie in a lack of knowledge of the additional language compounded by a lack of familiarity with the way in which academic text is structured rhetorically, syntactically, and lexically. As a result of this perception, the development of academic literacy has traditionally been addressed by the provision of adjunct programmes or courses which have tended to focus on remedial instruction in the second language and 'how to' classes in academic reading and writing skills (22).

Boughey and Niven (2012) attribute the demise of academic support due to the challenges to the universities made by academics such as Vilakazi (1986) and others who argued that it was not students who were 'underprepared' for higher education but rather the other way round: universities were underprepared for the task of embracing the diversity that would characterise student populations following a shift to democracy. (Chapter 1 of this study traced the provision of academic support and academic development at tertiary institutions in South Africa pre- and post-apartheid as well as the call for universities to change). AL at HEIs were then transformed into academic development structures and were offered in faculties as either generic, embedded or separate courses. As academic development structures, AL courses that are generic and decontextualised use general texts to teach and serve students from a wide range of disciplines. AL courses that involve collaboration and partnerships in the form of team teaching between academic literacy specialists and disciplinary specialists are embedded courses. Alternatively, AL can be offered as a separate course within a faculty, using the content of a particular discipline to impart the literacies or genres required for that discipline.

Generally, AL courses have been conceived as intervention measures with the purpose of remedying any existing gaps in literacies required for students' reading, writing and speaking that stem from their educationally disadvantaged backgrounds. Such a view then perceives the role of AL as being able to provide students with a list of decontextualised skills that require mastery for academic success. Such a view is likely to confine the acquisition of literacies to the boundaries of the AL lecture venue, thus depriving the disciplinary specialists[33] of the opportunity to make explicit the literacy practices essential for their own disciplinary discourse/epistemology.

AL has been perceived as a 'quick-fix' or 'language-repair-facility' where, for example, after a year-long exposure to academic reading and writing in science in the AL classroom,

[33] A disciplinary specialist, in the context of this study, refers to the HE academic (tutor/senior tutor/lecturer) who has knowledge of the academic fields of biology, chemistry, mathematics or physics, having specialised in its study. The disciplinary specialist conveys this knowledge to the students studying a particular discipline.

underpreparedness is expected to be remedied and transformed into proficiency. There exists the misconception or superficial notion that AL teaching involves “an autonomous list of transferable generic skills” (Jacobs, 2007: 875), the surface features of English and the rules of grammar which, once mastered, means a resolution of students’ difficulties in language and subsequently, improved academic performance. I concur with Jacobs (2007) that this type of understanding “perpetuates higher education practices that identify students as the problem, thereby absolving lecturers from critically reflecting on their own practices” (878). Street’s (2003) suggestion that “literacy varies from one context to another” and cannot be viewed as “neutral and universal” (77) is relevant to this study.

2.4.3 AL Modules offered at Tertiary Level

The AL modules or models outlined below serve as institutional measures used to meet the needs of a number of students whose inadequate academic literacy levels pose as a challenge to them being able to cope with the demands of the academic environment that constitute the tertiary studies. The reason for introducing the nature and scope of the academic literacy modules within this study is to contextualise the rationale of AL modules within the higher education environments. This is relevant as this study explores issues regarding the acquisition of discipline-specific literacies in science in the foundation modules of biology, chemistry, mathematics and physics offered within the FP. Furthermore, the outline of the scope of other AL modules helps draw some comparisons and contrasts with SCOM.

2.4.3.1 A Bridging Programme Model

van Wyk (2002) and van Wyk and Greyling (2008) outline the rationale for an academic reading and writing course at the University of Free State (UFS). They state that, in an attempt to address the issue of imbalances at secondary schooling and its impact on underpreparedness for tertiary level, UFS offered a year-long bridging programme in the early 1990s which included the English Language Course. The aim of the course was to develop students’ reading and writing potential so that they could reap academic success at tertiary level. The aim of concentrating on academic reading skills revolved around the need to pay attention to students’ comprehension and critical skills. The focus on reading had the dual purpose of improving students’ extensive and intensive reading capabilities.

Extensive reading skills ensured that students read widely and engaged meaningfully with a variety of books, simultaneously incorporating skills such as text processing skills and academic vocabulary acquisition; and intensive reading drew students' attention to pertinent features of a reading text. The course emphasized "explicit teaching of the process of reading-for-writing" (van Wyk, 2002: 228). The academic writing component of the course paid attention to the students' ability to express information and ideas clearly and logically. This course incorporated grammar as part of its syllabus and used the technique of process writing, i.e. the traditional writing process of planning, writing, revising and editing to enhance students' writing skills. Overall, it attempted to socialize the students into the academic discourse[34] community. Although this English Language Course identified reading as the core, it does bear similarities with the SCOM course offered in the FP. In the English Language Course, reading content is science-based and texts are deconstructed through the mechanism of scaffolding[35]. Writing in SCOM is developed and implemented in a similar manner.

2.4.3.2 The Writing Centre (WC)

Although academic models feature prominently in foundation programmes offered at tertiary institutions, the establishment of the Writing Centre (WC) has also become a common feature. The WC is often described as skills-based units that provide walk-in, individual consultancy services for students from all faculties and all academic levels of the university. The WC offers one on one consultation to assist students with a draft assignment or writing task. It has been intimated that a consultation is a useful moment of intersection between the content and the individual approach to learning (Harris, 1995). Archer (2007) explains that the WC was traditionally considered a remediation centre aimed at rectifying language deficiencies in students but its purpose has changed over the

[34] "A *Discourse* is a socially accepted association among ways of using language, of thinking, feeling, believing, valuing, and of acting that can be used to identify oneself as a member of a socially meaningful group or 'social network', or to signal (that one is playing) a socially meaningful 'role' " (Gee, 1990; 143). This concept is expanded on in Chapter 3.

[35] The term *'scaffolding'*, first used by Wood *et al.* (1976), refers to "the support that a teacher can give learners so that they can work at a much higher level than is possible on their own. Scaffolding support enables learners to successfully practise complex skills; as they become independently competent, the scaffolding is gradually withdrawn" (Rose *et al.* 2003). This concept is further explained in Chapter 3.

years. The WC has to now deal with the fact that most students at HEIs are expected to write in English, a language which is not their mother tongue. As a university endeavour, WC provides a service to all academically underprepared students, more especially those from disadvantaged backgrounds. However, all students need to learn the academic discourses of different disciplines and the WC is particularly useful since students come to tertiary institutions with different literacies and cultural conventions (Archer, 2007). One example of a WC is at the UCT. It emerged in 1994 as a result of concerns about the quality of student writing. This centre served as a consultancy unit for students from all faculties, including those registered for foundation courses. It was an initiative aimed at addressing the difficulties experienced by students with disadvantaged schooling backgrounds in acquiring academic literacy skills essential for university study, namely writing and reasoning skills.

The essential purpose of the WC was to offer individual consultancy with students and allow the writing consultants to work with teaching staff in various academic departments with the shared aim of making writing instruction an explicit, integrated component of course curricula (Churms, undated). The concept of cross-disciplinarity in such an intervention model is a useful way of creating dialogue and discussion around academic conventions. Although in this study I do not intend to explore the viability of the WC as a support mechanism, the provision of assistance in academic writing offered in it as a response to the challenges faced by the students who are not adequately prepared for academic writing in the higher education setting has certain parallels with the purpose of SCOM.

2.4.3.3 Embedded Models of AL

Other intervention measures offered at HEIs are best described as integrated models. An example of this is the AL course that was developed and initiated in 2001 at the Durban University of Technology (DUT), (formerly known as the Durban Institute of Technology) to serve the purpose of overt language intervention. According to McKenna (2003), this course which was embedded in the mainstream curriculum, facilitated negotiated collaboration between disciplinary specialists and academic literacy specialists. The purpose of doing so was to induct students into the literacy norms of disciplines. The foundation courses offered at DUT have been integrated into mainstream subjects and the consequence of this is that the AL lecturer has to interact with the mainstream lecturers. The integrated AL model had enabled the mainstream lecturers to make changes to their curriculum in respect of teaching methodology, syllabi and assessment in an effort to facilitate the students' acquisition of academic literacy. The AL module offered was assessed through discipline-specific portfolios and mainstream assessments. This intervention model contributed to the move from AL being a 'quick-fix' solution to a developing model owned by disciplines or departments who took charge of the change needed to improve students' academic literacies.

Such an AL course offered at DUT has useful links for this study which intends to explore the discipline-specific literacies needed in and for science in the FP; the perceived challenges that these discipline-specific literacies in science could present to the students in the FP; and, the extent to which the disciplinary specialists (who are referred to as DSs[36] in this study) who teach the foundation module in the disciplines of science pay any attention to such literacies in order to improve reading, writing, speaking and doing science.

Various studies have focussed on collaboration between academic literacy and disciplines within specific faculties. This allows the development of academic literacies such as reading, writing and speaking in the language of the discipline in which it is engaged. Such embedded courses involve the teaching of content knowledge by disciplinary specialists, with accompanying input about literacies fed from academic literacy specialists. AL modules are also embedded within particular disciplines at tertiary level. Jacobs' (2005a) study conducted within the context of an Engineering Faculty at the Cape Peninsula University of Technology explored the integrated role of embedding academic literacies in the various sub-disciplines of Engineering. This integrated approach promoted close collaboration between language and engineering lecturers achieved by placing language lecturers within the Engineering Faculty. It is in this context that Jacobs' (2005a) study enabled the teaching of reading and writing within the discursive practices of the different sub-disciplines of Engineering.

[36] The Disciplinary Specialists teach one of the following foundation modules in the BSc4 (Foundation) programme: biology, chemistry, mathematics or physics. In this study, they are referred to as DSs.

Jacobs' (2005a) findings indicate that engineering lecturers regard language lecturers as being responsible for inducting students into the literacy practices of engineering discourses. Her study also indicates that since engineering lecturers knew the rules of engineering discourse at an unconscious level, working with language lecturers would be able to allow the tacit knowledge of rules of engineering discourse to become more conscious and explicit to their students, thereby encouraging the role of collaborative partnership between members of two distinctive faculties: language and engineering.

This study is not angled at evaluating the various forms of academic literacy courses offered at tertiary level but drew attention to them in view of the nature of this study which is the acquisition of discipline-specific literacies in science.

2.5 Academic Writing

At tertiary level, students need to be inducted into academic writing. Academic writing indicates the extent of a student's content knowledge and the ability to write at an appropriate level using the appropriate genre, register and discourse of a particular discipline. Academic writing should not be viewed as a mere technical skill. Rather, academic writing should be viewed in the light of process writing that considers the epistemologies, practices and discourses of particular disciplines and their accompanying content. Students registered for the modules in the FP in science need to produce academic writing in science. They need to familiarize themselves with the writing conventions expected in different foundation modules in science at tertiary level. Dong (1997) notes that academic writing "involves learning a new set of academic rules and learning how to play by these rules. Often these rules change from discipline to discipline, and the audience and the purpose of writing vary according to each writing context" (10). Academic writing can thus pose a problem for students in the FP for whom English is a second or additional language, and who may have entered university with limited writing skills and may be grappling with the changes and challenges in writing conventions from secondary school to tertiary institutions.

At tertiary level, each discipline has its own conventions required for academic writing. There are academic writing tasks assigned to students in the foundation modules in science. Thus, students would need to acquire, engage and produce the academic writing demanded by each foundation module. As explained by Lea and Street (1998), learning to write in the academy means acquiring a repertoire of linguistic practices that are based on complex sets of discourses, identities, and values. This is further acknowledged by Paltridge (2004b) who states that “students learn to switch practices between one setting and another”. Johns (1997) and Samraj (2004) comment specifically on the academic essay. They state that there is no such thing as the one-size-fits-all academic essay that can be written in all areas of study. This view is supported by Zamel and Spack (1998) when they state that “it is no longer possible to assume that there is one type of literacy in the academy and that there is one ‘culture’ in the university whose norms and practices simply have to be learnt in order for our students to have access to our universities” (ix). Hyland (2002a), too, argues that we need to revisit the notion of specificity in the analysis and teaching of academic writing and focus on the texts, tasks, language features, skills and practices that are appropriate to the purposes and understandings of particular disciplinary communities. Academic writing involves the relationship between language, text and context, which is thus dependent on the use of Systemic Functional Linguistics (SFL) (Halliday, 1978).

2.6 Bloom’s Taxonomy (Bloom *et al.* 1956)

Benjamin S. Bloom (1956) and a team of researchers identified three domains of educational activities: cognitive (mental skills/knowledge), affective (growth in feelings or emotional area/attitude), and psychomotor (manual or physical skills). In this study, reference is made to the cognitive domain which involves knowledge or intellectual skills. The cognitive domain was further divided into six subcategories or levels which represented a hierarchy of learning from the simplest to the most complex. The categories of the cognitive domain are referred to as Bloom's Taxonomy of Learning (Bloom *et al.* 1956). According to Kreitzer and Madaus (1994), “the essential structure of the [t]axonomy was a cumulative hierarchy: *hierarchy* because the classes of objectives were arranged in order of increasing complexity, and cumulative because each class of behaviors was presumed to include all the behaviors of the less complex classes” (66). These six categories in the cognitive domain, from the simplest (or lowest level) to the most complex (or highest level) are illustrated in Figure 1 on the following page and is further elaborated on:

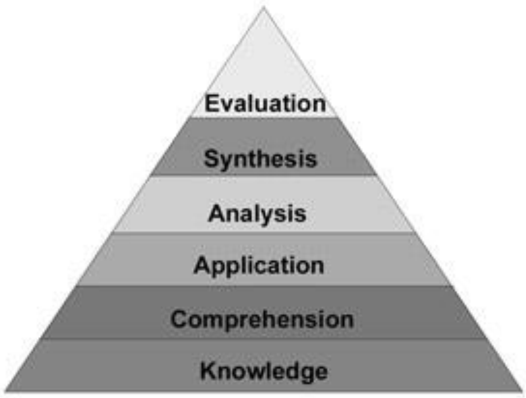

Figure 1: Bloom's Taxonomy: A multi-tiered model of classifying thinking (Bloom *et al.* 1956)

1. Knowledge - recall previously learned information.
2. Comprehension - the ability to grasp the meaning of material.
3. Application - the ability to use learned material in new and concrete situations.
4. Analysis - the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of the parts, analysis of the relationships between parts, and recognition of the organizational principles involved.
5. Synthesis - the ability to put parts together to form a new whole.
6. Evaluation - the ability to judge the value of material for a given purpose.

In Bloom's Taxonomy (Bloom *et al.* 1956) hierarchy, "knowledge and comprehension were regarded as lower-level processes whereas application, analysis, synthesis and evaluation were considered higher-level processes" (Kastberg, 2003: 402). Each successive level in this hierarchy requires mastery of all lower-level categories (Bloom *et al.* 1956). According to Forehand (2005), this means that a student functioning at the application level has also mastered the material at the knowledge and comprehension level.

Bloom's Taxonomy (Bloom *et al.* 1956) has been widely applied to many different learning environments and situations for a variety of purposes, i.e. designing assessments and designing coursework, designing curricula (Forehand, 2005). It has been useful for formulating course objectives and as a basis for providing a framework for devising performance and assessment tasks and questions. "It is a tool to devise, assess and evaluate student learning" (Lord and Baviskar, 2007: 41).

Categorising questions according to this taxonomy determines whether a task is cognitively undemanding (lower levels of questions) or cognitively demanding (higher levels of questions). Cotton (1988) explains that lower cognitive questions are also referred to as fact, closed, direct, recall and knowledge questions; higher cognitive questions are also called open-ended, interpretive, evaluative, inquiry, inferential, and synthesis questions. Accompanying each category of Bloom's (Bloom *et al.* 1956) cognitive domain (in Table 1 below) is a list of task words (or action verbs) which are also referred to as "question cues" (Dalton and Smith, 1986: 36); "language functions" (Kramer *et al.* 2010: 45); "key terms" (Bearne, 1999: 62); or "operative words" (Bulman, 1986: 188).

Thinking Skills	Question Cues
Evaluation	judge, select, choose, decide, justify, debate, verify, argue, recommend, assess, discuss, rate, prioritise, determine
Synthesis	create, invent, compose, predict, plan, construct, design, imagine, propose, devise, formulate
Analysis	analyse, distinguish, examine, compare, contrast, investigate, categorise, identify, explain, separate
Application	solve, show, use, illustrate, construct, complete, examine, classify, advertise
Comprehension	explain, interpret, outline, discuss, distinguish, predict, restate, translate, compare, describe
Knowledge	tell, list, describe, relate, locate, write, find, state, name

Table 1: Task words (Dalton and Smith, 1986: 36)

2.7 Transfer of Skills or Literacies

Learning to transfer literacies from one discipline to another is essential for students at university. Mestre (2002) defines transfer of learning as:

> the ability to apply knowledge or procedures learned in one context to new contexts. A distinction is commonly made between near and far transfer. The former consists of transfer from initial learning that is situated in a given setting to ones that are closely related. Far transfer refers both to the ability to use what was learned in one setting to a different one as well as the ability to solve novel problems that share a common structure with the knowledge initially acquired (3).

In the FP, students would benefit immensely if they transferred reading, writing and speaking literacies across the disciplines in which they have enrolled. Grayson (1997) outlines the need to 'teach for transfer' as being an educational philosophy of the FP in science:

> One reason to promote transfer of learnings is to deepen students' conceptual understanding by providing altered contexts in which to apply the concept. Another important reason is that it provides students with more than one opportunity and more than one context to practice a particular skill, be that skill cognitive, practical or metacognitive in nature. Whilst we believe that skills must be taught in the context of particular content, they should not remain context-bound. The application of a skill in several contexts reduces the chance that this will happen (112).

On the way in which transfer of learning takes place in the FP in science at UKZN, Kirby and Dempster (2011) state that:

> Teaching for transfer is a key instructional principle and this is facilitated by both a broad integration of the discipline modules, and also integration of the different components within each module. Specific content relevant to each subject is chosen as a vehicle for the development of useful scientific skills rather than for its own sake (1109).

When students acquire knowledge in a context that is relevant to them, it is stored in a mental box. In a new context, the student is unlikely to look in the mental box for knowledge already acquired unless of the course instructor cues him or her to do so (Bassok and Holyoak, 1993). This means that effective transfer is more likely to happen when students are consciously made aware of it and encouraged to actively apply knowledge in different and/or new contexts. In this regard, Perkins and Salomon (1998) point out that transfer does not "[take] care of itself" (23). This is supported by Boughey (2000) who advocates the need to make the "rules and conventions of academic disciplines as overt as possible" (289). This issue of transfer can be applicable to SCOM where students are apprenticed into the literacy practices of learning to write science genres (an issue already alluded to in Chapter 1 in this dissertation) which are fundamental for conveying scientific discourse in the FP disciplines of science.

When students compartmentalize their learning, this means that they are unable to successfully transfer the literacies in science that they have acquired in the AL classroom to their science learning contexts. According to Kirby and Dempster (2011), in the foundation biology module offered in the FP at UKZN, "apart from tutorial and practical components of the module, students are exposed to tasks that require them to practice their reading and writing skills in the form of independent reading and the submission of answers to written questions given as assessment tasks. However, because each of the assignments carries so few marks, many of the students elect not to do them or plagiarize from other students" (1114). Kirby and Downs (2007) claim that FP students generally show reluctance to take responsibility, motivate themselves and engage in self-regulated learning. This has not only been applicable to FP. An example of this occurring at mainstream level is cited by McKenna (2003) when she states that students who could write perfect essay introductions according to the academic criteria taught in English for Academic Purposes (EAP) classes, failed to do so in an essay assignment for a mainstream subject (60). Since students have problems with transferring specific strategies to the particular academic literacy demands of each course, Nel *et al.* (2004) recommend that "lecturers provide experiences that immerse students in the 'language of the academy' and the specialised languages of the disciplines" (100).

2.8 Facilitating Discourse Literacies

As communicated thus far, the role of the AL facilitator is to help induct students into the university environment by helping them acquire and develop the relevant literacy practices needed for academic discourse. Similarly, DSs whose task is to convey disciplinary knowledge to students should help induct them into the discourses required for their specific disciplines. This is an important facet of this study where the question of the ways in which DSs teaching in the FP assist students to acquire the literacies required for their respective disciplines is addressed through responses to critical research question 3. Researchers such as Kotecha *et al.* (1990) claim that "[s]ubject specialists are in the best position to know the language and conceptual demands of their courses" (211). Moore *et al.* (1998) state that "linguistic competence cannot be separated from the cognitive demands of [a] [task] ... and that explicit focus on language needed to be embedded in the teaching of mainstream courses" (11). This study seeks to ascertain the extent of this comment in the light of this study and, in doing so, to explore not only the views that the DSs have of AL, but also their understanding of the literacies required in the disciplinary discourse that they teach. This is obtained through critical research question 1.

Each discipline has its own specialised discourses and "subcultural rules" (Ballard and Clanchy, 1988: 14). Kapp (1998) describes these as "the specialized literacy practices which characterise disciplines, but which are seldom made explicit" (27). An interesting point Kapp (1998) raises is that many lecturers "assume that immersion in the discourse of the discipline will automatically result in sub-conscious acquisition" (28). She goes on to state that, in many cases, academics are themselves so immersed in their disciplines as to be unaware of the specificity of the cognitive and linguistic demands they are making (28). This brings me to the point of responsibility for disciplinary discourse practices.

Researchers have sought to encourage DSs who teach content knowledge to infuse literacy instruction with the teaching of content (Starfield, 1994; Johns, 1997; Moore *et al.* 1998; van Rensburg and Lamberti, 2004; Granville and Dison, 2005; Jacobs, 2007; Siebert and Draper, 2008). Having stated this, I would like to draw attention to the issue of resistance to incorporating literacies in content-area disciplines raised by various researchers (Stewart and O' Brien, 1989; Muth, 1993; O'Brien *et al*. 1995; Draper, 2002; Barton *et al.* 2002). A particular relevant point is the belief held by content-area teachers that: a.) they should not have to engage in literacy instruction because it is someone else's responsibility to teach reading and writing; b.) they lack the ability or training to teach reading and writing and; c.) they do not have the time to provide literacy instruction along with their full content curriculum (cited in Draper, 2002: 357). Similarly, Stewart and O'Brien (1989) have documented two factors underlying the resistance of content-area teachers to incorporate reading instruction in their content-areas: feelings of inadequacy or lack of confidence concerning their effectiveness at incorporating reading instruction into their content lessons; and, doubt about whether or not reading instruction should rightfully fall within their domain (397).

2.9 Epistemological Access in the HE Environment

Students need to acquire the literacies of specific disciplines to become members of the discipline. For McKenna (2009), this process of becoming part of a culture requires both engagement and immersion (13). Bartholomae (1985) describes this as the process of acculturation, stating that "to become members of a particular discipline, students have to appropriate (or be appropriated by) a specialized discourse, and they have to do this as though they were members of the academy" (4). This issue of acculturation is linked to 'epistemological access'. For Morrow (1994), this means that "mere formal access to institutions which distribute knowledge is different from and, not [a] sufficient condition for 'epistemological access', which is about learning the standards of practice or learning how to become a participant in academic practice" (77). In this respect, Clarence (2010) explains that "the academic staff and the students need to become explicitly aware of their discipline's 'epistemological core,' of the kind of knowledge valued by the discipline, of what kinds of knowledge are excluded from it and of which linguistic constructions are best used to represent those values" (19). The essence of this is that once students have been able to gain admission into HEIs and become part of the higher education process, it is the institutional environment that should aid in their acquisition of 'epistemological access'.

Rollnick (2010) elaborates on this issue of epistemological access by stating that "in order to become a participant in academic practice, students have to learn the forms of knowledge and accepted standards of the practice which may also be considered as 'gaining access' to the particular discipline" (93). This can be achieved if those involved in teaching at any level are able to encourage student participation in the learning environment. This point of view is further supported by Boughey (2005) who states that epistemological access is more than the provision of social and academic skills required to cope with academic learning. "It is about bridging the gaps between the respective worlds students and lecturers draw on" (Boughey, 2005: 240). She suggests that foundation programmes should be designed in a way that allows for engagement with the demands of the content material, enabling students to become participants in their discipline.

The FP in science should be able to develop students holistically in terms of epistemology, intellectual capacity and social functioning. Simply put, the foundation programmes should enable students to acquire discourse and also assist them in immersing themselves in the culture of the university. In other words, students need to become actively engaged in university activities; they would have to participate actively in the different disciplines. The students would have to learn the ground rules of a discipline which are the values, attitudes and ways of thinking characteristic of a discipline. This would include the acquisition of new knowledge in a specific discipline and the way in which new knowledge is produced.

Conclusion

This Chapter focussed on two crucial issues in this study, educational disadvantage and the LoLT especially for EAL students, linking these to the need for the provision of institutional academic support in the context of higher education, with specific reference to the provision of academic literacy. The salient issue of the nature of academic tasks and their dependency on well-developed CALP (Cummins, 1979) has been provided. The rationale for including an understanding of CALP (Cummins, 1979) is that academic reading and writing require CALP (Cummins, 1979). This Chapter has also shown the evolution of the concept of 'literacy' from being a mere reference to being able to read and write 'text' to one that incorporates multiple dimensions. One of the major issues that this Chapter has dealt with is that of the provision of academic literacy in the tertiary sector. This is especially relevant in this study which explores the acquisition of such literacies within the domains of not only science, but the science disciplines that cater specifically for students' from educationally disadvantaged backgrounds, who enter the HE arena confronted with language barriers (especially in light of the LoLT), complex readings and writing genres as well as the challenges of communicating disciplinary knowledge using the appropriate disciplinary discourse practices. This thus required a commentary on the role of DSs in disciplinary discourse facilitation, to enable participation in the university learning environment. The discussion of academic literacy is particularly relevant especially in the light of the inclusion of an academic literacy course in the foundation programme in science in this study. One of the particularly salient issues is that of the transfer of literacies across domains, especially from academic literacy, especially in light of infusing literacy with content. An understanding of disciplinary literacy is essential in light of the issue of discipline-specific literacies in this study. An understanding of Bloom's taxonomy (Bloom *et al.* 1956) has been outlined primarily for its use in devising performance and assessment tasks and questions in the foundation modules in science.

Chapter 3 offers a comprehensive outline of the theoretical and conceptual framework that informed and directed this study.

CHAPTER 3

THEORIES AND CONCEPTS TO THINK ABOUT THE PHENOMENON

Introduction

The previous Chapter made reference to the challenges presented to students who enter the HE sector where the LoLT is not their native language. They would have to use the LoLT to engage with conceptually dense academic texts especially if their CALP (Cummins, 1979) is inadequate for such textual engagement. The Chapter also offered the various definitions of literacy, and their role in negotiating academic texts. Included in the Chapter, was a description of institutional support measures offered in higher education sectors, focusing specifically on the development of AL. This was followed by an outline of academic writing and a discussion on Bloom's Taxonomy (Bloom *et al.* 1956). The latter is useful for formulating questions in science-related tasks. The Chapter concluded with reference to the key issues of discourse facilitation, acculturation and Morrow's (1994) "epistemological access".

This Chapter deals with the theoretical and conceptual framework of this study. It provides the theories, core concepts, terminologies and ideas that contribute to an exploration of this study that focuses on the acquisition of discipline-specific literacies for science in the FP. This Chapter commences by exploring the theory of New Literacy Studies (NLS) (Street, 1984; Gee, 1990) distinguishing, too, between the autonomous and ideological models of NLS. This has thus necessitated an explanation of Discourse (Gee, 1990) in the academic field as well as a discussion around concepts such as 'discourse practices' and 'discourse community' (Gee, 1990). This Chapter then distinguishes between 'primary' and 'secondary' discourse (Gee, 1999) and examines Bernstein's (1971) 'restricted' and 'elaborated' codes in use in differing situations and circumstances. Included in this Chapter, is an explanation of Bourdieu's (1977) 'cultural capital'.

The purpose of academic discourse as a mechanism to indicate the ability to participate within the academic environment is outlined. Owing to the need to be able to use academic language appropriately, this Chapter pays attention to the nature of three different academic literacies models (Lea and Street, 2006), i.e. study skills model, academic socialization model and the academic literacies model. A detailed explanation of Halliday's Systemic

Functional Linguistics (SFL) (1978; 1985a) is offered to show the relationship between language, text and context. This Chapter informs of the nature of Grammatical Metaphor (GM) (Halliday and Martin, 1993), paying specific regard to nominalisation and lexical density, especially for its use in the language of science as well as an outline of the meaning of 'construal' (Langacker, 1987). Thereafter, is an explanation of 'genres' and genre pedagogy (Hyland, 2002b) which are useful for this study which focuses on the genres required for conveying science discourse. This Chapter ends with a portrayal of pedagogic practices such as Zone of Proximal Development (ZPD) (Vygotsky, 1978b) and scaffolding (Wood *et al.* 1976) which are efficient teaching and learning tools to assist students' in their acquisition of science knowledge.

3.1 Interpreting the New Literacy Studies (NLS) (Street, 1984) and Gee (1990)

The New Literacy Studies (NLS), developed by the theorists Street (1984) and Gee (1990), proposes a new tradition of examining the nature of literacy. It views literacy as a social practice rather than the acquisition of skills (Street, 1984). "NLS takes a sociocultural view of literacy, emphasizing the description of literacy practices of everyday life, and challenging approaches which emphasize decontextualised basic skills" (Stephens, 2000: 10). From the NLS perspective, viewing literacy as a social practice means that it is dependent on context, on power relations and on the relationships that people form with each other when literacy comes into play (Dracklé, 2006). In other words, NLS argues that literacy is not a socially-neutral technique, but a socially-embedded practice, inseparable from the historically-specific ideologies and institutional frameworks within which cultural events of reading and writing are given shape and significance (Street, 1984; Collins, 1995).

NLS, which sees literacy as a social activity, is specifically relevant for this study especially since:

- it views literacy as a social practice ... that is always embedded in socially constructed epistemological principles;
- it is about knowledge; the ways in which people address reading and writing are themselves rooted in conceptions of knowledge, identity, and being;
- it is also always embedded in social practices, such as ... a particular educational context and the effects of learning that particular literacy will be dependent on those particular contexts and;
- the ways in which teachers or facilitators and their students interact

> is already a social practice that affects the nature of the literacy being learned (Street, 2003: 77 and 78).

The core element of this study is the discipline-specific literacies required by the FP students in order to acquire science discourse. Therefore, literacy is to be understood primarily within the framework of NLS which advocates a sociocultural view of literacy which represents a new tradition in considering the nature of literacy, focusing not so much on acquisition of skills, as in dominant approaches, but rather on what it means to think of literacy as a social practice (Street, 1984). This is because the literacies acquired are conveyed through the interaction between the students (who, in this study, are those registered in the BSc4 (Foundation) Programme) and the facilitators (who, in this study, are the ALSs and the DSs) within the educational context of science. The discipline-specific literacies in science enable students to gain epistemological access into the world of science, thus allowing for the construction of an identity first as science students; then, science graduates; and finally, as citizens of the country where they can contribute to future productivity and the development goals of the country in the fields of science, engineering and technology.

3.1.1 The Autonomous and Ideological Models of Literacy (Street, 1984)

Street (1984) distinguishes between the autonomous and ideological models of literacy. According to Street (2003), the autonomous model assumes that providing literacy to the illiterate poor, for example, has the advantage of enhancing their cognitive skills and improving their economic prospects, allowing them to develop into better citizens but it tends to neglect the core economic and social reasons for their literacy in the first place. The autonomous model does not indicate any cultural and ideological assumptions. Instead, it is a model which assumes that a neutral and universal literacy is capable of enhancing cognitive skills and improving economic prospects (77). The autonomous model views literacy independently of its social context.

Street (2003) holds the notion that literacy varies in context and culture; different literacies are expected to surface in different conditions. The ideological model offers a more culturally sensitive view of literacy practices as they vary from one context to another. This model does not merely view literacy as a technical or neutral skill, or as literacy being an acquisition of skills or decontextualised skills but rather frames it as always being embedded in socially constructed epistemological principles. The ideological model is about knowledge: the ways in which people address reading and writing are themselves rooted in conceptions of knowledge, identity and being.

“The ideological model sees literacy practices as being embedded in social practices such as those of a particular job market or a particular educational context and the effects of learning that particular literacy will be dependent on those particular contexts” (Street, 2003: 78). For Street (1984), “literacy practices” (1) are the beliefs that people have about reading and writing, which are not only embedded in cultural and social contexts but also in power and authority relationships (Street 1984). For Barton and Hamilton (2000), “the notion of literacy practices offers a powerful way of conceptualising the link between the activities of reading and writing and the social structures in which they are embedded and which they help shape” (7). Street’s literacy practices are intertwined with Heath’s (1983) literacy event which is defined as “any occasion in which a piece of writing is integral to the nature of the participants’ interactions and their interpretative processes” (50).

3.1.2 Using NLS in this study

Street’s (1995) ideological view of literacy which falls under NLS is the basis for the theoretical framework of this study. The reason for choosing the ideological view of literacy is that it emphasizes the contextual nature of literacy practices and the fact that literacy is socially constructed; it is not just technical and neutral skills, on the contrary, it is always embedded in socially constructed epistemological principles (Gee, 1990). This is relevant to this study as the research is undertaken in the specific context of science-based modules. With the ideological view of literacy being assumed to be a set of social practices, this study outlines that literacy has a social base. An interpretation of Street’s (1995) view of literacy as ideological implies that the cognitive processing of linguistic parts is wholly dependent on context because it takes place within cultural wholes and within structures of power (161).

The notion of literacy presented by Street (1984; 2003) is particularly pertinent to this study especially for critical research question 1 in terms of the discipline-specific literacies required to learn science. The acquisition of the literacies in science within the FP does not merely involve the acquisition of a series of technical vocabulary and grammar skills.

Conversely, it is the acquisition of literacies by students involved in the acquisition of scientific knowledge. It involves student engagement with scientific readings and writing, creating a space for the students to acquire practice in science meaning and discourse thereby enabling them to create for themselves a sense of identity and belonging in science. The responses of the research participants to critical research question 1 contribute to an understanding of the way in which the acquisition of the discipline-specific literacies helps to create an identity in science.

3.2 Literacy as Discourse

The issue of literacy as being a socially-embedded practice has also been advocated by other theorists. Gee (1996) not only argues for a contextual understanding of literacy but also, more specifically, that literacy is a discourse. Discourses, according to Kress (1989), are "systematically-organised sets of statements which give expression to the meanings and values of an institution" (7). He goes on to say a discourse provides a set of possible statements about a given area, and organises and gives structure to the manner in which a topic, object or process is to be talked about (7).

Like Street (1984), Gee (1990) sees literacy as a socially-constructed practice in which individuals are active agents who construct meaning while they develop perceptions, values, goals, and purposes about ways in which literacy is used. It is for this reason that he sees literacy as being embedded within particular sociocultural contexts, within specific social practices and within specific discourses (Gee, 2001). This is a construction of literacy as "ways of being in the world, or forms of life which integrate words, acts, values, beliefs, attitudes, social identities, as well as gestures, glances, body positions and clothes" (Gee, 1990: 142). An acquisition of these practices within specific contexts means gaining membership into a particular discourse community (i.e. the community of science) which would have been ascertained from critical research question 1. Discourse is embedded in "communities of practice" (Lave and Wenger, 1991), including the subject-matter and disciplinary communities in which the students are socialized. The issue of the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies is, in the context of this study, explored via the responses to critical research question 2.

Gee (1990) distinguishes between the "use of discourse (with a lower case "d") and Discourse (with upper case "D"); the former (discourse) is used in connected stretches of language that make sense, like conversations, stories, reports, arguments, essays while the latter (Discourse) is always more than just language; it is a saying-writing- doing-being-valuing-believing combinations" (142). Gee (1989; 1990) employs the upper-case "D" to indicate a larger, more encompassing view of discourses (thus, *D*iscourses) as "identity toolkits that involve more than textual forms" (Hicks, 1997: 464).

Arising from this, Gee (1990) defines Discourse as a socially accepted association among ways of using language, of thinking, feeling, believing, valuing and of acting that can be used to identify oneself as a member of a socially meaningful group or 'social network', or to signal a socially meaningful role (143). Discourse, thus, does not only include ways of speaking, reading and writing, within particular contexts, but also ways of behaving, interacting, valuing, thinking and believing that are acceptable within specific groups of people in particular contexts. "A Discourse is a sort of 'identity kit' which comes complete with the appropriate costume and instructions on how to act, talk, and often write, so as to take on a particular social role that others will recognize" (Gee, 1990: 142). These notions of discourse are relevant in this study as students need to acquire the appropriate discourse in science, to acquire an identity in science. They need to be able to read, write and talk the language of science so that they can become members of the community of science. This ties up with NLS, mainly the contextual nature of literacy practices and the fact that literacy is socially constructed.

Discourse is not separable from social practices. With regard to the issue of Discourse, Gee (1989) states that discourses govern how we talk, think, and interact as members of a culture. Gee (2001) elaborates on the interpretation of discourse, maintaining that "a discourse integrates ways of talking, listening, writing, reading, acting, interacting, believing, valuing, and feeling in the service of enacting meaningful socially situated identities and activities" (719).

Draper (2008) identifies the relevance of these definitions of discourse to content-area teachers who maybe striving in their attempts to help students to acquire new identities (71). This idea is further accented by Wenger (1998) who states that "it is in content-area classrooms where students are able to master or control a particular discourse; this is done by helping students to learn how to act appropriately and interact with the texts used to communicate and participate within disciplinary communities of practice" (127).

Gee (1999) distinguishes between "primary discourses and secondary discourses: primary discourses being the way of using language a child acquires in its first few years of life through primary socialization within the family; and, secondary discourses which are developed in association with and by having access to and practice with secondary institutions such as schools, workplaces, stores, government offices, businesses, and churches" (5). For Gee (1987), "the primary discourse is the oral mode which is developed in the primary process of enculturation" (5). He goes on to explain that "secondary discourse involves uses of language either written or oral or both that go beyond primary discourse" (Gee, 1999: 6). It is the challenges of the secondary discourse – in the way that it is used in science that this study explores.

3.2.1 Discourse Practices

According to Gee (1990), "discourse practices are always embedded in the particular world view of particular social groups: they are tied to a set of values and norms. In apprenticing to new social practices, a student becomes complicit with this set of values and norms: this world view. The student is acquiring a new identity, one that at various points may conflict with [his] initial enculturation[37] and socialization, and with the identities connected to other social practices in which [he] engages" (67). This view of discourse practices by Gee (1990) highlights the link between language and literacy acquisition, as forms of socialization into mainstream ways of using language in speech and print and mainstream ways of taking meaning and making sense of experience. The view of literacy put forward by Gee (1999) as that which is "mastered through acquisition ... it requires exposure to models in natural, meaningful and functional settings" (6) is pertinent to this study. This is mainly because it explores the issue of discipline-specific literacies in science that students acquire within the FP.

[37] "The socio-cultural view suggests learning is not necessarily an individual, isolated activity, but instead usually takes place in a historical, social and cultural context. The focus in this view is on the 'internalisation and appropriation of cultural tools and knowledge' (Luckett and Luckett, 2009: 470) through a process of enculturation or induction, whereby the learner accesses the Discourse of the discipline or community" (Ellery, 2011: 1079).

3.3 Distinguishing between Bernstein's (1971) Language Codes

Literacy enables individuals to gain membership into particular discourses. According to Bernstein (1971), people learn their place in the world by virtue of the language codes that they use. It is the social theory postulated by Bernstein (1971) which states that people have different ways of using language, or coding orientations which are manifested in the ways in which they participate in interaction. It is this theory that suggests that "people are positioned differently ... based on the social relations that are characteristic of their experiences in a particular social class and culture; [t]he coding orientations mean that even when participating in the same contexts such as schooling, students from different backgrounds will use language in different ways" (Colombi and Schleppegrell 2002: 9). Bernstein (1971) advocates the sociolinguistic theory of coding – the 'restricted' and 'elaborated' language codes. According to Bernstein (1971), the code used by an individual symbolizes their social identity.

The restricted code is suited for situations where there is a great deal of shared and taken-for-granted knowledge amongst a group of speakers. "The restricted code is economical and rich, conveying a vast amount of meaning in a few words, each of which has a complex set of connotations" (76). According to Dawson (2005), people who use the restricted code rely upon shared background knowledge and understandings between those included in their group. Restricted codes are used amongst family and friends in close socials settings and are implicit. Yi (2012) describes the restricted code as being more localized, stereotyped and contingent. In respect of this study, the restricted code, as was Gee's (1999) primary discourses, is insufficient for students to engage with scientific texts.

The elaborated code is used in circumstances wherein everything needs to be spelled out so that people can understand what is being said (Dawson, 2005). It is thus explicit and specific (Bernstein, 1972: 476) or "abstract and context-independent" (Yi, 2012: 2). "Little, if any, prior or shared understanding or knowledge is assumed" (Bernstein, 1971: 135). The use of the elaborated code gives a student cultural or 'symbolic capital' that can translate into power and goods (Kelder, 1996). Neither of the two codes is superior to the other. According to Bernstein (1971), people who were more mobile geographically, socially and culturally found use for both the restricted and the elaborated codes. The restricted code could be used in local contexts featuring close interpersonal relationships while elaborated code would be employed in communicating with outsiders from the wider society.

Just as both Street (1984) and Gee (1990) who do not see literacy as a technical skill but rather as a social practice, Bernstein (1971) too sees a link between language and culture. He states that language is more than just grammar and vocabulary. Language shapes the essential characteristics of culture and enables the formation and expression of cultural identity. "The way in which speech codes are realized is a function of the culture acting through social relationships in specific contexts" (Bernstein, 1971: 173-174).

The restricted codes and the elaborated codes have bearing in this study. Students who are enrolled in science modules in the FP are more likely to be exposed to the elaborated language code used by DSs to disseminate science content. "Speakers of the elaborated code use longer, more complex, and more grammatical sentences, and a more varied vocabulary ... the language of the elaborated code speaker is more abstract, logical and precise ... written text[s] [seem] to contain a very elaborated code" (Schallert *et al*. 1977: 18). Although students may have some degree of prior knowledge in science from their secondary schooling, they could very likely have less knowledge of discipline-specific literacies in science. Seeing that the elaborated code is generally viewed as being complete and detailed, students registered in the FP in science would need to make sense of the explicit language that is used to teach science content. Students will have to become familiar with using the elaborated language code to communicate with the 'outsiders' (the DSs) from the wider society (the university). The students will then be able to acquire the necessary science discourse and create for themselves a sense of cultural identity within the academic setting of the university. In the previous Chapter, reference was made to the fact that students need to acquire an understanding of academic discourse for which they need CALP (Cummins, 1979). The reference to the "elaborated code" (Bernstein, 1971) is significant in this study because it is the code through which academic discourse in the disciplines of science is mainly conveyed.

3.4 An Understanding of Bourdieu's (1977) "Cultural Capital"

While Bernstein (1971) theorised about the restricted and the elaborated codes, Bourdieu (1977) developed the concept of cultural capital. For Bourdieu (1977), as with Bernstein

(1971), “language is conceptualized as a complex symbolic means through which knowledge is transmitted and transmuted, identities are constructed and expressed, and class legacies organized and imposed” (Collins, 2000: 66). The relation between institutional expectations and student language was theorized and analyzed in terms of cultural capital (Bourdieu, 1977). This concept of cultural capital, especially in its “institutionalised state such as educational qualifications” (Nash, 1990: 432) is relevant to this study. Bourdieu (1977) states that cultural capital consists of familiarity with the dominant culture in a society, and especially the ability to understand and use 'educated' language. The possession of cultural capital varies with social class, yet the education system assumes the possession of cultural capital. This makes it very difficult for lower-class pupils to succeed in the education system. Bourdieu (1977) claims that, since the education system presupposes the possession of cultural capital, which few students in fact possess, there is a great deal of inefficiency in 'pedagogic transmission' (i.e. teaching). “This is because students simply do not understand what their teachers are trying to get across” (Sullivan, 2002: 145). Students are thus seen in a deficit light.

The notion of cultural capital is significant in this study especially since the students in the FP, as EAL speakers, are compelled to gain knowledge at the research site of this study (a university in South Africa) in a language that is not their ‘own’, i.e. English and “students are outsiders to the discourses of academia” (Smit, 2010). Thus, where home language and literacy socialization patterns differ, there exists the likelihood of emergent challenges in respect of the use and understanding of the language which in this study is the language of science discourse, an issue addressed in this study through critical research question 2. Debates on the language policy of the tertiary sector is not within the scope of this research, however the responses from both the DSs and the ALSs in this study serves to show how pedagogical practices implemented in FP help address challenges created through language barriers in the research site chosen for this study.

3.5 The Purpose of Discourse

The value of discourse is further outlined by Leibowitz (2005). According to Leibowitz (2005), discourse is used in different settings in a variety of ways. She explains that discourses include attitudes, ways of behaving, ways of using print literacy, gesturing, or thinking, and they are strongly influenced by ideology, social class and power relationships. She also highlights the fact that an individual may master or adopt a variety of these discourses during his or her life and within different settings. Leibowitz (2005) concurs with Street (1984) in stating that literacy, which is closely associated with language and discourse, is a social practice. Literacy, is embedded in, and influences, the social settings in which it is practiced. Gibbons (2007), too, claims that "one of the major functions of classroom discourse is to socialize learners into the kinds of discourse associated with academic learning" (704).

McMillan (2005) explains that at university, usually for the first time, students are faced with field-specific discourse and are required to take an active role from within this new discourse. McMillan (2005) cites Dison and Rule (1996) who provide a metaphor for understanding what discourse is and how it operates. They suggest that a discipline might be understood as a subculture. Its discourse is made up of codes (linguistic, intuitive, creative, etc.), conventions (essay structure, research, referencing, reporting, etc.), concepts (main ideas and debates in the discipline etc.), values (what qualifies as knowledge or evidence, and caring, etc.), canons (primary texts and theories/authorities, etc.), and skills (both cognitive and linguistic) in order to operationalize within specific discourses at university. Added to this, is the relevance of the registers associated with academic learning and language, which are "the specific technical language and grammatical patterns - and generic structures particular to that subject" (Gibbons, 2007: 702). This indicates that students studying a particular discipline, such as science content, need to learn about its salient discourses in order to reap academic success in the discipline.

3.6 Academic Discourses

According to Duff (2010) academic discourse refers to "forms of oral and written language and communication – genres, registers, graphics, linguistic structures, interactional patterns" (175). Lee and Fradd (1998) offer a comprehensive explanation of academic discourse, which they say is:

> closely related to literacy development and refers to the language used in abstract, decontextualized activities requiring students to work independently, to rely on their own understandings of both the language and the content of the task, and to be singly responsible for an outcome (15).

Academic discourse is usually linked to specific disciplines or professional areas. In this regard, Airey and Linder (2009) interpret disciplinary discourse as embracing a variety of modes such as "spoken and written language, mathematics, gesture, images (including pictures, graphs and diagrams), tools (such as experimental apparatus and measurement equipment), and activities (such as ways of working – both practice and praxis, analytic routines, actions, etc.)" (27).

For students to perform at university level, the academic discourse needs to be acquired, developed or learnt. Students need to be able to write in specific contexts for specific audiences. To do so, they need to acquire the conventions of the discipline. Academic discourse is "a form of enculturation, social practice" (Duff, 2010: 170). However, in terms of enculturation into the discipline, Emerson *et al.* (2006) reflect that it is not only about the language issue but also the conventions of knowledge and thinking (67). Prior (1998) regards disciplinary enculturation as very much a case of ongoing negotiation between students and their professors, mentors, and peers, rather than just a case of learning the language and culture of the academy.

Entering the academic arena means that students need to become part of the discourse community. Berkenkotter *et al.* (1991) indicate that "discourse communities are not physical entities but are inferred from the discourse through which the members of community communicate" (191). Thus, discourse community is a powerful metaphor joining writers, texts and readers in a particular discursive space (Porter, 1992). In Herrington's (1985) view, a community is created through on-going interactions and shared sense of roles and purposes. According to Gee (1990), becoming accepted as a member of a discourse community involves becoming part of the culture and taking on the values of the discourse community. Ivanič (1998) offers a comprehensive interpretation of discourse community as:

> The abstract element in the term 'discourse community' relates to the context of culture, the socio-historically produced norms and conventions of a particular group of people who define themselves by, among other things, their discourse practices ... When people interact with each other mainly through written language, their sense of 'community' may seem to be held together by abstract norms and conventions, rather than the identities, values and practices of real individuals (78).

A more concrete description of discourse community is where Harris (1989) refers to many theorists who seem to want to use the term to suggest that "there really are 'academic discourse communities' out there, real groupings of writers and readers, that we can help 'initiate' our students into" (15).

Since the students in the FP are registered for foundation modules in biology, chemistry, mathematics and physics, they are exposed to the spoken and written conventions and discourses pertinent to a specific module. Each module carries its own register, discourse and epistemologies to which students are exposed and expected to use. This study, by means of the inclusion of critical research question 1, examines the discipline-specific literacies needed for science.

Indications in this study have shown thus far that "literacy is a social practice" (Street, 1984); and students need to be apprenticed into the discourse community of science. For students to gain "epistemological access" (Morrow, 1994) into science, they need access to "the ways of being" (Gee, 1996) in the disciplines; they need to learn the Discourses (Gee, 1990) of the discipline. To participate in academic practices, they need effective use of both secondary discourses (Gee, 1999) and the elaborated code (Bernstein, 1971). For this to happen, the Discourses (Gee, 1990) need to be made explicit. Chapter 2 isolated the purpose of academic literacy and foundation programme measures in contributing to the possibility of this goal being attained.

3.7 Academic Literacies

Lea and Street (2006) define academic literacies as "the diverse and multiple literacies found in academic contexts such as disciplinary and subject matter courses" (227). However, perceptions of academic literacy have been subject to change. Paltridge (2004b) explains that "there are those who would view academic literacy as a singular phenomenon, comprising a set of skills to be acquired and problems to be fixed; [a] different view would see the development of academic literacy as a socialization process through which we explain university culture to [our] students so they can learn its requirements through a kind of apprenticeship" (90).

Lea and Street (2006) have suggested three models by which student writing and literacy in academic contexts can be contextualised. These being:

> 1. The study skills model which sees writing and literacy as primarily an individual and cognitive skill. This approach focuses on the surface features or language form and presumes that students can transfer their knowledge of language and literacy unproblematically from one context to another.
>
> 2. The academic socialization model is concerned with students' acculturation into disciplinary and subject-based discourses and genres. Students acquire the ways of talking, writing, thinking, and using literacy that typified members of a disciplinary or subject area community. The academic socialization model presumes that the disciplinary discourses and genres are relatively stable and that once students have learnt and understood the ground rules of a particular academic discourse they are able to reproduce it unproblematically.
>
> 3. The academic literacies model is concerned with meaning making, identity, power and authority and foregrounds the institutional nature of what "counts" as knowledge in any particular academic context (368).

The academic socialization model is pertinent in this study because it is "concerned with students' acculturation into disciplinary and subject-based discourses and genres" and "[s]tudents acquire the ways of talking, writing, thinking, and using literacy that typified members of a disciplinary or subject area community" (Lea and Street, 2006: 368).

An academic literacies approach sees learning to write in the academy as learning to acquire a repertoire of linguistic practices which are based on complex sets of discourses, identities and values (Lea and Street 1998). An academic literacies perspective treats reading and writing as social practices that vary with context, culture and genre (Street, 1984). The literacy practices of academic disciplines can be viewed as varied social practices associated with different communities. In addition, an academic literacies perspective also takes account of literacies which are not directly associated with subjects and disciplines, but with broader institutional discourses and genres. An academic literacies perspective views student writing and learning as issues of epistemology and identities, rather than of skill acquisition or academic socialisation alone, although the perspectives are not mutually exclusive and individuals may move between them according to context and purpose. From the student point of view, a dominant feature of academic literacy practices is the requirement to switch their writing styles and genres between one setting and another, to deploy a repertoire of literacy practices appropriate to each setting, and to handle the social meanings and identities that each evokes (Lea and Street, 2006: 368). Both the academic socialization model and the academic literacies model pay attention to the relationship between epistemology and acts of writing and literacy in subject areas and disciplines (Bazerman, 1988).

Responses to critical research question 1 in this study can reflect which of these three models – the study skills model of literacy, the academic socialization model or the academic literacies model is effective for the acquisition of literacies in science. Both the academic socialization model and the academic literacies model satisfy the requirements of NLS in view of its sociocultural view of literacy which views literacy as social practice; and in terms of meaning making and the construction of identity. The academic socialization model helps with the acculturation of students into disciplinary and subject-specific discourses and genres.

In light of this, this study explores the literacy practices adopted by DSs to engage the students in science to facilitate not only acquisition of knowledge and language, but also to enable the students to be apprenticed into the university community and the various disciplines that students will encounter as they progress in the pursuit of their undergraduate and perhaps later, postgraduate studies. At this point, to strengthen this view, it is useful to quote Ballard and Clanchy (1988) who maintain that:

> learning within the university is a process of gradual socialization into a distinctive culture of knowledge, and that 'literacy' must be seen in terms of the functions to which language is put in that culture ... [t]he task required of the student, then, is to learn not only the general rules of discourse and argumentation that sustain the culture but also the appropriate disciplinary or sub-cultural rules which govern how thinking and ... language may function in specific contexts of knowledge (14).

3.8 Systemic Functional Linguistics (SFL) (Halliday, 1978)

Coffin and Donohue (2012) describe Systemic Functional Linguistics (SFL) (Halliday 1978; 1985a) as a theory of language which highlights the relationship between language, text and context. It sets out to explain how humans make meaning through language and other semiotic resources, and to understand the relationship between language and society (65). This means that language cannot be separated from either its speakers or its context (Holtz, 2009). For Polias (2004), context is the non-verbal environment of the text. It is made up of two parts: the broad context of culture and the more specific context of situation.

Halliday and Martin (1993) summarize the five orientations of SFL as:

- the description of language as a resource rather than a system of rules;

- concern[ed] with texts - rather than sentences – as the basic unit through which meaning is negotiated;
- focuses on the solidary relations between texts and social contexts rather than on texts as decontextualized structural entities in their own right;
- concern[ed] with language as a system for construing meaning and;
- developing an elaborate model in which language ... can be viewed in communicative (i.e. semiotic) terms (22).

Halliday (1994) sees language as a social phenomenon and language is explained as a result of countless social interactions. "Halliday's (1994) Systemic Functional Linguistics model sees language as a social meaning system where text is situated in context. Hence, every interaction reveals some information about the situational context itself and the cultural context in which that language is used" (Polias, 2004: 3). As a theory of language, SFL is particularly relevant for this study in terms of the way in which it highlights the relationship between language, text and context. One of the key tenets of SFL is that language is a resource for making meaning. In this study, students need to understand how language is used to convey meaning in specific contexts of situation, showing the interrelationship between language and context. In SFL, texts are analysed in terms of linguistics as well as its social meaning, fitting in with the NLS view of literacy as being a social phenomenon. Critical research question 1 of this study outlines this relationship between language, text and context. SFL sees language and social context as complementary abstractions, which is outlined in Figure 2 below:

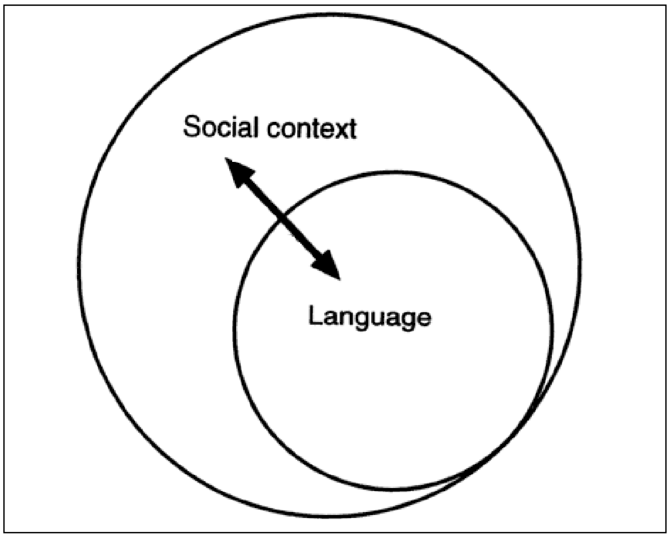

Figure 2: Language as the Realization of Social Context (Martin, 1997: 4)

In the model (Halliday and Martin, 1993; Martin, 1997) above, concentric circles are used to illustrate the establishment of one semiotic system (language) as the realization of another more abstract semiotic system (social context). Halliday and Martin (1993) explain that "the notion of 'realization' implies that one system redounds with the other: language construes, is construed by and (over time) reconstrues and is reconstrued by social context. Their use of the double headed arrow in the diagram symbolizes this mutual determination" (24). Expanding on this, Derewianka (2007) notes that "context and language are co-constructed: the context helps to shape [the] use of language and the language choices [made] to help to shape the context" (849).

In SFL, the immediate context of a text is described in terms of the main variables that influence the way language is used (Mohan and Slater, 2005: 155): 'field' (the subject matter or the activity being developed), 'tenor' (the social role and relationships between the interactants) and 'mode' (the medium and role of language) (Derewianka, 2007: 849). In terms of this study, SFL is necessary in exploring the role of language in disciplinary meaning making and this is explored through critical research question 1 which pays attention to 'field' and 'mode'. The way in which 'tenor' influences how language is used in context is explored through critical research question 3. By doing so, this satisfies the dictates of SFL which is to expand students' meaning making resources by providing them with the linguistic competencies necessary to do so, allowing them to engage with the discourses of the academy.

For Halliday (1985a), the structure of language reflects the functions it serves, as indicated in the following metafunctions:

- experiential or ideational function (representing our experiences of the world);
- the interpersonal function (mediating interaction) and;
- textual function (structuring the flow of information) (Derewianka, 2007: 849).

The three main variables (field, tenor and mode) are respectively related to each of the three metafunctions as indicated in the Table 2 below.

Metafunction	Contextual correlate
Experiential or ideational	Field
Interpersonal	Tenor
Textual	Mode

Table 2: Metafunctions and Contextual Categories (Adapted from Halliday and Martin, 1993: 30)

In representing the social action, the field refers to the nature of the social action that is taking place: what is it that the participants are engaged in? Depending on the field being developed, certain choices will be made from the experiential or ideational system. Tenor is indicative of the role structure, referring to who is taking part, the nature of the participants, their statuses and roles: and what kinds of role relationships are obtained among the participants. Depending on the tenor of the situation, certain choices will be made from the interpersonal system. Mode, in representing the symbolic organization, refers to the role language is playing, in other words, what is it that the participants are expecting the language to do for them in the situation. Depending on the mode and medium, certain choices will be made from the textual system. In any given utterance, all three metafunctions operate simultaneously (Halliday, 1985a; Halliday and Martin, 1993; Schleppegrell, 2002; Derewianka, 2007). Halliday and Martin (1993) describe this as the metafunctional cross-classification of planes which they have represented diagrammatically in Figure 3 below.

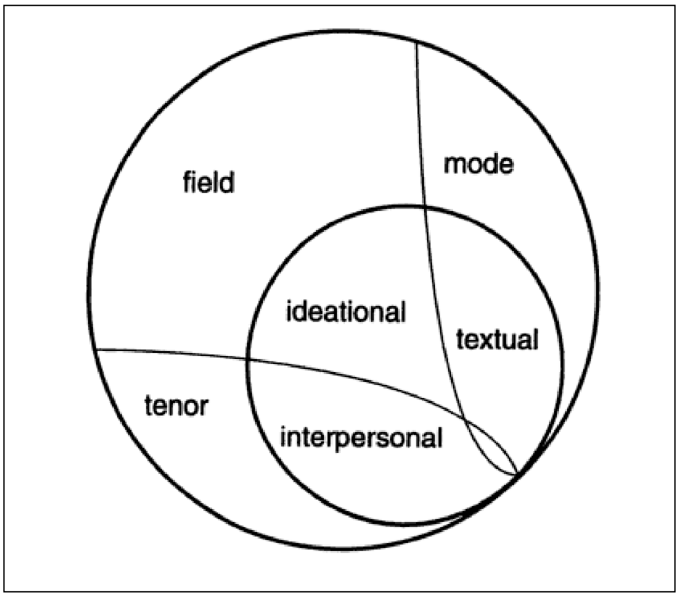

Figure 3: Meta-functional solidarity across planes (Halliday and Martin, 1993: 30)

Figure 4 on the following page is a comprehensive diagrammatic representation of Halliday's (1994) SFL (adapted from Polias, 2004; Halliday and Martin, 1993: 30).

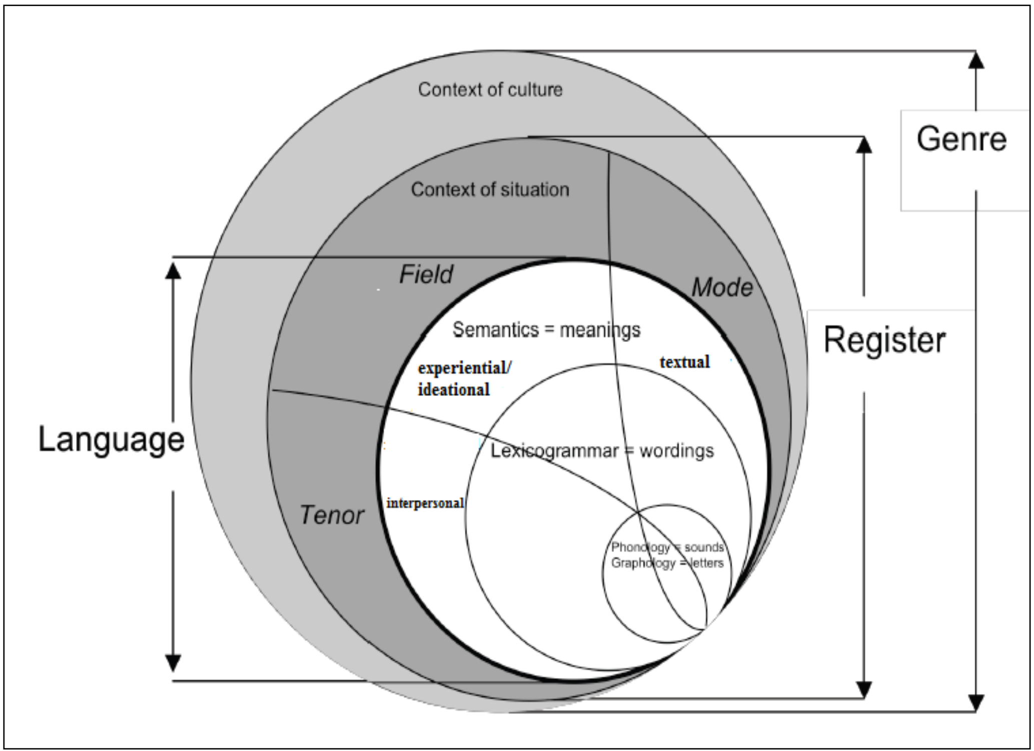

Figure 4: Halliday's Functional Model of Language (adapted from Polias, 2004: 3; Halliday and Martin, 1993: 30)

In the diagram above, Polias (2004) explains that context is the non-verbal environment of the text and it is made up of the broad context of culture and the more specific context of situation. The context of situation is organized according to field, tenor and mode. The combination of these three variables makes up the register (4). A register is the constellation of lexical and grammatical features that characterizes particular uses of language (Halliday and Hasan, 1989; Martin, 1992). "Registers refer to the fact that the language we speak or write varies according to the type of situation" (Halliday, 1978: 31).

On the subject of registers, Schleppegrell (2001) states that:

> Registers vary because what we do with language varies from context to context. The choice of different lexical and grammatical options is related to the functional purposes that are foregrounded by speakers/writers in responding to the demands of various tasks. Texts produced for different purposes in different contexts have different features ... In other words, the grammatical choices are made on the basis of the speaker's perception of the social context, and those choices then also serve to instantiate that social context (432).

Register, which outlines the link between context and lexicogrammatical choices, is a fundamental element in this study as students studying the disciplines of science need to become conscious of register as a mode of conveying science content knowledge. Register distinguishes one type of genre from another. Furthermore, the register that is required in academic reading and writing differs immensely from that of everyday conversation. (Register, in the context of language in science, is discussed in Chapter 4 in this study).

The social context determines grammatical options. The social context includes what is talked about (field), the relationship between speaker and hearer or between writer and reader (tenor), and expectations for how particular text types should be organized (mode) (Halliday, 1994). Hasan and Perrett (1994) mention that the Systemic Functional (SF) model recognizes three strata that are internal to language (as denoted in Figure 5 below): 1.) semantics; 2.) lexicogrammar; and 3.) phonology (188). Derewianka (2007) draws attention to language that operates at each level: the semantic plane (meanings), the content plane (lexico-grammar), and the expression plane (phonology: sounds and graphology: letters). These levels are related through a process of realization (850). Meanings are expressed through words and patterns; and sounds and letters.

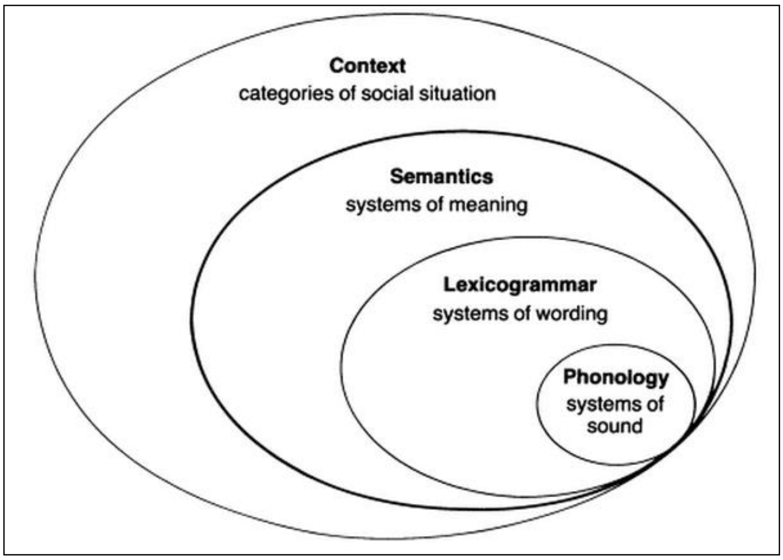

Figure 5: The Four Strata of the SF model (Hasan and Perrett, 1994: 189)

In terms of semantics and metafunctions, experiential meaning considers the use of grammar in construing [one's] experiences of the world (in terms of the kinds of events taking place, the participants in the events and the circumstances surrounding the events); interpersonal meaning is concerned with the grammatical resources for interacting and the development of subjectivity (e.g. speech functions and speech roles); and textual resources which make a text coherent and cohesive, organizing the flow of information in particular ways (Hasan and Perrett, 1994: 183; Derewianka, 2007: 850).

In summary, Gibbons (2007) states of SFL that:

> the experiential and the interpersonal metafunctions of language exist in any instance of language use at one and the same time; language not only is the means by which experiential learning is constructed but also, through its interpersonal resources, constructs the role of relationships and the identities of interactants in a particular situational context (706).

Briones *et al.* (2003) regard Halliday's (1985a) Systemic Functional Theory as being functional in three respects:

> a) it is designed to account for how language is used and the way it is organized to fulfil communicative functions;
> b) each element in a language is explained by reference to its function in the total linguistic system; i.e. each part is functional with respect to the whole system; and,
> c) it aims to account for three basic kinds of meaning – ideational, interpersonal and textual (136).

3.9 Explaining 'Construal'

Another relevant issue in this study is the central claim of cognitive grammar that grammar is symbolic, which is the pairing of the semantic and phonology structures. Langacker (1988) states "[g]rammar is intrinsically symbolic, having no independent existence apart from semantic and phonological structure. Grammar is describable by means of symbolic units alone, with lexicon, morphology, and syntax forming a continuum of symbolic structures" (5). "This 'unit' comprises all and only those cognitive structures which are automised by the speaker in such a way that they can be used as integrated wholes, without the speaker having to pay attention to their individual parts" (Langacker, 1987: 494). The symbolic unit is the symbolic relationship between the semantic and phonological structures, thus making grammar meaningful. However, the meaningfulness of grammar is a reference to its conceptual semantics; it has to fully accommodate our manifest and multifaceted ability to construe the same situation in many different ways as an expression's meaning is not just a matter of the conceptual content it evokes, but is equally dependent on the construal it imposes on that content (Langacker, 1993; 2003).

Construal combines a set of basic human cognitive abilities with which speakers operate when they verbally convey their specific conceptualization of an event (Langacker, 1987). Construal rests on mental operations by which speakers structure a given situation, comprising their ability "to construe a situation in alternate ways for purpose of thought or expression" (Langacker, 1991: 549). As situations and events can typically be arranged in alternate ways, the choice of particular lexemes and particular grammatical structures mirrors only one of different possible construals (Höche, 2009). Höche (2009: 56) mentions Langacker's (1987) position that meaning is a function of both conceptual content and the image imposed on it by way of the following expressions:

i. A car hit Cathy.
ii. Cathy was hit by a car.

In the above expressions both evoke the same conceptual concept, yet they differ semantically due to the different construals they verbalize. In the examples above, this difference lies in the prominence which is given to the participants of the event, i.e. whether the attention is directed at the *car* (as in *i*.), describing what the car 'did', or at *Cathy* (as in *ii*), focussing on what happened to her (i.e. *Cathy*).

Similarly, Halliday (1994) writes that experience of the phenomenal world is construed by language; in other words, experience is transformed into meaning; the transformation is effected by the grammar of [the] language – the grammatical systems of [the] language, and the words and structures through which these systems are realized (9). It is thus through Halliday's (1985a) grammatical metaphor that everyday meanings are construed in new ways.

This concept of construal is addressed in this study through the responses to critical research question 2 as a way of knowing how students construe conceptual content in science.

3.10 Grammatical Metaphor (GM) (Halliday and Martin, 1993)

Halliday (1985a) explains that there are two kinds of expressions:

a. congruent, non-metaphorical or non-marked; and,
b. incongruent, metaphorical or marked

Briones *et al.* (2003: 139) offer examples of each of the above:

a) The light that <u>is emitted</u> by a fluorescent tube ... (congruent) and;
b) <u>The emission</u> of light by a fluorescent tube... (metaphorical)

"It is generally considered that people, places and things are realized by means of a noun; actions are realized verbally; and circumstances are realized by prepositional phrases and adverbs. This is the typical, congruent relationship between semantic and grammatical categories that usually happens in spontaneous spoken language. However, all meanings may have more than one way of realization, and sometimes, in written language and especially in the language of science, the realizations of the semantic functions of the clause are not typical, but marked. This realization constitutes a Grammatical Metaphor (GM)" (Briones *et al.* 2003: 137). GM is thus defined as:

- "a substitution of one grammatical class, or one grammatical structure by another" (Halliday and Martin, 1993: 79);
- the process whereby meanings are multiply-coded at the level of grammar" (Martin, 1993: 230); or as
- a variation in the grammatical forms through which a semantic choice is typically realized in the lexicogrammar" (Sáenz, 2000: 498).

Halliday (1985a) notes that in Grammatical Metaphors, "the variation is essentially in the grammatical forms although often entailing some lexical variation as well" (320). Halliday (1993) also expresses the point that GM is "like a metaphor in the usual sense except that, instead of being a substitution of one *word* for another, it is a substitution of one grammatical class, or one grammatical structure, by another; for example **his departure** instead of **he departed**" (79). With regard to this example cited, Halliday and Martin (1993) comment that:

> the words (lexical items) are the same; what has changed is their place in the grammar. Instead of pronoun **he** + verb **departed**, functioning as Actor plus Process in a clause, we have determiner **his** + noun **departure,** functioning as Deictic[38] plus Thing in a nominal group. Other examples are **her recent speech concerned poverty** instead of **she spoke recently concerning poverty; glass crack growth rate** instead of **how quickly cracks in glass grow.** Often the words may change as well as the grammar, as in the last example where **how quickly** is replaced by **rate** (79).

"Academic writing has a reliance on GM" (Halliday, 2004a: xvi). GM is a very economical means of packaging information and is consequently frequently used in scientific information where the "real" actors are often absent from the scene, replaced by the nominalised processes. "Besides efficiency, GM lends an appearance of objectivity to the text" (Stålhammar, 2006: 100). Schleppegrell (2009) explains that "grammatical metaphor enables a writer to create abstractions that can participate in building arguments and structuring texts in ways that enable the development of an explanation, and to infuse a clause with causal and other meanings without explicit conjunctions ... While grammatical

[38] The *Deictic* 'indicates whether or not some subset' of 'a class of things' is 'intended' (e.g. 'all','some'), and, used 'demonstratively', can stipulate 'proximity to the speaker' (e.g. 'this') or 'possession' (e.g. 'your') (Halliday, 1991 cited in de Beaugrande, 1991).

metaphor increases the density of text, it also enables conciseness and precision" (13-14). Halliday (1998) notes lexical density, nominalisation and grammatical metaphor as the main lexicogrammatical characteristics of the written (academic) language.

Nominalisation "is the single most powerful resource for creating grammatical metaphor" (Halliday, 2004b: 656). Nominalisation is commonly used in science discourse (Hyland, 2002; Halliday, 2004b; Holtz, 2009 and Hadidi, 2012). Through nominalisation, processes (linguistically realized as verbs) and properties (linguistically realized, in general, as adjectives) are re-construed metaphorically as nouns, enabling an informationally dense discourse (Holtz, 2009). Nominalized structures in academic writing include nouns that have been morphologically derived from verbs (e.g. *development, progression*) as well as verbs that have been 'converted' to nouns (e.g. *increase, use*) (Biber and Gray, in press). "Nominalization turns actions or processes into concepts, while also reducing the number of clauses and compressing more information into each nominal group (Hadidi, 2012: 349).

Halliday and Martin (1993) provide examples to illustrate the use of GM in science discourse:

1. Glass cracks more quickly the harder you press on it.
2. Cracks in glass grow faster the more pressure is put on.
3. Glass crack growth is faster if greater stress is applied.
4. The rate of glass crack growth depends on the magnitude of the applied stress.
5. Glass crack growth rate is associated with applied stress magnitude (55).

In a discussion of these examples, Biber and Gray (in press) note that the first of these examples above is the most 'congruent', where the meanings of words correspond to the expected meanings of the grammatical categories used. For example, the verbs *cracks* and *press* are used to refer to those processes. In contrast, examples 4 and 5 above illustrate a dense use of grammatical metaphor, with qualities and processes being expressed by nouns rather than adjectives and verbs.

One way of contrasting the relative complexity of speech and writing is by means of lexical density. Lexical density, according to Halliday and Martin (1993), "is a measure of the density of information in any passage of text, according to how tightly the lexical items (content words) have been packed into the grammatical structure. It can be measured, in English, as the number of lexical words per clause" (76). Lexical density can be expressed either as a percentage of lexical words within all the words of a text (Ure, 1971)[39] or the number of lexical items as a ratio of the number of clauses" (Halliday, 1985b: 67)[40].

Originally, Ure (1971) proposed that lexical density should be treated as the proportion of the number of lexical items per the number of running words. The following example illustrates how lexical density is calculated using the method proposed by Ure (1971):

> "*The* **Trust** *has* **offered advice** *to* **local government authorities** *on* **cemetery conservation**" (Halliday, 1985b: 61).

In the above example, there are eight lexical items (in bold type) and four grammatical items (italicized), giving a proportion of eight lexical items out of twelve items in total. Using Ure's (1971) method, lexical density would be sixty seven percent (see footnote[40]).

The following sentence illustrates how lexical density is calculated using the method proposed by Halliday (1985b):

> "The **basic 'stuff'** of **living organisms** is **protoplasm**/. There is no **set composition** of this/and it **varies** between one **individual** and the next/ (Halliday, 1985b: 67).

In the above example, there are nine lexical items (in bold type) and three clauses (denoted by the forward slash, /), giving the ratio nine out of three. Using Halliday's (1985b) method, lexical density would be three (see footnote[41]).

In order to measure lexical density, it is necessary to distinguish between grammatical items and lexical items. Grammatical items or 'function words' include all modals and auxiliary verbs; determiners (articles, demonstrative, possessive adjectives, quantifiers and numerals); pronouns and 'this' and 'that' when used to replace clauses; some classes of adverbs (interrogative adverbs - what, when, how and negative adverbs - not, never) and finite verbs; prepositions; conjunctions; sequencers (next, finally); and quantifier phrases (anyway, somehow, whatever) (Johansson, 2008; To *et al.* 2013).

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[39] Using Ure's (1971) method, "the lexical density of a text can be measured by counting the total words in a text and then counting the lexical words, that is, the content words, excluding the grammar or function words, and calculating the lexical words as a percentage of the total words; the higher the percentage, the higher the lexical density" (McCarthy, 1990: 71).This would then be Lexical density = number of lexical items x 100/total numbers of words (Ure, 1971).

[40] Lexical density = $\frac{\text{number of lexical items}}{\text{number of clauses}}$

Nouns, verbs, adjectives and adverbs are the four word classes belonging to lexical items since they have autonomous meaning even in isolation and new members can be added to these categories (Le *et al.* 2011). According to To *et al.* (2013), Halliday (1985b) uses the term ‘items’ rather than ‘words’ when discussing lexical items and grammatical items since they many contain more than one word in the usual sense. For example, the phrasal verb ‘stand up’ consists of two words: a lexical verb and a preposition but Halliday (1985b) treats them as a lexical item. In contrast, Ure (1971) would count ‘stand up’ as two separate words (the lexical word, ‘stand’; and the preposition, ‘up’).

Lexical density levels are higher in writing than in speech. “Informal spoken language is made grammatically out of chains of short clauses, linked by coordinating or subordinating conjunctions: “and”, “but” “or” “because”, “when”, etc., while formal written language compresses the information into heavily modified nominal groups” (Whittaker, 2010: 34).

A discussion on GM is significant in this study which examines the use of discipline-specific literacies in science. The language of science is heavily reliant on the use of lexical density and nominalisation which are discussed in greater detail in Chapter 4 of this dissertation. The issue of GM is relevant to this study as students in the FP in science are exposed to dense scientific articles and textbooks that they would have to decode, deconstruct, interpret and study. This does not only involve understanding science content, but also becoming familiar with academic language and register. Scientific articles and texts convey content through the use of secondary discourse and elaborated code. Effective engagement with them means decoding such types of complex language and requires well-developed CALP (Cummins, 1979). This will involve the use of new ways of expressing themselves using academic language in science.

The FP students have to rely on new linguistic resources to understand and make sense of science context in order to complete academic tasks in science. It is thus the intention of this study to investigate what discipline-specific literacies those academics (viz. the ALSs and the DSs) who teach the modules offered in the FP believe are required by the students enrolled in the FP. This is obtained via critical research question 1. The ways in which the DSs, in particular, assist students in the acquisition of the discipline-specific literacies needed for science discourse is explored via critical research question 3. The perceived challenges confronting students in respect of coping with the challenges of the language of science (for example, the way in which GM features in science discourse) and the discipline-specific literacies in science, are measured through critical research question 2.

3.11 Genres

Genres are defined as "abstract, socially recognised ways of using language for particular purposes within particular contexts" (Hyland, 2003: 21). For Hyland (2002b), genre analysis is based on the assumptions that "the features of a similar group of texts depend on the social context of their creation and use and that those features can be described in a way that relates a text to others like it and to the choices and constraints acting on text producers" (114). Language is seen embedded in (and constitutive of) social realities, since it is through recurrent use and typification of conventionalized forms that individuals develop relationships, establish communities and get things done (Hyland, 2002b: 114).

Of relevance to this study is Martin's (1984) definition of genre which describes it as a staged, goal-oriented purposeful activity in which speakers engage as members of our culture. Hyland (2002b) explains genre from the SFL perspective as "particular configurations of field (what is going on), tenor (who is involved), and mode (what the role of language is); and patterns of discourse for expressing meanings in context - the basic components of meaning being ideational, interpersonal and textual" (119). Similarly, Martin and Rose (2003) describe genre as a particular configuration of register variables of field, tenor and mode.

The advantage of genre pedagogy to this study is that knowledge of genres gives students an explicit understanding of what is required *in* and *for* science discourse and in terms of how they need to structure their own writing. "Providing writers with a knowledge of appropriate language forms shifts writing instruction from the implicit and exploratory to a conscious manipulation of language and choice" (Hyland, 2007: 151) and demonstrates ''the ways in which patterns of language work for the shaping of meanings" (Christie, 1987: 45). Genre pedagogy brings together language, content and context while offering teachers a means of presenting students with explicit and systematic explanations of the ways writing works to communicate (Christie and Martin, 1997).

Of significance to this study are Martin and Rose's (2007) discussions of genre as recounting events, explaining processes, describing entities, debating issues, or evaluating other texts. These researchers explain that genre weaves together the three other dimensions of the social context of texts: field, tenor and mode. They explain that the field of an academic text is located within one or more disciplines. Its tenor enacts relations of academic authority between readers, writers and other authors in these disciplines while its mode is typically densely written, technical and abstract, including accompanying images. They further expound that the contextual dimensions – genre, field, tenor and mode – are realised as discourse semantic patterns in texts (2).

The discussion of the genre approach in the analysis of the reading of academic texts by Martin and Rose (2007) is pertinent to this study. They point out that reading an academic text involves recognizing its genre, field, tenor and mode which in turn requires recognition of discourse semantic patterns which genre and register are realised. Writing an academic text involves using these patterns to construct its genre and register. Of equal relevance, too, is the link between disciplinary cultures and genres which foregrounds the socially situated nature of genres. "Genre helps unite the social and the cognitive because they are central to how we understand, construct, and reproduce our social realities" (Hyland, 2002b: 123). Berkenkotter and Huckin (1995) noted that genre conventions signal a discourse community's norms, epistemology, ideology and social ontology (2).

Hyland (2007) draws attention to "genre instruction which stresses that genres are specific to particular cultures … urging us to go beyond syntactic structures, vocabulary, and composing to incorporate into our teaching the ways language is used in specific contexts" (150). Paltridge (2004a) expounds on genre pedagogy which outlines that language is functional. It occurs in particular cultural and social contexts and can only be understood in relation to these contexts. Speakers and writers use particular genres in order to fulfil certain social functions and to achieve certain goals within particular social and cultural contexts. Language then, is both purposeful and inseparable from the social and cultural context in which it occurs.

The advantages of genre pedagogy "in pulling together language, content and contexts" (Hyland, 2007: 150) are summarized by Hyland (2004: 10-16):

Explicit	Makes clear what is to be learnt to facilitate the acquisition of writing skills
Systematic	Provides a coherent framework for focusing on both language and contexts
Needs-based	Ensures that course objectives and content are derived from students' need
Supportive	Gives teachers a central role in scaffolding students' learning and creativity
Empowering	Provides access to the patterns and possibilities of variation in valued text
Critical	Provides the resources for students to understand and challenge valued discourses
Consciousness-raising	Increases teachers' awareness of texts to confidently advise students on writing

Table 3: Benefits of Genre Pedagogy (Adapted from Hyland, 2004: 10-16)

These characteristics of genre pedagogy are of consequence to this study. Students studying science need explicit understanding and practise in the genres required for science (which have been discussed in Chapter 2). This is in line with one of the advantages of genre pedagogy listed in the Table 3 above, that it is "systematic by providing a coherent framework for focusing on both language and contexts" (Hyland, 2004: 10-16). Genre pedagogy has the added benefit of providing students with "an explicit understanding of how target texts are structured and why they are written in the ways they are ... the writing outcomes are clear ... and [students] acquire the genres they need from repeated writing experiences" (Hyland, 2003: 26; Hyland, 2007: 151). This entails an explicit provision of specific language patterns needed to express the genre. The characteristic of being 'supportive' is crucial in learning situations dealing with students for whom the LoLT is not their native language. The reference to "[g]ives teachers a central role in scaffolding students' learning" is essential as it points to the use of scaffolding (Wood *et al.* 1976) as a teaching strategy (which is discussed in the ensuing paragraphs in this Chapter). Knowledge of and the ability to use the appropriate language patterns are empowering. In terms of conscious-raising, "by categorising and analysing the texts they ask their students to write, teachers become more attuned to the ways meanings are created and more sensitive to the specific communicative needs of their students" (Hyland, 2007: 151).

Engaging in the discourses of different disciplines requires that students draw on the register features that help them simultaneously realize ideational, interpersonal, and textual meanings in appropriate ways, construing the field, tenor and mode anticipated by the genre assigned (Schleppegrell, 2002: 120). There has been much research commentary regarding the connection between literacy skill and the learning of content knowledge in specific disciplines. Meltzer and Hamann (2005) distinguish between “two types of content-based literacy instruction strategies: generic literacy strategies that can be applied in similar ways across the content areas and literacy strategies that differ greatly depending upon the particular subject. They add that discipline-specific literacy strategies are “heavily dependent on the particular content being studied” (44).

Lee (2004) defines disciplinary literacy as the ability to understand, critique, and use knowledge from texts in content areas and is the primary conduit through which learning in the academic disciplines takes place. Meltzer and Hamann (2005) suggest that “in order to apprentice students into the disciplinary demands of a content area, teachers themselves must be cognizant of the literacy demands specific to their discipline and the range of strategies they might use to teach others to meet those demands” (45). As stated throughout this Chapter, this study also explores ways in which disciplinary specialists assist students with discipline-specific literacies in science.

Framing genre pedagogy in this study is achieved through critical research questions 1 and 3. The first critical research question seeks to find out the discipline-specific literacies required in science. Reference to ‘genre’ in science, viz. scientific genres of laboratory report writing, academic essays, scientific posters and oral presentations has been made in the Chapters before this. If genres are constructed using specific register, then critical research question 1, which pays attention to literacies required for science, should attempt to isolate those literacies needed for the specific scientific genres in required by students in FP. This can then lead to the ways in which these genres are acquired by students which can then be answered by critical research question 3. Genre pedagogy links with the NLS especially since literacy is dependent on social contexts.

3.12 Pedagogic Practices

3.12.1 Zone of Proximal Development (ZPD) (Vygotsky, 1978b)

There are a number of pedagogic practices in the form of interventions and strategies that can help to support students in their acquisition of science knowledge. This is particularly necessary for students in the foundation programme who are from disadvantaged backgrounds and are EAL speakers.

Vygotsky's (1978b) Zone of Proximal Development (ZPD) is commonly referred to as the theoretical underpinnings of the concept of scaffolding as a teaching and learning strategy. ZPD is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978b: 86) or "what the child is able to do in collaboration today he will be able to do independently tomorrow" (Vygotsky, 1987: 211). Chaiklin (2003) simplifies this to mean that the ZPD presupposes an interaction between a more competent person and a less competent person on a task, such that the less competent person becomes independently proficient at what was initially a jointly-accomplished task. van der Valk and de Jong (2009) state that the more capable person who guides the learner through the tasks, is in essence, "guid[ing] the learner through the ZPD towards a new actual development level in the gradual process of scaffolding" (832). Figure 6 below offers a diagrammatic representation of progress through ZPD. It indicates how at the initial stage, learning begins with guidance by a competent other to aid with developing new concepts and understanding; with the eventual aim of acquiring knowledge and skills independently.

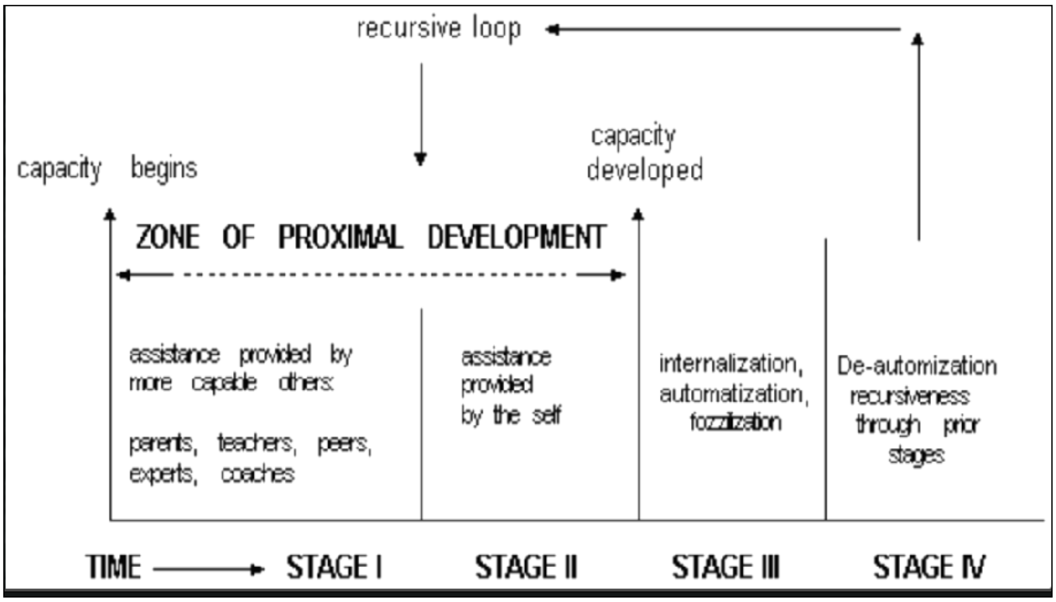

Figure 6: The genesis of a performance capacity: Progression through the Zone of Proximal Development and beyond (Gallimore and Tharp, 1990: 183).

In Figure 6 above, stage I demonstrates the reliant interaction between the learner and the more competent others in performing the task. Gallimore and Tharp (1990: 185) express the point that "during the earliest periods of the ZPD, the [learner] may have a very limited understanding of the situation, the task, or the goal to be achieved; at this level the parent, teacher, or more capable peer offers directions or modelling" (185) and the child's response is acquiescent or imitative (Wertsch, 1979). In stage II, the [learner] carries out a task without assistance from others. However, this does not mean that "the performance is fully developed or automatized" *(*Gallimore and Tharp, 1990: 185). The ZPD occurs between the first and second stages. In stage III, the task is performed automatically after being internalized, and according to Vygotsky (1978b), is fossilized. Task execution is smooth and integrated. It has been internalized and automatized. Assistance from the adult or the self is no longer needed. At stage IV, deautomatization of performance leads to recursion through the ZPD. The lifelong learning by any individual is made up of the same regulated, ZPD sequences – from other-assistance to self-assistance – recurring over and over again for the development of new capacities *(*Gallimore and Tharp, 1990).

ZPD is an important concept in this study. The philosophy of FP and SCOM rely on supported learning as a way of helping students to eventually be able to complete tasks without assistance and allow for the capacity of new self-learning. Critical research question 3 should be able to cast light on the mechanisms used by the DSs to assist FP students to reach Stage IV of ZPD. The responses in this question are a consequence of those perceived challenges in the discipline-specific literacies in science fielded in critical research question 2.

3.12.2 The Concept of Scaffolding (Wood *et al.* 1976)

The concept of scaffolding (Wood *et al.* 1976), which reflects ZPD, has been extensively used in a number of institutional contexts as an instruction strategy to assist students to achieve specific goals through the aid of support. Scaffolding has been widely significant in teaching and educational research and has been particularly used in the teaching of academic literacy. The concept of scaffolding was originally used by Wood *et al.* (1976) to describe how learning takes place in families to portray the temporary, but essential nature of parental support in the language development of young children. It followed the social learning model of Vygotsky (1978b). Wood *et al.* (1976) explain that:

> Discussions of problem solving or skill acquisition are usually premised on the assumption that the learner is alone and unassisted. If the social context is taken into account, it is usually treated as an instance of modelling and imitation. But the intervention of a tutor may involve much more than this. More often than not, it involves a kind of "scaffolding" process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts. This scaffolding consists essentially of the adult "controlling" those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence. The task thus proceeds to a successful conclusion. We assume, however, that the process can potentially achieve much more for the learner than an assisted completion of the task. It may result, eventually, in development of task competence by the learner at a pace that would far outstrip his unassisted efforts (90).

The concept of scaffolding has been increasingly used as a metaphor by several researchers to describe and explain the role of adults or more knowledgeable peers in guiding [children's] learning and development (Stone, 1998; Verenikina, 1998; Wells, 1999; Daniels, 2001; Hammond, 2002). Since ZPD is the "area between what children can do independently and what they can do with assistance" (Clark and Graves, 2005: 571), Rosenshine and Meister (1992) have stated that this area must be considered when initiating scaffolding techniques as scaffolds are only useful within the student's own ZPD. Wiseman *et al.* (2005) hold the view that students' background should be considered to ensure they are able to learn a new strategy or grasp a new tool and teachers should use scaffolding to help students navigate their ZPD and extend current knowledge and skills.

Graves and Braaten (1996) clarify scaffolding as the process by which an expert provides temporary support to learners to "help bridge the gap between what [the learner] know[s] and can do and what [he or she] need[s] to accomplish in order to succeed at a particular learning task" (169). Scaffolding has been increasingly used as "a metaphor for the particular kinds of support given to students to enable them to successfully complete a task … that alone, he or she would be unable to complete" (Gibbons, 2007: 703). Upon completion of this task, a learner is better able to make the connection between prior knowledge and internalize new information. Rose *et al.* (2003) elucidate on scaffolding support which they say enables learners to successfully practise complex skills; and, as the learners become independently competent, scaffolding is gradually withdrawn (42). Scaffolding is intended to bring learners closer to a state of competence which will enable them eventually to complete the task on their own. It involves the teacher structuring the learning activity such that the teacher's own support and expertise can be gradually withdrawn until the learner can complete the task independently.

Wells (1995) distinguishes between two levels of scaffolding which are the macro and micro levels of scaffolding. The macro level involves the overall design of the unit of work to achieve specific outcomes including the sequence of tasks within each lesson and types of resources to be utilized. It takes account of the teacher's goals; understanding of the language demands of the planned tasks; knowledge of students' current abilities, understanding and interest; sequencing of tasks to achieve the outcomes and planning for handover which is mainly when the student is in charge of completing the task. The micro level refers to the moment by moment interactions within the lesson between the teacher and students and students with each other. This type of scaffolding at the 'point of need' provides opportunities of support for students' understanding of the task or topic through discourse strategies such as questioning or relating to students' previous experiences and multimodal strategies (Wells, 1995).

Sharpe (2006) explains that discourse and multimodal strategies constitute the nature of scaffolding. Discourse strategies include repeating, recasting and appropriating language to develop technical vocabulary and recontextualize the content; increasing the prospectiveness of questions to extend or reformulate students' reasoning; cued elicitation to encourage joint construction and 'track' students' understanding; use of analogy to draw on students' existing background knowledge; and 'metacomments' to summarize key concepts. Multimodal support is provided through visual (maps, diagrams pictures), gestural and actional cues. Discourse and multimodal strategies aid in mediating students' learning process (211). This study intends to outline the strategies used by DSs.

The advantage provided by the technique of scaffolding is that it allows support for a student to work on and complete a task that would otherwise have not been possible to complete. On the benefits of scaffolding strategies for reading and writing, Rose *et al.* (2003) note that they are designed to:

> Focus learners' attention on patterns of language and to recognise the meanings they express. In academic reading and writing these language patterns are highly specialised, and often involve dense abstract concepts and technical terms that are part of academic fields. [T]hrough the use of scaffolding strategies, a teacher can support learners to read and write far more complex texts than they normally could on their own. This supported practice

> allows learners to develop reading and writing skills that they can then use independently (41).

The strategy of scaffolding is used to teach academic reading and writing. Rose *et al.* (2003) explain that this technique enables [students] to pay attention to the highly specialised patterns of language and dense abstract concepts and technical terms which characterise academic reading and writing. As an instructional technique, scaffolding strategies help support learners to read and write far more complex texts than they normally could on their own. This supported practice allows learners to develop reading and writing skills that they can then use independently.

Explicit modelling, as a type of scaffolding, is a way of guiding, supporting and apprenticing students into academic discourse communities. In the sciences, skills and procedures can be modelled using laboratory reports, research papers, notes, posters charts, graphs, and diagrams as models (Galguera, 2003). Parkinson *et al.* (2008) highlight the offering of advice and questioning as other techniques of supporting the acquisition of new competencies (14). Scaffolding is intensively used in the SCOM module offered in the FP to teach students to read and understand complex academic texts in science; to acquire and display knowledge of science genres. Responses to critical research question 3 serve to show whether scaffolding features as a learning support mechanism in the FP.

Conclusion

Chapter 3 explored New Literacy Studies (NLS) (Street, 1984; Gee, 1990) as a theoretical framework underpinning this research. It outlined the two models of NLS, the autonomous and ideological models of literacy and offered an explanation as to how the ideological model of literacy to underpins this study. This Chapter emphasized the importance of social practices in the acquisition of literacy. In doing so, issues such as Discourse, discourse practice, discourse community and the distinction between primary and secondary discourses (Gee, 1990) were explained. Chapter 3 included an outline of “primary” and “secondary” codes (Gee, 1999); language codes, distinguishing between the “restricted and elaborated codes” (Bernstein, 1971) as well as the concept of “cultural capital” (Bourdieu, 1977).

Owing to the need to be able to use academic language appropriately, this Chapter paid attention to the nature of three different academic literacies models (Lea and Street, 2006), i.e. study skills model, academic socialization model and the academic literacies. An understanding of Halliday's Systemic Functional Linguistics (SFL) (1978; 1985a) was provided as was the nature of Grammatical Metaphor (GM) (Halliday and Martin, 1993), paying specific regard to nominalisation and lexical density. The concept of "construal" (Langacker, 1987) was discussed, in terms of grammar and meaning. The relevance of genres and genre pedagogy (Hyland, 2002) were discussed. The Chapter offered comments on pedagogic practices such as Zone of Proximal Development (ZPD) (Vygotsky, 1978) and scaffolding (Wood *et al.* 1976).

Chapter 4 discusses language *in* science and *for* science.

CHAPTER 4

EXPLORING THE LANGUAGE OF SCIENCE

Introduction

Chapter 3 explored the New Literacy Studies (NLS) (Street 1984; Gee, 1990) as a theoretical framework underpinning this study. It explored the nature of two models of NLS which are the autonomous and ideological models of literacy and offered reasons for the choice of the ideological model of literacy to undertake this study. It drew attention to the importance of social practices in the acquisition of literacy. In doing so, issues such as academic discourse, discourse practice and the distinction between primary and secondary discourses were explained. In Chapter 3, Bernstein's (1971) language codes, namely the distinction between the 'restricted' and 'elaborated' codes as well as Bourdieu's (1977) concept of 'cultural capital' were explained. The Chapter also focused on the link between content and literacy. Because of the need to be able to use academic language appropriately, the nature of three different academic literacies models were outlined, i.e. study skills model, academic socialization model and the academic literacies (Lea and Street, 2006) Systemic Functional Linguistics (SFL) (Halliday, 1978; 1985a) and the essence of Grammatical Metaphor (GM) (Halliday and Martin, 1993) were extensively discussed. The relevance of genres and genre pedagogy were discussed. The Chapter offered commentary on pedagogic practices such as Zone of Proximal Development (ZPD) (Vygotsky, 1978a; 1978b) and scaffolding (Wood *et al.* 1976).

Chapter 4 engages with the discourse of 'science' and science as a discipline in four demarcations. The first part explores the need for graduates in science, engineering and technology, with a view to enhancing South Africa's economic and social development. This is followed by a discussion on acculturating students into the science environment in the HE arena, drawing specific attention to the significance of creating an identity in science. This entails a detailed explanation of academic discourse and the discourse commanded by science.

The second part in the Chapter highlights the nature of the language used to convey science discourse. It discusses the nature of science discourse, detailing how it differs from everyday discourse. An outline of the scientific register, sentence and grammatical structures relevant to science is provided. This is relevant as this study explores the 'language' used in science and seeks to draw attention to the presence of any perceived challenges with discipline-specific literacies in science.

The third part notes the specific literacies required for the foundation modules offered in the FP in science, viz. biology, chemistry, mathematics and physics. It highlights the conceptual and procedural knowledge, as well as the problem solving literacies required for effective learning of biology, chemistry, mathematics and physics in relation to the 'language' of science.

The final part offers a review of literature outlining the articulation gap between secondary schooling and the higher education sector, with particular reference to the issue of students' underpreparedness for tertiary science, by referring to studies at both secondary education and tertiary levels. Finally, Chapter 4 ends with a discussion of studies specific to literacies in science.

4.1 The Role of Higher Education Institutions (HEIs) in Contributing to Development in South Africa

Since South Africa's transition from minority rule and apartheid policies to democracy, the challenge of redressing the inequalities of the past has remained. Redress and equity implied a change in the higher education system so that it "serves a new social order, meets pressing national needs, and responds to new realities and opportunities. It must lay the foundations for the development of a learning society which can stimulate, direct and mobilize the creative and intellectual energies of all the people towards meeting the challenge of reconstruction and development" (Education White Paper, DoE, July, 1997b: 1.1).

If the HE sector in South Africa can develop its students' potential, talents and intellectual capacity, then these students can make a positive contribution to the social and economic needs of the country. Higher education in South Africa can satisfy the country's call for skilled and highly trained individuals in specialized professions or vocations. One of the functions of the transformed, nationally co-ordinated higher education system in South

Africa is to ensure that individuals who qualify for admission into tertiary studies are given the opportunity to realize their potential.

4.1.1 The Strategies of The National Plan for Higher Education in South Africa (NPHE)(2001)

The National Plan for Higher Education in South Africa (NPHE) (2001) provides an implementation framework and identifies the strategic interventions and levers necessary for the transformation of the higher education system in respect of the vision for this which was outlined in the earlier release of the Education White Paper (DoE, 1997b). One of the priorities of the NPHE (2001) is "to increase participation, success and graduation rates of black students in general and African students in particular" (30). The document also makes mention of changing the balance of enrolments in science, engineering and technology to satisfy the demands of the labour market (26). The HE sector can then heed the country's call for an increased number of black graduates in the fields of science, engineering and technology.

One of the outcomes of the NPHE (2001) is the need to equip all graduates with the skills and qualities required for participation as citizens in a democratic society and as workers and as professionals in the economy. Apart from the need for technical skills, the NPHE (2001) states that "employers want graduates who can demonstrate a strong array of analytical skills and a solid grounding in writing, communication and presentation skills" (UNESCO/World Bank Report, 2000:85, cited in NPHE, 2001: 27). With respect to this, the NPHE (2001) is explicit that the issue is not just about increasing enrolments in specialized fields of study, but whether "the higher education system is geared towards the skills and competencies required for all graduates in the modern world" (27).

The extracts of the visions of transformation of Higher Education in South Africa outlined in the Education White Paper (DoE, 1997b) and the intervention strategies contained in the NPHE (2001) are particularly relevant to this study's concern with the disciplines of science in the FP at a university in South Africa. The offering of the FP heeds the call of access to, and participation in science by educationally disadvantaged black students. The goal is to increase the number of potential black graduates in the sciences. The importance of ensuring that graduates leave HEIs equipped with the necessary skills and competencies to enter the work force in South Africa is significant to this study. For this reason, this study explores the discipline-specific literacies required for academic understanding and success in the disciplines of science offered in the FP. It also seeks to ascertain how the perceived challenges in the discipline-specific literacies can impact on interpretation of science content.

4.2 Students' Entry into the Academic Arena

Upon entry into HEIs, students need to become acculturated into the university culture and to acquire epistemologies relevant to their chosen fields of study (Issues of becoming members of the discourse community and epistemological access have already been noted earlier in this study). Students who enter tertiary institutions in South Africa bring with them a history of reading, writing and speaking conventions that they had experienced, acquired or learnt from their secondary schooling. These literacies, as well as mathematical and scientific competencies, are expected to be a solid foundation to facilitate further learning at HEIs. With all these literacies and competencies present, it is assumed that HEIs can proceed with its teaching and learning practices from the point where secondary schooling has ended.

However, the teaching and learning process at university does not necessarily unfold as easily. Its students hail from differing educational backgrounds and experiences which invariably impact on the way in which they learn at university. With the disparate education system prevalent in South Africa and the articulation gap at secondary school levels in South Africa, a large number of students arrive at universities 'poorly prepared' or 'underprepared' for the rigours of academic study. Therefore, it cannot be assumed that students can automatically manipulate the academic discourse of HE studies. Students who are underprepared for tertiary studies enter the HE environment with a number of challenges (which have already been alluded to earlier in this dissertation). Upon entry into the tertiary sector, students are expected to "manipulate language academically, a skill which presupposes a constellation of acquired abilities" (Mgqwashu, 2011: 22). Mgqwashu (2011) elaborates that "these abilities … can be learned only if interaction between students and lecturers is underpinned by … an explicit teaching practice driven by a view that pedagogic communication needs to signal the discourse's constructedness … [which] is fundamental for epistemological access in higher education" (22).

In the Faculty of Science at a number of South African tertiary institutions, the establishment of foundation and augmented programmes has enabled students from educationally disadvantaged backgrounds with academic potential an opportunity to pursue further studies in science (Chapter 1 offered a presentation of these programmes). These, effectively, address the call for the country to produce more black graduates in the under-represented fields of science, engineering and technology. Students involved in the study of university science need to become familiar with scientific discourse.

4.2.1 Discourse Participation

As outlined in the preceding Chapter, when students enter university, they should become members of the university community. This means that they need to acquire epistemologies necessary for them to participate in their chosen disciplines. In other words, they are expected to acquire and learn the discourse of disciplines. Gee (1990) defines Discourse as "a socially accepted association among ways of using language, of thinking, feeling, believing, valuing and of acting that can be used to identify oneself as a member of a socially meaningful group or 'social network', or to signal (that one is playing) a socially meaningful role" (143). He adds on that Discourses govern how we talk, think and interact as members of a culture. It is this discourse that integrates ways of talking, listening, writing, reading, acting, interacting, believing, valuing, and feeling. "Discourse is a 'sort of identity kit' – a way of belonging and being recognized as belonging to a particular group" (Gee, 1996: 127). This definition of Discourse implies the need for participation in the Discourse, in the sense of acquiring an identity within it. To be a member of any group means behaving in a manner acceptable to the group, allowing one to remain an insider of the group. The concept of Discourses is evidently significant in this study which draws attention to the discourses needed by students in the FP to not only acquire and display scientific knowledge, but to be able to belong to the community of science.

Gee (1989) distinguishes between primary and secondary discourses. "Primary discourses are acquired through face-to-face interactions in the home and represent the language of initial socialization. Secondary discourses are acquired in social institutions beyond the family (e.g. school, business, religious and cultural contexts), and involve acquisition of specialized vocabulary and functions of language appropriate to those settings" (5). Gee (1990) draws attention to the fact that Discourse he refers to "does not just involve talk or language" (142), it involves the use of language within contexts which informs its members how the language is to be used. Although secondary discourses can be acquired in any domain, for example, the fields of economics or theology, it is often associated with schooling as schooling determines acquisition, learning and language. The university is an example of a social institution where secondary discourse is acquired. Understanding the language and the specialized vocabulary used in various discourses requires academic language proficiency. Secondary discourse is relevant in this study.

Gee (1989) explains that secondary discourses build on primary discourses and he defines literacy as "control of secondary uses of language" (6) or "mastery of a secondary discourse" (Gee, 1996: 143). He goes on to say that "any discourse (primary or secondary) is, for most people, most of the time only mastered through acquisition, not learning. Thus, literacy is mastered through acquisition, not learning. That is, it requires exposure to models in natural, meaningful and functional settings" (1989: 6). In seeking to explain how discourse is mastered, the distinction between acquisition and learning is necessary. Gee (1989) states:

> Acquisition is a process of acquiring something subconsciously by exposure to models and a process of trial and error, without a process of formal teaching. It happens in natural settings which are meaningful and functional in the sense that the acquirer knows that he needs to acquire the thing he is exposed to in order to function and the acquirer in fact wants to function. This is how most people come to control their first language.
>
> Learning is a process that involves conscious knowledge gained through teaching, though not necessarily from someone officially designated a teacher. This teaching involves explanation and analysis, that is, breaking down the thing to be learned into its analytic parts. It inherently involves attaining, along with the matter being taught some degree of meta-knowledge about the matter (3).

"A learner who enters the Discourse of a discipline has to 'acquire' the language, social practices and functioning of the group by participation involving trial and error in natural settings. Alongside acquisition, learning can occur, but learning is primarily a process of gaining meta-knowledge, primarily about the difference between secondary Discourse to be acquired and the learner's primary Discourse" (cited in Rollnick, 2010: 155). This study intends to show how students 'get' these discipline-specific literacies in science. This, therefore, necessitates an understanding of the practices and strategies that the DSs implement to help students to 'achieve' these. Evidence of this is shown in the responses to critical research question 3.

This notion of Discourse is particularly relevant in this study. Students entering the discipline of science, for example, need to become participants in the discourse of science. They need to take on an identity of the membership of science. They would therefore have to think and act like scientists. Students pursuing science studies learn the disciplinary content knowledge, but also need to acquire the literacies used in the disciplines within the field of science.

4.2.2 Distinguishing between Academic Discourse and Social Discourse

Academic discourse used in HE studies differs from social discourse. Lee and Fradd (1998) define "social discourse as the language used when participating in concrete, context-embedded interactions where students learn by observing, imitating, and interacting with others so that no single student is responsible for a particular outcome. In contrast, academic discourse refers to the language used in abstract, decontextualized activities requiring students to work independently, to rely on their own understandings of both the language and the content of the task, and to be singly responsible for an outcome" (15).

4.2.3 Cummins' (1984b) *notion of context-embedded and context-reduced communication*

Cummins (1984b) expresses two ways in which meaning is expressed or received. These are "context-embedded" and "context-reduced" communication. Context-embedded communication occurs when the participants actually negotiate meaning, usually in a face-to-face situation. The opportunities for immediate feedback to clarify meaning in context are evident. This type of communication derives from interpersonal involvement in a shared reality which does away with the need for explicit linguistic elaboration of the message. With context-reduced communication, the reliance is primarily on linguistic cues to derive meaning. In this type of communication, a shared reality cannot be assumed: language needs to be elaborated precisely and explicitly to minimize misinterpretation. Everyday interpersonal communication is context-embedded as opposed to lectures and written academic communication, which are context-reduced. In this study, there is reliance on context-reduced communication as science discourse is particularly dense and abstract which, as stated in the previous Chapter, is conveyed by means of the "elaborated code" (Bernstein 1971). The issue of misinterpretation of context-reduced communication on account of its language being elaborate and specialized is fathomed through critical research question 2.

4.2.4 Academic Language

Students who enter the academic arena are exposed to academic language. Academic language is the language used for purposes of learning. "Academic language refers to forms of oral and written language and communication – genres, registers, graphics, linguistic structures, interactional patterns – that are privileged, expected, cultivated, conventionalized, or ritualized, and, therefore, usually evaluated by instructors, institutions, editors, and others in educational and professional contexts" (Duff, 2010: 6). For Schleppegrell (2009), "academic language construe multiple and complex meanings at all levels and in all subjects of schooling ... becoming more dense and abstract as students advance" (3). "Academic language is used by teachers and students for the purpose of imparting new information, describing abstract ideas, and developing students' conceptual understandings" (Chamot and O'Malley, 1994: 40). Angélil-Carter (1994) describes the language of academia as being specialized discourse; "every task performed requires a certain level of proficiency" (Gasa *et al.*, 1994: 48).

As outlined in the definitions above, academic language used in oral and written academic communication can be cognitively demanding, differing from everyday language and interpersonal communication which are cognitively undemanding. In reference to Cummins' (1984b) distinction between context-reduced and context-embedded communication explained earlier in this Chapter, academic texts are context-reduced, and thus cognitively demanding, in contrast to interpersonal communication, which is context-embedded. Interpreting meaning of any form of communication requires some degree of proficiency in the language of communication.

This distinction between the two types of communication ties up with Cummins' (1984b) explanation of two types of language proficiency, viz. BICS and CALP (which have been outlined in Chapter 2). BICS refer to conversational fluency in a language while CALP refers to students' ability to understand and express, in both oral and written modes, concepts and ideas that are relevant to success in school. Cummins' (2000) associates CALP specifically with the social context of schooling, hence the term 'academic'. He defines academic language proficiency as "the extent to which an individual has success to and command of the oral and written academic registers of schooling" (67).

Krashen and Brown (2007) propose that CALP or academic proficiency can be analyzed as containing specific components which are:

> 1. knowledge of academic language, characterized by complex syntax, academic vocabulary, and a complex discourse style;
> 2. knowledge of academic content (subjects and disciplines) and;
> 3. strategies that serve to make input more comprehensible and thereby help in the acquisition of academic language (1).

Academic proficiency is essential for learning. According to Krashen (1981), language is acquired and literacy is developed by understanding messages, not by consciously learning about language and not by deliberate memorization of rules of grammar and vocabulary. This mirrors how Gee (1987) views the acquisition of literacy, a point already referred to earlier in this Chapter.

Since academic language is dense and complex; is used to explain abstract concepts and higher order thinking required for academic success; it is far more demanding than basic, conversational communication and can pose a greater challenge, especially when it is used by students for whom English is a second or additional language. In relation to this study, learning content knowledge in science means that students need to become exposed to academic language, and thus CALP. The way in which the presence of any perceived challenges experienced by the FP students as a consequence of limited or underdeveloped CALP is transmitted in this study through the interrogation of data obtained to critical research question 2.

4.2.5 Discourse of Disciplines

Engagement with the discourse of a discipline is not only about the acquisition of knowledge but also its standards and practices. Each discipline in HE has its own register, conventions, genres and a set of ground rules that require mastery. These conventions define the way in which knowledge is construed. At university level, students in a discipline need to know what counts as knowledge and how new knowledge is constructed, disseminated and contested. Dison and Rule (1996) explain the notion of discourse in a discipline:

> The discipline itself is like a sub-culture and its discourse is made up of: codes (linguistic, intuitive, creative, etc.), conventions (essay structure, research, referencing, reporting, etc.), concepts (main ideas and debates in the discipline, etc.), values (what qualifies as knowledge or evidence, and caring, etc.), canons (primary texts and theories/authorities), and skills (both cognitive and linguistic) (87).

To succeed at university, novice students, especially, need to "acquire both 'cognitive competence' (modes of analysis, key concepts) and 'linguistic competence' (terminology, style, convention, codes)" (Rule, 1994: 100). Being initiated into the academic culture of the university and the sub-cultures of the various disciplines is what Ballard and Clanchy (1988: 19) view as "acculturation, learning to read and write the culture". In addition to this, as stated by Langer (1987), is the need to develop the structure of values, attitudes and way of thinking and doing necessary for success within the discipline. In terms of science, according to Lee and Fradd (1998), this means "acquiring scientific knowledge of the world and scientific habits of the mind, especially where the latter means acquiring scientific values, attitudes and a scientific world view" (15). The way in which students in the FP become acculturated into the 'sciences' is revealed via the responses from the DSs to critical research question 3.

4.3 Science Discourse

As explained earlier, upon entry into a discipline, students need to acquire a sense of identity – of membership – forged within the discipline and learn to acquire the secondary discourse of the discipline. For students to communicate efficiently in HEIs, they need to write, talk, listen and read in ways that conform to the dominant discourse of their practice (McKenna, 2004). This is the academic language or the language of the content areas of a specific discipline where the goal of learning reading is that students should be able to read specific sorts of texts written in specific ways (Gee, 2003). These hold true for science, too, except that "science instruction involves learning to observe, predict, analyze, summarize, and present information in a variety of formats, such as orally, in writing and drawing, and through tables and graphs" (Lee and Fradd, 1998: 13).

The acquisition of scientific discourse means learning to use the discourse and "learning to talk the language of science"; learning to 'talk' science means learning to communicate in the language of science and act as a member of the community of people who do so"

(Lemke 1990: 1). For Lee and Fradd (1998), the development of scientific knowledge involves "knowing" science, "doing" and "talking" science (15). In isolating what is meant by 'knowing science', Driver *et al*. (1994) explain this as making meaning of scientific knowledge and vocabulary. This, in essence, is gaining the epistemology of a discourse. Students enter university with knowledge and experiences that can contribute to their acquisition and learning of new knowledge. 'Doing science' involves manipulating materials, making observations, proposing explanations, interpreting and verifying evidence, and constructing ideas to make sense of the world (National Research Council, 1996). "Talking science involves formal and informal discussion around science discourse. Oral discourse offers insight into ways that students relate to science and share their understanding with others" (Lee and Fradd, 1998: 17). The multi-faceted nature of science outlined here is important for this study. The ways in which students are apprenticed into science in the FP are indicated by responses to critical research question 3.

4.3.1 Scientific Literacy

The study of science at higher education level involves reading, writing, conversing, computing and practising science. There is explicit use of visual representations (e.g. figures, diagrams, symbols, formulae, tables and pictures), exposure to academic language in the form of scientific readings (e.g. journal articles and text books) and writing (e.g. laboratory reports, scientific abstracts, scientific essays and posters). Each of these academic practices in science is used to immerse students in scientific discourse; to gain and apply scientific knowledge. Therefore, understanding and practice require literacies specific to disciplines.

The definition of scientific literacy quoted below stresses the gain of intellectual capabilities in science through the learning and application of scientific knowledge and the understanding of science concepts, principles and phenomena. At school level, South Africa's Curriculum 2005 (C2005) (1997) policy document states that scientific literacy involves:

> the ability to apply scientific concepts and principles to everyday life and being able to recognise their use or non-use in a variety of contexts … and scientific literacy is enhanced when [science knowledge] is accessible to learners. Therefore language development is crucial for both science education and scientific literacy (2).

Implicit in this definition is the reference to 'knowing, doing, and talking' science. The reference to the importance of language is particularly significant for this study as science education can hardly be divorced from scientific literacy. Another vital point raised in the definition is the fact that science content knowledge has significance beyond the formal learning environment.

Scientific literacy involves more than just text (Zwiers, 2008). It extends to "understanding multimedia genres and making meanings by integrating the semiotic resources of language, mathematics and a variety of visual-graphical presentations" (Lemke, 2002 cited in Schleppegrell and Colombi, 2002: 21). Scientific literacy enables individuals to develop a sound understanding of scientific facts and the scientific inquiry process, and an awareness of the relationships among science, technology, and society (Bauer, 1992).

The definitions of scientific literacy also portray science as a social practice of relevance to the world, beyond the classroom, as outlined in the C2005 (1997) definition. This is the ability of controlling the discourse of science for sociocultural purposes (Gee, 1999). The conception of scientific literacy as a sociocultural enterprise is to see literate practices associated with science as the literate practices of a scientific community. Thus, to become scientifically literate, one has to first become scientific, and then appropriate the literate practices involved in doing science (Reveles and Brown, 2008). As students in the FP are learning to participate in the discourse practices of a scientific community, they are simultaneously learning to participate in the culture of science while taking on the identities of those who do science within a community of practice. This is important in the way in which it relates to NLS (Street, 1984, Gee, 1990).

4.3.2 The Scientifically Literate Individual

Scientifically literate persons are those that have scientific knowledge, scientific inquiry skills, and the abilities to make thoughtful decisions about socio-scientific issues (Jenkins, 1990; Laugksch, 2000). Norris and Phillips (2003) note that science literacy involves being fluent in the language, discourse patterns, and communication systems of science, and in the derived sense being knowledgeable, learned, and educated in science.

Showalter's (1974 cited in Rubba and Anderson, 1978: 450) definition of a scientifically literate person comprises seven dimensions. Contained in this definition are references to the cognitive, ideological and social implications of being scientifically literate:

i. understands the nature of scientific knowledge;
ii. accurately applies appropriate science concepts, principles, laws, and theories interacting with his universe;
iii. uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe;
iv. interacts with the various aspects of his universe in a way that is consistent with the values that underlie science;
v. understands and appreciates the joint enterprises of science and technology and the interrelationship of these with each and with other aspects of society;
vi. has developed a richer, more satisfying, more exciting view of the universe as a result of his science education and continues to extend this education throughout his life and;
vii. has developed numerous manipulative skills associated with science and technology (450).

To be scientifically literate means participating in, learning, using and applying the language of science which not only differs from the language used in social conversations, but also the language used across various other academic disciplines. This study aims to gauge answers in respect of moulding the scientifically literate FP student via critical research question 1.

4.4. Language used *in* Science and language needed *for* Science

Academic language draws on the discourses of various disciplines, becoming more challenging at every level, from school to HE studies. At tertiary level, students encounter academic language at a higher conceptual level (in both oral and written forms) in lectures, tutorials, text books, journal articles, course manuals, laboratory and technical reports, research projects and studies, assignments, tests, examinations and presentations. For students studying science, "the development of scientific knowledge involves 'knowing' science (i.e. scientific understanding), 'doing' science (i.e. scientific inquiry), and 'talking' science (i.e. scientific discourse)" (Lee and Fradd, 1998: 16). This means interacting with and responding to the language of science.

However, science can be very intimidating. Lemke (1990) gives a rather interesting portrayal of science when he states that:

> in teaching the content of the science curriculum, and the values that often go with it, science education, sometimes unwittingly, also perpetuates a certain harmful mystique of science (author's emphasis). That mystique tends to make science seem dogmatic, authoritarian, impersonal, and even inhuman to many students. It also portrays science as being much more difficult than it is, and scientists as being geniuses that students cannot identify with. It alienates students from science (xi).

This picture of science is likely to be even more daunting for students who have to read and write science in a non-native language, and it is not uncommon that this language (the LoLT) is students' second or additional language. Critical research question 3 is used in this study to give an indication of the measures taken to help students to acquire discipline-specific literacies for science.

Since "science seeks to portray itself as a source of *objective* knowledge" (Wellington and Osborne, 2001: 65), it removes itself from narrative, personal, subjective and emotional forms of writing. It shuns the use of figurative language such as idioms and personification. Commenting on the language of science, Lemke (1990) refers to it as a style that avoids colloquial forms, uses unfamiliar technical terms (e.g. *mitosis* and *meiosis*) and familiar words (e.g. *energy, force* and *power*) in unfamiliar contexts.

Students in pursuit of HE studies are exposed to academic language which involves the use of academic vocabulary that is common to academic discourse (e.g. *interpret* and *theory*) and technical vocabulary which is useful within specialized fields of study, but which varies across disciplines. However, academic writing is also interspersed with everyday language. As this study explores the link between science content and discipline-specific literacies, an explanation of the register applicable to science and the vocabulary and grammar usage in conveying knowledge in science is particularly relevant. This study shows through critical research question 2 if any of any perceived challenges with the use of the discipline-specific literacies are a consequence of the ability to use the register of science.

4.4.1 Register

Science has its own particular register. According to Halliday and Hasan (1976), in SFL, *register* refers to the 'clustering of semantic features according to situation types" (68). Mohan and Slater (2006) explain that registers are typically associated with particular social contexts and are described in terms of three main variables that influence the way language is used: *field*, *tenor*, and *mode*. *Field* is concerned with the activity being pursued or the subject matter the activity revolves around. *Tenor* refers to the social roles and relationships between the people involved, and *mode* is the medium and role of language in the situation. These three variables relate to three key areas of meaning in language (305).

"When linguists identify a "scientific register," then, they not only describe a style of language but also the practices, interactional patterns, and means of communication associated with scientific contexts" (Bawarshi and Reiff, 2010: 30). Issues relating to SFL and scientific register and the way in which these are to be explored in this study have been discussed in Chapter 3 of this dissertation. Biber (2006) describes register as "situationally-defined varieties" (11), including the speaker's purpose in communication, the topic, the relationship between speaker and hearer, spoken or written mode, and the production circumstances (Biber *et al.* 2002b: 10). Registers can be described at any level of generality. For example, methodology sections in chemistry research articles are a highly specialized register (Biber *et al.* 2002b: 10).

4.4.2 Defining Vocabulary Usage in Science

Science uses specific vocabulary and grammar to "describe complex ideas, higher-order thinking processes, and abstract concepts" (Zwiers, 2008: 20). The language of science is unambiguous and precise. This means that the reader is exposed to "a large number of scientific terms, each with their own precise meaning outside familiar context clues, all embedded in an extremely complicated sentence structure" (Bulman, 1986: 21) The words used in scientific discourse need to be learnt within particular contexts; and since the words used in science are accurate, precise and objective; memorising a string of highly specialized scientific terms and concepts serves very little purpose. Word choice in science discourse is diverse. The language of science is made up of technical words and non-technical words.

Non-technical vocabulary refers to terms that have one or many meanings in everyday language but which have a precise and sometimes different meaning in a scientific context (Cassels and Johnstone, 1985). Examples of non-technical words are *principal, random, excess, relative, illustrate, negligible* and *tabulate.* Studies conducted by Cassels and

Johnstone (1985) deemed these words as being most troublesome and indicated that it is these non-technical words that resulted in students' misunderstanding of science. Non-technical words used within the sciences can pose as obstacles for students who learn science in a second or additional language. In addition, common to the discipline of science are the use of metalinguistic and metacognitive words (Wilson, 1999). "Metalinguistic verbs are words which take the place of the verb to 'say' (e.g. *define, describe* and *explain*) while metacognitive verbs are words which take the place of the verb to 'think' (e.g. *predict, calculate* and *deduce*)" (Wilson, 1999: 1069). In support of this, research by Clark (1997) found that for learners in Grade 9 in South Africa, it was the use of non-technical and familiar words used in science to be most problematic to second language learners of science.

Learning science involves two types of patterning: creating taxonomies of new technical terms that differ from everyday understandings, and creating logical sequences of reasoning, such as cause–effect relations (Halliday, 1998). Since science is a highly specialized discipline that cannot be explained using everyday language, the reliance on technical words that are context- and discipline-specific is crucial. This means that within the broad discipline of science, there are technical words, terminology and concepts that have specific meanings in, for example, the disciplines of biology, chemistry, mathematics and physics. Technical words typify the language of a discipline. Examples of commonly used words across science are *reaction, equation, volume, hypothesis* and *theory.* Science disciplines feature technical terms which replace common every day words, for example *mammalia* in place of *mammals* or *sodium chloride* in place of *salt*. As expressed earlier in this paragraph, there are technical words used in science that are specific to academic disciplines, such as *chromosome* in biology; *anion* in chemistry; *hypotenuse* in mathematics; and *torque* in physics. These technical words in science are best conveyed when used in a scientific explanation – either orally or as a written text. Biber (2006) points out that most of these highly technical words do not have commonplace synonyms because they refer to entities, characteristics, or concepts that are not normally discussed in normal everyday conversations. He contrasts the use of specialized discourses in the sciences with that of humanities and social science textbooks which are more likely to deal with aspects of everyday life, discussing people, events and social behaviour from new perspectives.

Included in the vocabulary of science discipline are familiar words that students confront and even use in everyday interactions and normal inter-personal conversations, however, such words, for example, *power*, *energy* and *frequency* have different meanings in new contexts such as science classrooms and textbooks. Moji and Grayson (1996) have isolated examples of concepts (e.g. *power* and *force*) which have specific meanings in science but translate into a single term in the African languages isiZulu and seSotho. "Science terms, to some extent, are metaphors", for example a *field* in the context of science is not really a reference to a playing field (Wellington and Osborne, 2001: 5). As conveyed by Parkinson *et al.* (2007), it is thus the use of everyday words in the context of science that creates barriers to understanding science.

In scientific register, complex phrases are created by combining more than one concept (e.g. *least common multiple*) and words are derived from Greek and Latin (e.g. *parabola, denominator* and *coefficient*). Common to the science disciplines is the use of two or more words to differentiate between things which are different in themselves, but belong to the same general topic (e.g. *converge and diverge; sequence and series; interpolation and extrapolation*). Bulman (1986) cites "polysyllabic words such as *orthorhombic, phosphorous* and *diaphragm* used in science which are difficult to spell and pronounce" (21).

4.4.3 Grammar in Science

Although science is perceived as being experimental, practical or operational, the language in science texts is dense and conceptual and is conveyed in an authoritative manner. Reid and Hodson (1987) comment that "the writing of science is expository, turgid and more information oriented" (87). A feature common in scientific texts is increased lexical density which makes reading more difficult. Science uses its own unique specialized lexicon, semantics and grammatical structure to construe scientific knowledge and values. The grammatical features that dictate how scientific texts present knowledge are nominalisation, lexical density grammatical metaphor, causal and reasoning verbs, logical connectives and passive verb usage. (GM has been adequately explored in Chapter 3). The critical research questions relate to discipline-specific literacies in science and thus the nature of science discourse. Consequently, responses to critical research question 2 intend to show whether any of the perceived challenges that arise are a consequence of any of the grammatical features of scientific texts, especially nominalisation and lexical density.

4.4.3.1 Using Nouns and Nominalisation which contribute to Lexical Density

Unlike spoken communication, the language of science has a greater reliance on the use of nouns rather than verbs. This is illustrated in the sample paragraph below cited by Biber (2006) from an ecology textbook which distinguishes the greater use of nouns (in bold) as opposed to the use of verbs (underlined):

> **Wildlife photography** represents the nonconsumptive **use** of **wildlife**, which is the **use**, without **removal** or **alteration**, of natural **resources**. For much of this **century**, the **management** of **wildlife** for the **hunter** has been emphasized by **wildlife managers.** In recent **years**, however, **management** for nonconsumptive **uses** such as **wildlife photography** and **birdwatching** has received more **attention** (48).

"In the paragraph sample above there are three main clauses *(Wildlife photography represents ...; management has been emphasized ...; wildlife photography has received ...)* and one dependent clause *(use of wildlife, which is ...).* The primary function of the verbs is to connect long and complex noun phrases, which convey most of the information in the paragraph *(e.g. the management of wildlife for the hunter, management for nonconsumptive uses such as wildlife photography ...)"* (Biber, 2006: 49*).* Such complex linguistic styles in science make reading of the texts harder to access. Examples of the expression of science information as indicated in the example cited above illustrate that when events are represented as nouns rather than verbs, texts not only become more compact and dense, but more difficult and inaccessible. These impact on the way second language speakers decode, deconstruct and comprehend, process and eventually produce scientific texts.

It is through nominalisation that "actions, events and qualities are construed as nouns, and thus represented as objects" (Halliday and Martin, 1993: 52). Nominalisation which features prominently in science language makes actions or processes (verbs) become concepts (nouns) or noun phrases. An example of a sentence containing a scientific fact in which an action (e.g. *to recover*) is construed as a noun (*recovery)* is conveyed by Parkinson and Adendorff (2004): *"In the first stage of the recovery of magnesium, limestone ($CaCO_3$) is heated at high temperatures"* (381). Nominalisation has a tendency to make sentences more complex, especially since several abstract ideas are packed into one single sentence. Through nominalisation, verbs change from actions to concepts, making sentences harder to grasp, for example: the use of nominalisation changes the following simple sentence: "*If you reduce the length of the string you will increase the speed of the pendulum"* to "*The reduction in the length of the string will produce an increase in the speed of the pendulum*" (Bulman, 1986: 23). In the examples of nominalisation cited, changing the verbs *recover* and *reduce* respectively to *recovery* and *reduction*, are examples of grammatical metaphors used in the language of science.

"A grammatical metaphor (GM) is a substitution of one grammatical class, or one grammatical structure, by another" (Halliday and Martin, 1993: 79). As a mechanism used to "describe processes of knowledge construction and reproduction" … and "a characteristic of scientific writing and thought" (Massoud and Kuipers, 2008: 214-215), nominalisation in the context of science is used to depict cumulative knowledge as in the following example:

1. The water decomposed.
2. The decomposition of water involved forming new molecules.

(Massoud and Kuipers, 2008: 215).

For students to engage with science, they need to become familiar with the way in which nominalisation features in science texts and practice. Even though nominalisation enables the writer to write concisely, thus satisfying the discourse community of science, it creates lexically dense texts that can be challenging to students' comprehension of them, more especially for students for whom the language of academic texts is not their native language.

This intense use of nouns in science language brings out a linguistic feature that is prominent in science, referred to as lexical density. Lexical density is the measure of the density of information in a text, depending on how tightly the content words have been packed into the grammatical structure of the text (Halliday and Martin 1993: 76). It can be measured by the number of lexically dense words per clause. Lexical density is higher in formal and planned language such as academic language but it is not uncommon to find the lexical density of science texts to be considerably higher and therefore more difficult to read.

The following examples extracted from Halliday and Martin (1993) are an indication of tightly packed lexical clauses: "(1) A *parallelogram* is a *four-sided figure* with its *opposite sides parallel* (which has a lexical density that measures six); and, (2) The *conical space rendering* of *conical strings' gravitational properties applies* only to *straight strings* (which has a lexical density that measures ten)" (76). A distinct feature of science content is the use of a string of lexically dense words such as '*conical space rendering'* that has no grammatical words between them.

Wellington and Osborne (2001) outline the point that scientific texts contain a large number of explanations *e.g. an explanation of how stars are formed*. "Explanations are accounts that focus on the processes ... they have [high] proportion of action verbs; these actions are organized in a logical causal sequence" (70). This necessitates the use of logical connectives such as *therefore, in addition, essentially* and *because* as a way of ensuring that texts are presented in a logical and coherent way. Gardner (1977) defines logical connectives as "words or phrases which serve as links between sentences, or between propositions within a sentence, or between a proposition and a concept to form a more complex proposition" (v). Gardner (1977) differentiates between "logical connectives indicating inference (e.g. *consequently* and *thus*); comparisons and contrasts (e.g. *alternatively* and *unlike*); generalizations (e.g. *often* and *in general*) or logical connectives as additives (e.g. *in addition* and *furthermore*) or apposition terms (e.g. *namely* and *for instance*). The way science texts are composed means that a student needs to process both the technical words used in science as well as the non-technical words, included within which are the logical connectives. The perceived difficulty apparent in the use of logical connectives is the fact that not all of them belong to one grammatical category: connectives can be co-ordinators (e.g. *and; but; or*) or adverbials (e.g. *hence, exactly*)" (11).

Students require linguistic competence to comprehend the specialized concepts in science and the grammatical patterns used to convey such concepts. Students require linguistic cues to negotiate meaning of the "context-reduced communication" (Cummins, 1984b) prominent in scientific texts which are cognitively demanding. This requires reliance on Cummins' (1984b) CALP. As with academic texts in general, science texts contain complex vocabulary, grammatical and discourse features.

4.5 Writing Science Objectively

Scientific research is inclined to be supported by evidence/s, proofs, statistics and data. In science, information is typically presented accurately and objectively, as well as in an assertive tone (Schleppegrell, 2001). In order to do so, the author must distance himself or herself from the text by refraining from using:

1. first person references (e.g. *I am writing.*);
2. references to his/her mental processes (e.g. *I think; I suppose*);
3. discourse fillers for monitoring information flow (e.g. *you know; well*);
4. direct quotes (e.g. *He says,"I am tired."*); and,
5. vagueness and hedges (e.g. *sort of; stuff like that*) (Chafe, 1982).

Therefore, in science, the genre of report writing is conveyed objectively via the use of passive verbs. The passive voice is commonly used in scientific writing to create an objective, impersonal science text, mainly used to explain the method or procedure of conducting an experiment. One of the elements peculiar to science is genre pedagogy (Hyland, 2002) (which has been discussed in the previous Chapter). This study also explores the nature of genre writing, the tools used to teach it and any accompanying difficulties that emerge in relation to it.

Being authoritative, the language of science differs tremendously from everyday conversational language. Due to lack of familiarity with the type of reading and writing commanded in the sciences, students can experience difficulty engaging with the scientific language and can display poor competence at scientific writing. Therefore, being a serious discipline that uses a non-familiar writing style that relies on specific register, sentence and grammatical structures, science language can present challenges in reading and writing. This study, after having fathomed the discipline-specific literacies required in science (by means of critical research question 1); uses critical research question 2 to indicate the perceived challenges associated with the language of science and discipline-specific literacies in science and finally; through the inclusion of critical research question 3, shows the type of support measures used by the DSs to address to help foundation students registered to study modules in the FP with the acquisition of them.

4.6 Visual Representation Use in Science

Scientific knowledge is not only communicated via the spoken and written word. There is ample use of pictures, photographs, charts, images, models, diagrams, illustrations, figures, graphs, symbols, calculations, equations, formulae and abbreviations which, together with words, convey meaning. According to Wellington and Osborne (2001), these are known as "'semiotic modes' which involve using words and other modes of communication to make meaning" (7). Visual forms in science can be used to explain, reinforce, clarify, compare and contrast information.

As noted by Avraamidou and Osborne (2009), "science deviates from the discourse of everyday life in that its language increasingly becomes multi-semiotic. The graphs, symbols, and diagrams of the modern scientific paper do not merely serve an additional supplementary illustration; rather, they are integral to its communicative function" (1684). Therefore, they need to be learned and understood in relation to the concepts they represent and the conventions under which they can be used. According to Porush (1995), "visual illustrations present testimony about an empirical observation or a set of observations" (149).

4.7 **Quantitative Literacy (QL)**

Students would require competence in Quantitative Literacy (QL) to be able to critically read and interpret various representations of data such as figures, equations, tables, charts and graphs and texts; draw conclusions from percentages, averages and forecasts; explain trends and patterns in a given situation; perform basic computational/arithmetic operations; demonstrate skills at estimating and approximating; show basic problem-solving skills; make inferences from statistics; and, understand and apply basic concepts of probability. QL has become an increasingly important and visible[41] feature in some tertiary institutions

[41] The terms 'quantitative literacy', 'numeracy' and 'mathematical literacy' are often used interchangeably when naming a wide range of practices related to dealing with quantitative information (Frith *et al.* 2010).
With many students entering university without the appropriate quantitative literacy and computer literacy abilities, the Numeracy Centre at UCT (established in 1999) aims, through an 'Effective Numeracy' course, to increase students' competencies in these fields so that they can exercise these appropriately in the variety of contexts of their studies (Frith *et al.* 2010).
"At UKZN, the aim of a 'Basic Numeracy' module (offered as part of the Humanities Access Programme), is to develop in learner's basic numeracy skills and apply these skills in a variety of contexts (e.g. law, education and humanities). The content is: Decimal Numbers and Calculators; Percentages; Ratio, Rate and

in South Africa to assist students with the quantitative demands of the university curricula. The HE sector also has a responsibility to produce quantitatively literate graduates who would have to "participate in an increasingly quantitative world" (Frith and Lloyd, 2013: 272). The issue of QL has been widely researched (Steen, 2001; Hughes Hallet, 2002; Frith, 2006; Frith and Prince, 2009; Frith *et al.* 2010; Frith, 2011; and Frith and Lloyd, 2013). Frith and Prince (2006) define quantitative literacy as:

> the ability to manage situations or solve problems in practice, and involves responding to quantitative (mathematical and statistical) information that may be presented verbally, graphically, in tabular or symbolic form; it requires the activation of a range of enabling knowledge, behaviours and processes and it can be observed when it is expressed in the form of a communication, in written, oral or visual mode (30).

Research in the field of QL has not only highlighted its role within diverse HE sectors such as health science, law and humanities where the QL demands and practices differ (Hughes Hallett, 2001); but also the importance of students being equipped with QL which is applicable to everyday life and work situations – the world outside the tertiary environment, appropriately described by Steen (2001) as "mathematics acting in the world" (6).

According to Steen (2001) the knowledge and skills that are a part of everyday life and work situations are related to but different from traditional mathematics. Mathematics, as a discipline, is vastly different from QL and it cannot be assumed that students who have studied mathematics will necessarily be able to manage the quantitative demands of different disciplines as QL requires students to exercise competencies which the study of mathematics might not necessarily have developed. Hughes Hallett (2001 cited in Prince and Archer, 2005: 227) suggests that there are three main differences between mathematical knowledge and QL. Firstly, she characterizes mathematics as requiring students to climb the ladder of abstraction which rises above context and contrasts this with QL which requires students to stay in context. Secondly, she argues that mathematics is about general principles that can be applied to a range of contexts, while QL is about seeing *every* context through a quantitative lens. Lastly, she maintains that statistics is the

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Proportion; Statistics and Statistical Graphs; Interpretation of Statistical Graphs" (UKZN *College of Humanities Handbook*, 2013: 236).
UFS offers a first year Mathematical Literacy course for Humanities and Law students (UFS *Faculties of Humanities Handbook*, 2014: 11, 25).

quantitative tool that is most likely to be encountered in all aspects of life and thus statistics is closer to QL than is traditional school mathematics.

Frith and Prince (2009) "conceptualise QL as a social practice in which people manage situations or solve problems involving quantitative information" (85)[42]. QL is thus context-based. Hughes Hallett (2003) expands on this notion of QL:

> Quantitative literacy is the ability to identify, understand, and use quantitative arguments in everyday contexts. An essential component is the ability to adapt a quantitative argument from a familiar context to an unfamiliar context. Just as verbal literacy describes fluency with new passages, so quantitative literacy describes fluency in applying quantitative arguments to new contexts ... It [quantitative literacy] depends on the capacity to identify mathematical structure in context; it requires a mind searching for patterns rather than following instructions (91).

Engaging in QL, according to Frith (2011), means understanding the disciplinary context in which QL is framed, knowing the mathematical and statistical concepts required (the content); and the underlying thinking and behaviours needed to address the QL situation[43]. Since different QL practices are linked to different academic disciplines, Frith (2012) is of the opinion that "the development of QL cannot be disentangled from language development and [q]uantitative information and concepts are conveyed through language, often using precise terminology and discipline specific forms of expression which are associated with specific quantitative ideas" (3).

4.8 Communicating Science

Literacy development involves abilities well beyond being able to speak, listen, read, and write. Lee and Fradd (1998) mention that "in the case of science instruction, it involves learning to observe, predict, analyze, summarize, and present information in a variety of formats, such as orally, in writing and drawing, and through tables and graphs. Added to

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[42] Hughes Hallett (2003) cites the following examples of quantitative literacy in practice: "being able to make a mental estimate of the tip in a restaurant; reading graphs of the unemployment rate against time" (93).

[43] Frith *et al.* (2010) show this integration by offering the following QL situation: "A report in a South African newspaper in July 2009 said that striking construction workers (building 2010 Football World Cup infrastructure) settled for a 12% pay rise. To understand what this really means in the social context, you need to know that the average daily wage of a construction worker is R140 (context), to be able to accurately calculate 12% of R140 and to realise that this calculation would be useful (mathematical content). To assess the meaning of calculated quantity in the social context of the workers, you need to understand something about prices, the inflation rate, the average number of dependants a worker has and so forth (the context)" (4).

these are the functions of describing, reasoning, explaining, predicting, hypothesizing and reflecting" (14). All these functions are needed in science "process and communication" (Casteel and Isom, 1994). These functions need to be utilised for scientific experimental activities as well as for science oral and written communication. Christie and Derewianka (2008) describe the features of seven genres that students are expected to write in science classes: genres that *record* students' observations such as *procedural recounts, demonstrations, research articles,* and *field studies;* and genres that *interpret* natural phenomena, such as *reports, explanations,* and *discussion.*

4.9 Science Practical and Laboratory Activities

Practical work is a major component of the science curricula as a way of gaining scientific understanding. "Laboratory activities may be effective for learning process skills, reasoning, and how to deal with perplexing empirical data" (Singer *et al.* 2005). In terms of laboratory activities, Driver (1983 cited in Wright, 2008) comments on the importance of observation, implying the need for both action and language. This point ties up with Lemke's (1990) advocacy of 'talking science" (1). In other words, laboratory work is not just about 'doing' science but should incorporate the linguistic, commenting that laboratory activities involve both communicating and engaging in science discourse by "explaining, observing and interpreting" (Wright, 2008). In this way, students' understanding of facts and knowledge is demonstrated. Students' engagement with the laboratory activity is then transformed into spoken and written representations of the activity in a way that conforms to scientific conventions.

As a summary, Zwiers' (2008: 85) succinct description of the function of the language of science is pertinent for this study:

1. Describe relationships of taxonomy, comparison, cause and effect, hypothesis, and interpretation. Unlike language arts and history, science texts have few stories and narratives. The text structure is dense and hierarchical (topic, subtopics, details).
2. Describe procedures explicitly with procedural language, such as measure, observe, calculate ... These are used mostly in lab directions and lab reports.
3. Connect abstract ideas illustrated by various media. Photos, diagrams, graphs, charges, math and chemistry symbols, lab experiences, and text all overlap to communicate concepts.
4. Use generalized verbs in the present tense to describe phenomena, how something occurs, and why.

5. Be highly objective. The author construes message as fact rather than opinion, and there is a lack of first-person perspective and emotion.
6. Use large amounts of passive voice construction.
7. Use many new and big words with new meanings, many of which are nominalizations, such as condensation, refraction, induction.

4.10 Literacies across Science Disciplines

The use of academic language and the discourse of science outlined in the first part of this Chapter are operational in the various disciplines of the faculty of science. It was imperative that a discussion on the nature of the language that constitutes science as well as the vocabulary and the grammatical and sentence structures used in the disciplines of science be presented as they are the literacies referred to in this study which the FP science students need to acquire to be able to engage with "talking, doing and writing science" (Lemke, 1990: 1) in order to learn science and become productive citizens of the country. Having explained how the research questions address the core issue of discipline-specific literacies in science and the way in which these issues are explored in this study, the next section of this Chapter outlines how discipline-specific literacies manifest across the disciplines of biology, chemistry, mathematics and physics. These are of particular importance for this study.

4.10.1 Literacies for Epistemology across Science Disciplines

Science disciplines are cognitively demanding. "Deep scientific understanding includes a coherent system of facts, concepts, scientific inquiry and strong problem solving ability" (Staver, 2007: 11). In science, students acquire either conceptual or procedural knowledge. While conceptual knowledge requires a deeper understanding of underlying concepts, procedural knowledge implies completing operations by following steps. The sub-disciplines of biology, chemistry, mathematics and physics offered in the discipline of science share similar academic discourse, genres and literacy practices. They share, too, similar register and grammatical features in their presentation of content knowledge.

The disciplines of chemistry, mathematics, physics loosely viewed as the least language-dependent disciplines in the sciences, are inclined to rely on more extensive use of symbols, formulae, figures and equations to convey, interpret, analyze, solve and assimilate content knowledge. There is, however, the discursive space in their scientific content (e.g.

in reading and solving problems) to reason, infer, debate, discuss, hypothesize, question, solve and resolve. This, then, involves some measure of competence in both linguistic and science literacies.

This assertion above is clearly relevant to mathematics. Kilpatrick *et al.* (2001) highlight the five strands of mathematical proficiency required for successful mathematical competence noted below. I have amended the original extract by consciously drawing attention to the link between language and mathematics by highlighting the pertinent literacies in bold print:

- **Conceptual understanding: comprehension** of mathematical concepts, operations, and relations
- **Procedural fluency**: skill in **carrying out procedures** flexibly, accurately, efficiently, and appropriately;
- **Strategic competence: ability to formulate,** represent and **solve mathematical problems;**
- **Adaptive reasoning**: capacity for logical **thought, reflection, explanation, and justification** and;
- Productive disposition: habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy (116)

The point above can be substantiated by that of Gibbs and Orton (1994) who explain that mathematics discourse generally contains items that have linguistic, cognitive and contextual dimensions. Bohlmann and Pretorius (2008) define each dimension. The linguistic dimension involves both the receptive level (i.e. reading) and the productive level (e.g. writing, discussing). The cognitive dimension reflects the level of complexity of the concepts and cognitive skills such as logical reasoning, critical analysis and interpretation of abstract concepts. The contextual dimension reflects the level of contextual support provided (Bohlmann and Pretorius, 2008).

Bohlmann and Pretorius (2002) draw attention to procedural discourse in some parts of mathematics texts, which "provide instructions and explanations on how to carry out a task or algorithm" (197), "procedural fluency being the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately" (Engelbrecht *et al.* 2005). Conceptual understanding is a highly valued learning outcome in tertiary studies. Anderson and Schönborn (2008) describe conceptual understanding as multi-faceted and "requires competence in the cognitive skills of memorization, integration, transfer, analogical reasoning, and system thinking" (309). Engelbrecht *et al.* (2005) describe conceptual understanding as "involving the understanding of mathematical ideas and procedures and includes the knowledge of basic arithmetic facts" (701). In conceptual discourse, students "are not only expected to know the procedure that needs to be followed to solve a problem, but also why, when and how that procedure works" (Setati, 2005: 102); "they should be able to identify and apply principles, know and apply facts and definitions, and compare and contrast related concepts" (Engelbrecht *et al.* 2005: 701). Potgieter *et al.* (2008: 5) distinguish between *algorithmic* questions which are questions that can be answered by applying a step-by-step procedure to generate a response and conceptual questions that probe the depth of understanding of the concepts related to a question. (Bowen and Bunce, 1997). Algorithmic questions typically require lower order cognitive skills (Zoller *et al.* 2002). Engelbrecht *et al.* (2005) offer a distinction between procedural knowledge and conceptual knowledge:

> Procedural knowledge is the ability to physically solve a problem through the manipulation of mathematical skills, such as procedures, rules, formulae, algorithms and symbols used in mathematics. Conceptual knowledge is the ability to show understanding of mathematical concepts by being able to interpret and apply them correctly to a variety of situations as well as the ability to translate these concepts between verbal statements and their equivalent mathematical expressions. It is a connected network in which linking relationships is as prominent as the separate bits of information (701).

Science disciplines rely on the technique of problem solving to ascertain students' conceptual and procedural knowledge. There is a fair degree of consensus among physics instructors that the activity of problem solving is a powerful tool in assisting with changing and expanding the conceptual framework of the learner as it sets up situations which force the learner to grapple with new and unfamiliar concepts which may then be internalized, sometimes after conflict with existing conceptual structures (Buffler and Allie, 1993: 15).

Problem solving as a learning tool is just as useful in the discipline of chemistry. Effective problem solving skills in chemistry require intellectual skills such as focussing, information gathering, remembering, analyzing, generating, integrating and evaluating. Drummond and Selvaratnam (2008) identified four types of intellectual strategies that are particularly important in solving chemistry problems:

> 1. clarification and clear presentation of the problem;
> 2. focussing on the goal and identifying a strategy for moving towards the goal;
> 3. identification of the principles needed for solution and;
> 4. proceeding step by step (56)

In biology, students are expected to "acquire knowledge and understanding that is diverse at different levels of complexity and abstraction; flexibly transfer knowledge during problem-solving; and interpret and translate across multiple external representations ... the process of translation requires the comprehension and conversion of relationships between external representations such as diagrams, physical models and visuals" (Schönborn and Bögeholz, 2009: 931, 933).

Success at tertiary level science means being able to participate in the discourse of its disciplines, gaining an adequate knowledge base as well as learning and applying the specific genres and scientific activities required to communicate its epistemology. The components of academic discourse conveyed by Snow (2005) are applied in this context to illustrate what could contribute to academic success at higher education institutions:

1. linguistic understanding of lexical or word choice issues, syntactic or sentence structure issues, text structure, and language functions;
2. background knowledge of content and;
3. cognitive knowledge and critical thinking skills.

Achieving this academic success in science can be challenging for students when the LoLT is either a second, third or even an additional language. In this study, the LoLT at a South African university, the research site of this study, is English and the students in the FP speak EAL. Such students have to "immerse in two social practices together at the same time when learning science: one which has to do with learning a new language (i.e. English) and the other which has to do with learning science (i.e. language of science)" (Lemke, 1997). This becomes even more challenging when students who opt to undertake HE studies are underprepared for the rigours of academia as a consequence of the quality of their secondary schooling.

Thus, this study intends to find out, through critical research question 1, the specific discipline-specific literacies required in the foundation modules offered in the FP in the light factors such as reading, conceptual understanding, comprehension; procedural fluency, logical reasoning, and problem solving that have been discussed above. In doing so, critical research question 2 highlights the perceived challenges that can be presented by such literacies. Critical research question 3 then seeks to find out the mechanisms used by DSs to assist students in the FP with the acquisition of such discipline-specific literacies in science.

The core of this study is the acquisition of discipline-specific literacies in science and an understanding of any perceived challenges that the FP students experience in respect o the acquisition of such literacies. The reference to student underpreparedness for science at HEIs due to their educational disadvantage has already been alluded to (in Chapter 1). It has thus been necessary to review existing literature with regard to this issue. This is presented in next part of this Chapter.

4.11 The Impact of Educational Disadvantage on the Learning of Science

"Higher education [at tertiary institutions] focuses on the functions of teaching and/or research that prepare individuals to take up a variety of roles in society" (Raju, 2004: 1). However, this focus has become blurred in the light of the system of education offered in South Africa. Due to the imbalances in education already elucidated in Chapter 1 in this dissertation, many students from educationally disadvantaged backgrounds who enter HEIs to study science lack the necessary competencies in mathematics and science that are needed for academic success. This has been described as the 'articulation gap'. Of relevance to this study is an understanding of the articulation gap in the foundation disciplines of science.

4.11.1 The Articulation Gap in the Sciences

"The interface between school and higher education in South Africa has often been characterised in terms of discontinuity or 'articulation gap' "(ASSA*f* STEM, 2011). This is the gap between "students' capabilities and universities' expectations" (Marshall, 2009: 65) referred to by various other researchers (Basson, 2010; Potgieter, 2010; Frith and Prince, 2009; Potgieter *et al.* 2008; Reddy, 2006; Howie, 2003). Rollnick *et al.* (1998 cited in Rollnick, 2010) expand on the 'articulation gap' in the following outline where Stage A is the school and Stage B is the higher education institution: "A gap can be characterised by what happens at the interface between the two levels of education; between the end of Stage A and the beginning of Stage B, i.e. the articulation between the two courses or stages in education (91)".

This articulation gap is one of the factors that can compromise students' performance at HEIs. Student underpreparedness in secondary school mathematics and sciences becomes even more complicated and problematic for students who intend to pursue university science degrees. This point is attested by that contained in the country's NPHE (2001) which claims that "the school system then was unable to produce large numbers of matriculants who have the required proficiency in mathematics" (26). Besides the fact that university science studies necessitate competence in mathematics, life sciences and/or physical sciences, students would also have to cope with the literacies specific to each of these disciplines. Students who enter the faculty to pursue science or science-related degrees with inadequate science competencies face the possibility of poor or even under performance in their tertiary studies. Where this is coupled with language barriers to understanding science, then the chances of academic success becomes even more remote. This study serves to show whether this 'articulation gap' is manifested in the FP students and, if so, how this gap is narrowed.

4.11.2 Third International Mathematics and Science Study (TIMSS) Tests: Implications of Performance

If poor performance in mathematics and science at university level is traced to the articulation disjuncture at school level, then the statistics of the Third International Mathematics and Science Study (TIMSS) tests need mentioning. Research into the TIMSS has been undertaken by various researchers (Howie, 2001a; 2001b; 2003; Reddy, 2006; Dempster and Reddy, 2007). South Africa has consistently been the lowest-performing country (out of 38 to 50 participating countries) in mathematics and science in two successive TIMSS tests. Howie (2003) notes that in the TIMSS conducted in 1995, where South Africa participated with 41 other countries, South African mathematics learners came last with a mean score of 351, far lower than the international mean score of 513. Third International Mathematics and Science Study Repeat (TIMSS-R) conducted in 1999 revealed that Grade 8 learners once again performed poorly. Their mean score of 275 being significantly below the international mean of 487. Similarly, a later TIMSS-R conducted in 2003 revealed no improvement in mathematics and science by South African students.

Dempster and Reddy (2007) point out vast differences in the TIMSS average achievement scores of learners in schools categorized by ex-racially determined departments of education. These researchers investigated the relationship between the readability of the multiple choice questions in the test and the performance of two groups of students: one group, with limited proficiency in English and who attended 'African' schools; the other being those with better proficiency in English and who attended 'non-African' schools. The results from their study are quoted below:

> Learners from non-African schools performed significantly better than learners from African schools. Three readability factors (sentence complexity, unfamiliar words, and long words) were analyzed. High sentence complexity resulted in random guessing in non-African schools, and favouring an incorrect answer in African schools. Some TIMSS items have complex wording, with numerous prepositional phrases and clauses, and unclear questions. Recommendations for maximum readability and comprehensibility were not met, and these items are therefore invalid for learners with limited English-language proficiency. Learners employ a range of strategies in attempting to answer questions that they do not understand (906).

Evidence from the research undertaken by Dempster and Reddy (2007) is relevant for this study, especially because students in the FP, where this study is undertaken, come from largely educationally disadvantaged backgrounds and are accepted into the programme with low matriculation points in a science subject (as outlined in Chapter 1). These are EAL students, a factor relevant to this study which also explores whether the acquisition of science literacies is a consequence of language difficulties.

The TIMSS throws light on the relationship between performance in the sciences and language. Reddy (2006) outlines the nature of the test in respect of assessment:

> TIMSS assesses in the areas of mathematics and science and was framed by two organising dimensions: a content domain and a cognitive domain. The content domain defined the specific mathematics and science subject matter covered by the assessment and the cognitive domain defined the set of behaviours expected of learners as they engage with mathematics or science. The content domains that framed the mathematics curriculum were: number, algebra, measurement, geometry and data. The cognitive domains for mathematics were: knowing facts procedures, using concrete, solving routine problems, and reasoning. The content domains that framed the science curriculum were: life science, chemistry, physics, earth science and environmental science. The cognitive domains were: factual knowledge, conceptual knowledge and reasoning and analysis (xi).

The description of the nature of the TIMSS tests is relevant for this study, especially since science disciplines require conceptual and procedural understanding and intellectual strategies required for problem-solving which have already been discussed in the preceding part of this Chapter. The impact of the absence of these competencies in science students entering tertiary institutions, albeit at their lower schooling years can be detrimental, considering that science learning is hierarchical and cumulative, meaning that learning a new concept is dependent on the internalisation and understanding of previous ones.

Howie (2003) reports that in the TIMSS 1995 and TIMSS 1999 studies, more than 70% of the pupils wrote the achievement tests in their second or third language. A national option, an English test, was included together with the TIMSS-R mathematics and science tests in an attempt to ascertain the level of the pupils' language proficiency. The investigative study into student performance done by Howie (2003) to figure out the relationship between mathematical achievement and English-language proficiency revealed that learners tended to achieve higher scores in mathematics when their English language was higher and vice versa. The national overview by TIMSS reported significant language and communication problems with South African pupils who were learning mathematics in a second language. Pupils in all three Grades (7, 8, 12) showed a lack of understanding of both mathematics questions, and an inability to communicate their answers in instances where they did understand the questions. Pupils performed particularly badly in questions requiring a written answer (Howie, 2003).

The studies outlined above which were based on the mathematics and science literacy tests rather than the content-specialized test have revealed the impact of poor schooling and language proficiency on student performance in mathematics and science. Research (Monyana, 1996; Arnott and Kubeka, 1997; Adler, 1998; Taylor and Vinjevold, 1999; Mji and Makgato, 2006) points at the following indicators for poor performance by South African learners at school level mathematics and science (as well as in school studies in general):

> ... inadequate subject knowledge of teachers, inadequate communication ability of pupils and teachers in the language of instruction, lack of instructional materials, difficulties experienced by teachers to manage activities in classrooms, the lack of professional leadership, pressure to complete examination driven syllabi, heavy teaching loads, overcrowded classrooms, poor communication between policy- makers and practitioners, as well as lack of support due to a shortage of professional staff in the ministries of education (Howie, 2003: 2).

The reference to the factors above is pertinent to this study as it reflects the schooling environment and experiences of the majority of students who qualify to study tertiary science through the alternative access route, i.e. foundation programmes, the entry eligibility of which has already been commented on. This study intends to explore these issues. Although it may be argued that the TIMSS tests are a national survey researching the achievement of mathematics and science at secondary school level, it contributes to this study. It is essential because students entering higher education studies are expected to bring along with them basic knowledge, skills, literacies and competencies that form a foundation for higher order learning and thinking that are the essence of tertiary education. The deficiency of these at tertiary level has severe economic and social impacts. When educationally disadvantaged learners do not qualify for a direct entry into science disciplines in the HE sector or are underprepared for tertiary level science studies (resulting in higher attrition rates or failure to graduate within the stipulated time frame), then the pool of potential black scientists and engineers in South Africa becomes severely restricted.

The TIMSS tests have revealed students' difficulties in both English-language proficiency (especially with those attending the former DET schools) and literacies in science, both of which are significant to this study. Howie (2003) has isolated "inadequate communication ability of pupils and teachers in the language of instruction" (2) as being one of the performance indicators in school science and mathematics.

4.11.3 The Impact of Educational Disadvantage on Learning Academic Science

On the subject of LoLT, Dempster and Reddy (2007) state that "the official language policy in South Africa is that the home language should be the medium of instruction for the first three years of schooling. In many African schools, English is introduced as a subject in the third year but takes over as the LoLT from the fourth year" (909). This language policy necessitates a discussion around additive and subtractive bilingualism (Cummins, 1984a; 1984b).

In additive bilingualism, the first language continues to be developed and the first culture to be valued while the second language is added. In subtractive bilingualism, the second language is added at the expense of the first language and culture, which diminish as a consequence. "With "subtractive" bilingualism, the child's first language skills are replaced or "subtracted" in the process of acquiring the second language (Cummins, 1984a: 83).

Subtractive bilingualism can contribute to cognitive disadvantage. According to Cummins and Swain (1986), conceptual understanding and reading and writing skills may not have been developed in the first language before the switch to the second language. The impact of this is conveyed by Clarence-Fincham (2000) who states that learners have to develop their literacy skills and conceptual knowledge while learning the unfamiliar language, the medium through which the learning takes place. BICS develop more rapidly than CALP. Cummins' (1984a) studies of second language learners indicate that children can typically develop BICS over a period of one to two years but academic language, CALP, can take up to five to eight years to master. This issue of BICS and CALP (Cummins, 1984a) has already been outlined in Chapter 2. This study addresses the impact of underdeveloped CALP on science discourse acquisition.

Angélil-Carter and Paxton (1994) state that "because students from the ex-DET system lack mastery of CALP (Cummins,1984a), where a task is context-reduced and cognitively demanding, a situation of cognitive overload develops for the student from DET schooling" (8). These researchers qualify this point by stating that this load is increased by the fact that each discipline (at university) has its own specialized discourse. Students in HEIs who struggle with the LoLT (English), which may be their additional language, may thus miss the subtle linguistic cues used in science or at lectures by instructors who are either first language speakers of the LoLT or are highly proficient speakers of it despite it not being their native language. The existence of this is explored in this study.

Many South African students enter tertiary institutions with low reading speed, poor reading skills, the inability to grasp linguistic cues and incompetence at inferring from texts. They are therefore unprepared for the reading demands in the various academic disciplines (Pretorius, 2000a; Nel *et al.* 2004; Evans, 2002). A 2005 study undertaken by Kirkwood (2007) investigating the reasons why students in a science foundation programme at UKZN struggled with reading, the following factors were highlighted: reading was daunting because of unfamiliar vocabulary, the difficult language of the texts challenges the ability to unpack their meaning; texts are too long and reading the texts is time-consuming. Similarly, in Clark's (1993) view, the main reason for student difficulties with context-reduced science textbooks is that these reading strategies have not been developed. Besides, many students come from oral cultures and may have had hardly any exposure or interaction with books prior to formal reading at school, although the teaching of reading relies on learners already being apprenticed into such practices (Heath, 1994; Rose, 2004). Paxton (1998) explains that teaching at the former DET schools placed "a heavy emphasis on rote learning ... which elicited superficial comprehension rather than critical thinking" (139). These factors can impact negatively on student performance and progress in their tertiary studies. The issue of reading is addressed through critical research question 1 which extracts information on discipline-specific literacies needed in science; while critical research question 2 explores whether reading emerges as a perceived difficulty. In light of this, responses to critical research question 3 which outline the measures taken by DSs to assist students with acquiring discipline-specific literacies for science discourse is intended to show if reading strategies are an emerging theme.

A number of students entering university are underprepared for the demands and the writing genres that compose academic writing. A number of students from disadvantaged schooling backgrounds have been taught English as a first additional language at school. Their writing tasks were informal, descriptive, creative, narrative and personal. A study undertaken by Kapp and Arend (2011) into the 2008 and 2009 NSC English First Additional Language (EFAL) examinations taken by non-mother-tongue speakers of English (i.e. students for whom English is an additional language) revealed the following: "... texts that do not lend themselves to close, critical analysis, either at sentence or discourse level ... texts written at the level of oral conversation ... writing tasks that are mainly descriptive, decontextualised, uncritical and cognitively undemanding" (5-6)

Many of these students hail from schooling backgrounds where writing was perceived as "a technical process of transmitting finished thought from mind to paper according to a fixed set of grammatical rules. This is the instrumental view of writing as a set of discrete skills, which once learned, may be applied to any context" (Moore, 1998: 84). This involves the focus on grammatical competence, which is knowledge of the grammatical surface structures of the language such as rules or word formation, spelling and punctuation. Linked to this, is the belief that students' writing problems can be solved if attention is paid to grammar.

4.12 Underpreparedness for University Studies: Results of National Benchmark Test Project (NBTP)

There has been widespread research and concern about students' underpreparedness for university studies. Researchers (Cox, 2000; Lowe and Cook, 2003; Hay and Marais, 2004;

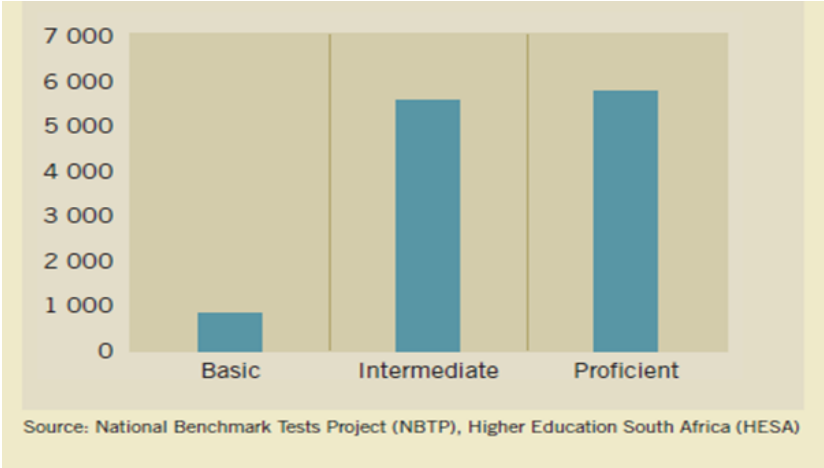
Nel *et al.* 2009; Wilson-Strydom, 2010; Bradbury and Miller, 2011; Marshall *et al.* 2011) have conducted various studies to pinpoint the reasons for the underpreparedness.

The most recent research on students' inadequate competencies and poor academic literacy skills have been evident in the results of the 2009 pilot study of the National Benchmark Test Project (NBTP). The NBTP, commissioned by Higher Education South Africa (HESA), was administered to more than 12 202 students entering university for the first time at seven South African universities. The participating universities were UCT, UKZN, Mangosuthu University of Technology (MUT), Stellenbosch University, Rhodes University, UWC and Wits. The domains tested were: academic literacy, quantitative literacy, and mathematics; and performance was categorized according to the benchmark levels: proficient, intermediate and basic.

According to Yeld (2009), the National Benchmark Tests (NBTs) have been designed to provide criterion-referenced information to supplement the NSC, the new qualification at the end of schooling. The objectives of the test were:

- to assess entry-level academic and quantitative literacy and mathematics proficiency of students;
- to assess the relationship between higher education entry-level requirements and school-level exit outcomes;
- to provide a service to higher education institutions requiring additional information to assist in placement of students in appropriate curricular routes and;
- to assist with curriculum development, particularly in relation to foundation courses (76).

In the academic literacy domain, the results of the test indicated serious weaknesses in basic grammar and syntax, understanding genre ('audience', register, tone), distinguishing main points from surrounding detail, and following arguments in text (Cliff, 2009 cited in Yeld, 2009: 78). The results for academic literacy revealed that more than half (52.63%) of the students were less than proficient (as reflected in Graph 1 on the next page).



Graph 1: February 2009 pilot results, academic literacy (Yeld, 2009: 78)

In an analysis of the statistics, Yeld (2009) offers the following commentary:

> It can be seen that the largest single category for academic literacy in the prevalent medium of instruction in higher education (English) is the proficient' band. However, almost as many students fall into the 'intermediate' category, and if one adds the numbers of students in the 'basic' category, those less than 'proficient' constitute a majority ... The poor achievement levels in the domain of academic literacy strongly point to the need for higher education institutions in South Africa to provide extensive support in language development, not only for a small minority of registered students, but for the majority (78).

The results of the mathematics test indicated major weaknesses in algebra, trigonometry and geometry and problem solving involving more complex reason procedures (Bohlman, 2009 cited in Yeld, 2009: 80). An outline of the AL as a university support structure has been discussed in Chapter 2 of this study. This study has included the responses of academic literacy specialists - responses which can be used to better understand the challenges of students' inadequate use of academic literacy presented here.

4.13 Underpreparedness for University Science

The articulation gap has been addressed among stakeholders in the HE sector with the view to providing informed perspectives on the ways forward for South African higher education. At the Academy of Science of South Africa Forum (ASSA*f*) (2009), Prof. Robin Crewe, the President of ASSA*f*, made mention of the fact that the overall student performance in science-based programmes at HEIs is below that of previous years ... it has become clear that the knowledge and skills with which students who obtained a NSC in 2008 entered HEIs were different from either the knowledge and skills that HEIs expect students to have or from those held by entering students in the past (7) and the comment by Grayson (2009) that .. “[i]n another part of the education system, higher education, students who wrote the new NSC seemed less well-prepared for university-level mathematics and science than their peers a year or two before them” (140).

Due to this, Crewe (2009) noted the need for an in-depth look at the curricula, teaching and assessment practices at school-level mathematics and science as well as the interface with these areas at higher education level. On account of this, one of the major topics identified for discussion by the body Science, Technology, Engineering and Mathematics (STEM), the standing committee of ASSA*f*, was the ‘STEM at the interface between school and higher education’. Subsequently, the ASSA*f* 2010 ‘Mind the Gap’ forum aimed to seek the response of the HE sector to the crucial issue of the ‘school-university gap’. As indicated earlier, this study intends to fathom the notion of student ‘underpreparedness’ in the FP and to field reasons for this.

Research into student performance in tertiary level science has attributed poor performance in science disciplines to poor conceptual knowledge and discipline-specific literacies in science. Mathematical knowledge tends to be hierarchical and cumulative. In order to master new advanced concepts, students need to have internalized previous ones. Student difficulties at senior secondary levels can be traced to teaching and learning at lower schooling.

For example, in an executive summary based on the TIMSS-R administered to Grade 8 learners, Howie (1999) illustrates the poor performance of South African learners in all content areas tested, viz. Earth Science, Life Science, Physics, Chemistry, Environmental and Resource Issues, and Scientific Inquiry and the Nature of Science. Performance in Mathematics read as follows: 37% for algebra; 45% for data representation, analysis and probability (11). The TIMSS-R analysis revealed learners’ difficulty at interpreting tables and graphic representations, answering complex questions and doing simple calculations. Many learners resorted to guessing in the multiple choice questions. Besides outlining learners’ deficiency in mathematical proficiency, the test revealed language difficulties, especially since less than 20% of the learners answered the open-ended items, demonstrating inadequate communication skills to articulate their scientific responses.

4.14 Research highlighting challenges with discipline-specific literacies in science

Research into student performance in the disciplines of science has outlined the link with discipline-specific literacies. Difficulties included poor conceptual understanding, problem solving skills and poor reading, comprehension and writing skills.

Poor performance in mathematics by students in HEIs in South Africa as a result of poor schooling, poor conceptual understanding and discipline-specific literacies, together with having to learn mathematics in a second language has been extensively researched (Bohlmann and Pretorius, 2002; Howie, 2003; Pillay, 2009; Moyo, 2010). Although mathematical competence is essential for students to progress and perform well in mathematics, other factors such as reading proficiency can impact negatively. A study undertaken by Bohlmann and Pretorius (2002) on foundation phase mathematics students at Unisa demonstrated that when students with poor reading skills are unable to pay attention to semantic and linguistic clues in texts, they either miss an argument of a text entirely or construct an erroneous or fragmented representation of it.

Drummond and Selvaratnam (2008) attribute students' difficulties with problem-solving to poor intellectual strategies. To explore this, they conducted a study between 1999 and 2001 at North West University to investigate the competence of first year chemistry students in some of the intellectual strategies and skills important for learning chemistry effectively. The students in the study spoke English as a Second Language (ESL). In the study, the method for testing intellectual strategies involved the comparison of students' performance in pairs of questions: 'standard' questions and 'hint' questions. The standard and hint questions were the same, except for one difference. The hint question had a 'hint' that suggested a strategy that should be used to solve the problem. The purpose of the study was to identify difficulties associated with learning strategies rather than knowledge of principles and concepts in chemistry. The results of the study indicated that some students were unable to carry out simple instructions, despite the provision of a hint, a weakness which could have been attributed to language difficulty. They were unable to deduce information from a simple diagram; and did not attempt to solve unfamiliar problems. Those who made some attempt to solve the problems did so using memorized procedures, rather than logic. Overall, the study revealed students' tested difficulties in applying intellectual strategies to solve problems.

An investigation into the procedural understanding of first-year ESL science students in the SFP at UCT was done by Allie *et al.* (1998). These researchers noted the relevance of the three areas of procedural understanding: “(1) identify a variety of 'frames' for doing experimental work, i.e. students' perceptions of the purpose of practical experimentation; (2) decisions about the experimental procedure are influenced by students' knowledge about how to manipulate the apparatus and; (3) the procedure adopted is critically influenced by the students' understanding of the issue of reliability of experimental evidence (Millar *et al.* 1996 cited in Allie *et al.* 1998).

The study by Allie *et al.* (1998) intended to show how informed perceptions of the reliability of the experimental data influence the design of a practical investigation, the ways the data are collected, reported and interpreted. In the study, written probes were used to explore ideas regarding the reliability of experimental data, in particular the need for repeating measurements, the spread of a set of measurements and the how to deal with sets of experimental data. In relation to students’ use of scientific language, the study of students’ responses to the probes revealed haphazard use of language: words were used interchangeably (e.g. *calculation, result, value*) as well as confusion about terminology (e.g. *error, range, precision*) (Allie *et al.* 1998).

In another study involving SFP students as subjects, Feltham and Downs (2002) used a set of three probes viz. a drawing quiz, a multiple choice question (MCQ) and open-ended questions to assess whether students’ background knowledge of biology was poor and whether this was, in any way, related to language proficiency. The assessment was not designed to probe students’ biological abilities. Although the subjects in the study did not perceive language as a problem in biology, the results of the study showed otherwise. Better performance in the drawing quiz (which was least language dependent) and the MCQ (requiring only reading ability) compared to the open-ended questions indicated students’ difficulties at written expression, an inadequacy that could disadvantage them.

The study undertaken by Feltham and Downs (2002) corroborates with that by Downs (2005) who conducted a study in the SFP at UKZN in which she investigated student performance in a range of tasks in biology and whether the final attained mark in biology reflected a students’ ability to cope with tertiary studies. The results of the study indicate that although students showed better performance in the practical component of biology and multiple choice questions, they experienced difficulties with answering short questions and essays testing theoretical knowledge. Downs (2005) attributes this to poorly developed higher cognitive and/or language skills. She also states that a combination of language problems and poor biological language knowledge lead to difficulties in constructing explicit scientific arguments.

Research into the difficulties in discipline-specific literacies in science has also been undertaken. Inglis (1993 cited in Rollnick, 2000), who worked with students' bridging into tertiary education, proposes that the quality of a student's writing is closely related to the student's conceptual understanding of the content of a particular assignment. Poorly written science assignments may be evidence of either poor language proficiency or poor conceptual understanding. According to Dempster and Reddy (2007), the learning of sciences requires a learner to be proficient in the language of instruction, as well as in the language of science, acquiring the specialized vocabulary that characterizes the sciences. They also state that poor performance in science assessment may be due to learners' misunderstanding of questions. Clerk and Rutherford (2000 cited in Dempster and Reddy, 2007), showed that misconceptions apparently identified in physics were frequently due to misinterpretations of questions.

Studies conducted within the (previous) Foundation Programme in Science (SFP) at UKZN include those undertaken by Keke (2008) and Pillay (2009). Concerned about students' educationally disadvantaged backgrounds and inadequate mathematical knowledge, Pillay (2009) embarked on a research study that focused on the advantages of implementing collaborative learning as a pedagogical intervention method to facilitate and improve mathematical skills and knowledge. The study outlines the relevance of understanding mathematical register and discourse which are necessary for mathematical communication, comprehension, reasoning and interpretation. Pillay's (2009) research illuminated the benefits of encouraging students to work together to create a mathematical community, to encourage interaction and to learn from each other. It also shows that students need to take responsibility for their own learning by working independently. Apart from this, the study showed that disciplinary specialists should be amenable to change and be prepared to veer from traditional teaching methods and utilize novel pedagogy to enhance student learning.

The study conducted by Keke (2008) explored how the experiences of students registered in the programme influenced their achievement and the mechanisms employed to improve upon their achievement. The research indicated that student achievement in the sciences was informed by academic, social and personal factors. Factors such as poor schooling, the articulation gap, the mismatch between expectations and the reality of the SFP, academic adjustment, financial difficulties, lack of family support, poor career choices and misconceptions of student support services were all identified as impacting on student achievement. Students attempted to combat these obstacles by using peers, mentors and counsellors positively with a view to enhancing their performance and success at university.

The research studies conducted in HEIs outlined thus far are pertinent to this study which seeks to explore the issues of discipline-specific literacies in science and the presence of any challenges that arise from poor understanding of them. As is the case with these studies, this study also looks at issues such as the impact of schooling experiences, LoLT, conceptual and procedural understanding on acquiring the discourse of science.

Conclusion

This Chapter commented on the need for the HE sector in South Africa to produce more skilled graduates in the fields of the sciences. It provided an understanding of how students who enter tertiary institutions should become participants in its culture and discourse practices. An explanation of the discourses needed to acquire tertiary level science has been provided. The characteristics of science discourse were highlighted as they are the literacies that feature in reading, writing, doing and talking science that FP students need to acquire and use as they engage with the texts and activities of science. This Chapter offered a discussion on essential literacies used in science disciplines at university. It illustrated the impacts of educational challenges and disadvantage at school level in South Africa on preparedness for tertiary level science. The research undertaken in this field serves to indicate concern among academics about difficulties associated with the acquisition of science discourse at university level and its impact on student learning and performance.

Chapter 5 discusses the research methodological practice that informed this study.

CHAPTER 5

METHODOLOGIES TO UNDERSTAND THE PHENOMENON

Introduction

Chapter 4 presented reasons the HE sector in South Africa needs to heed the call for an increase in the number of skilled black graduates in science, engineering and technology. It drew attention to the NPHE (2001) which states that besides technical skills, "employers want graduates who can demonstrate a strong array of analytical skills and a solid grounding in writing, communication and presentation skills" (UNESCO/World Bank Report, 2000:85, cited in NPHE, 2001: 27). The Chapter also drew attention to the need for students to become members of the university community. Reference was made to the need for students to learn the discourses of the discipline, i.e. the view of discourses (with a lower case "d") used in language for reading, writing and speaking; and the view of Discourse (with upper case "D") as an identity toolkit that includes ways of thinking, feeling, believing, valuing, acting, behaving and interacting (Gee, 1990). Such Discourse is concerned with broader values and worldviews. The Chapter offered a distinction between primary and secondary discourses (Gee, 1989). While primary discourse is acquired through face-to-face interactions in the home and represents the language of initial socialization, secondary discourses are acquired in social institutions beyond the family such as school and business contexts (Gee, 1989). Relevant to this study is secondary discourse which "involves the acquisition of specialized vocabulary and functions of language appropriate to those settings" (Gee, 1989: 5). The Chapter, furthermore, elaborated on the two ways in which meaning is expressed or received. In this context, it draws from Cummins' (1984b) continuum of context-embedded and context-reduced communication. While context-embedded interactions involve the use of social discourse, academic discourse relies on context-reduced communication. Context-reduced communication is specifically important in this study as science discourse is particularly dense and abstract. This necessitated a discussion in Chapter 4 on the nature of science discourse, with emphasis on scientific register, nominalisation, lexical density and the discipline-specific literacies required in science.

Chapter 5 discusses research methodological choices made in the process of conducting this study. This discussion concerns the research paradigm, research methodology and the research design deemed appropriate to realise the broad objectives of the study. The first part of the Chapter begins by explaining the rationale for choosing the interpretive research paradigm. The second part of this Chapter discusses the reasons for choosing the qualitative research approach and goes on to explain the types of data collected for this study, providing reasons for choosing triangulation as a strategy to ensure the accuracy of the findings. The third part engages with reasons for the choice of case study as the research design in this study. The fourth part offers the rationale for selecting the research sample. The final part of this Chapter discusses the choice of research instruments: semi-structured interviews, observation as well as documentary evidence (the course manuals used in the modules offered in the FP and the FP students' laboratory practical workbooks, laboratory reports, field reports, and test scripts). Thereafter, follows an outline of how the theory informed the method in this study. A brief discussion of issues around ethical considerations concludes this Chapter.

5.1 The Choice of the Interpretive Paradigm

This study was conducted using interpretivism as a research paradigm. A central endeavour of the interpretive paradigm is to "understand the subjective world of human experience" (Cohen *et al.* 2011: 17) and the interpretive researcher aims to understand how individuals interpret the world around them. To put it differently, this is a paradigm that assists researchers to understand a phenomenon under investigation through "the eyes of the participants" (Cohen *et al.* 2011: 293). Hence, each of the participants chosen in this study was actively engaged in the FP where each held the post of either a tutor or senior tutor or lecturer. Since different people hold differing views, expectations and perceptions, I expected the sample to provide me with an understanding of the phenomenon under investigation from different points of views. (The participants in this study are referred to as Research Participants, which, henceforth has been abbreviated as RPs[44]).

In terms of the interpretive approach, people define the world according to their subjective experiences, and behaviour is dependent on context. Thus, within this paradigm, behaviour and data are "socially situated, context-related, context-dependent and context-rich" (Cohen *et al.* 2004: 137). It is for this reason that this study was conducted in the specific

[44] Where necessary, RP in this study refers to the singular form, Research Participant.

context of the BSc4 (Foundation) programme in science within the research site of UKZN. In this study, one of the ways through which I acquired knowledge and meaning from the participants' actions, experiences and interactions was through interpretation. Hence, the interpretive paradigm provided an opportunity for the voices, concerns, perceptions, attitudes and practices of the RPs in this study to be heard. This was achieved through the process of conducting semi-structured interviews with each of the participants in this study. With regard to this study, I was also able to observe the RPs in action using observation as one of the research instruments for data collection.

Although the researcher interprets what is seen, heard or understood, the researcher's "interpretations cannot be separated from [his/her] own backgrounds, history, contexts, and prior understandings" (Creswell, 2009: 176). Thus, interpretivism recognises that all participants involved, including the researcher, bring their own unique interpretations of the world or construction of the situation to the research and the researcher needs to be open to the attitudes and values of the participants or, more actively, suspend prior cultural assumptions (Mackenzie and Knipe, 2006). Thus, the researcher and the participants in the study share a subjective relationship. This subjective relationship was negotiated by means of the selection of specific research instruments for data collection, viz. the semi-structured interviews and observation (further discussion on these research instruments later).

As much as my purpose was to explore the RPs' views on the discipline-specific literacies needed in the FP modules for science discourse, their responses to interview questions cannot be read and understood as though they are in a vacuum. On the contrary, the responses need to be read with the specific context in mind regarding where the RPs work and, in the case of this study, where, what and whom they teach. Through the interpretivist lens, I was able to understand why the RPs did what they did, as either disciplinary specialists or academic literacy specialists involved in the teaching of students in the FP and how they interpreted their roles within the FP. As a researcher, I had to rely on interpretive inquiry to interpret the subjective meanings of the RPs in the study and I shared an interactive relationship with them. As the interpretive paradigm is underpinned by observation and interpretation, I had to observe, i.e. collect data about events and interpret the data by drawing inferences. The main tenet of interpretivism is that it can never be objectively observed. It needs to be observed through the direct experience of the RPs, what Cohen *et al*. (2011) describe as "to get inside the person and to understand from within" (17). The choice of using the interpretive paradigm in this study had the added advantage of yielding insight and understanding of behaviour and practices within a particular context, and offered some degree of critical reflection regarding behaviour and practices. I used the interpretive paradigm to understand the research focus of this study:

- the discipline-specific literacies that academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by students to learn science;

- the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation) programme; and,

- the ways in which the disciplinary specialists teaching one of the foundation modules in science (biology, chemistry, mathematics and physics) assist the BSc4 (Foundation) students to learn discipline-specific literacies required for science discourse.

The available data was yielded through the semi-structured interviews; observation of lectures, tutorials, practicals and field research; as well as documentary evidence. I now turn to the discussion of the research approach used in this study.

5.2 Qualitative Research Approach underpinning this study

This study was conducted using the qualitative approach in a single study. The qualitative approach yields data that assist mainly to "understand social life and the meaning that people attach to everyday life" (McRoy, 1995: 2009). Given the fact that literacy in this study is understood to be a social practice (Street, 1984; Gee, 1990); and considering that the purpose of qualitative research is to understand a specific social situation, it is logical that the qualitative approach was to be chosen. In the context of this study, the use of the qualitative approach within the interpretivist paradigm made it possible from the RPs' accounts to elicit meanings, experiences or perceptions that were fundamental and central to the broader purposes of this study. The broader purposes being the discipline-specific literacies that the academic literacy specialists and disciplinary specialists who teach in the foundation programme believe are required by the foundation students to learn science. Qualitative research methodology enables the study of a phenomenon within its natural setting and, in the context of this study, the issue of discipline-specific literacies in science in the FP is investigated in the research site, UKZN.[45] This enabled data collection by means of close interaction with the RPs within the natural context. It is for this reason that the behaviour of the RPs was "context-related, context-dependent and context-rich" (Cohen *et al.* 2011: 219), leading to the formation of patterns or theories that helped me to explain the research issue in this study.

In adhering to the characteristics of qualitative approach, I served the role of the key researcher and collected multiple data from multiple sources by means of semi-structured interviews, documentary evidence and observation in order to construct a holistic account of the phenomenon under study. Maxwell (2005) argues that qualitative research should have both practical and intellectual goals. My goal in this study was "to generate results and theories that are credible and that can be understood by both participants and other readers" (Maxwell 2005, 21). The following intellectual goals of qualitative research are especially relevant to, and reflective of, this study:

- to understand particular contexts in which participants are located and;
- to develop causal explanations of phenomena (Maxwell, 2005: 21).

This study involved the collection of multiple sources of data, a characteristic of qualitative research. Data was gathered through the use of the following research instruments:

- semi-structured interviews with the academic literacy specialists and the disciplinary specialists teaching one of the foundation modules (biology, chemistry, mathematics, physics and academic literacy) offered in the BSc4 (Foundation) programme;

- documentary evidence such as course manuals and laboratory practical manuals used in the foundation modules; the BSc4 (Foundation) students' laboratory practical workbooks, laboratory reports, field reports, and tests; and monthly/semester foundation module reports; and,

- observation of lectures, tutorials, laboratory practicals and field trips.

As indicated by the choice of research instruments used in this study, data obtained from multiple sources served to give a more holistic understanding of the phenomenon under study. One of the reasons for including documentary evidence and observation as research instruments was to corroborate the data obtained through verbal responses by the RPs. Their responses were mainly in respect of discipline-specific literacies in science. There was the need to correlate these with the findings from the documentary evidence. This

[45] Chapter 1 offered a comprehensive discussion on the nature of the FP at UKZN and the institutional merger that lead to the creation of UKZN, a HE institution.

included the issue of module changes in respect of the research focus of discipline-specific literacies in science. The research issue required me to access documentary evidence such as students' laboratory practical tasks, laboratory reports, field reports, and tests pertinent to the foundation modules in science, i.e. biology, chemistry, mathematics and physics. This was undertaken to further my understanding of whether or not there were any perceived challenges by the students in the FP with regard to the use of language in science and the discipline-specific literacies in science.

With the foci of this study being on the discipline-specific literacies required by the FP students for science discourse, it was necessary to field the views of the RPs in respect of the discipline-specific literacies required for the foundation modules of biology, chemistry, mathematics and physics offered in the FP. I was able to do so by using semi-structured interviews to conduct interviews with all the RPs. I also used the observation of lectures, tutorials, laboratory practicals and field trips to engage further with the phenomenon under study. A combination of interviews and observation enabled me to integrate two types of data (verbal and practical), but also enabled space for corroborating verbal data. In an attempt to explore the presence of perceived challenges experienced by students in the FP in respect of the use of the language of science and the discipline-specific literacies in the foundation modules in the FP, I relied on the analysis of the documentary evidence in the form of the course manuals used in modules offered in the FP; the FP students' laboratory practical workbooks, their laboratory reports, field reports, as well as their test scripts. To gain richer and more detailed data in this respect, I included the observation of lectures, tutorials, laboratory practicals and field trips as a means of acquiring a firmer interpretation of data. In an attempt to explore the ways in which the disciplinary specialists assisted the FP students with the acquisition of discipline-specific literacies for science discourse, I interpreted the data obtained through the use of semi-structured interviews, observation and documentary evidence.

Triangulating data gave me a clearer understanding of the research focus in this study. It enabled me to increase the accuracy of the data collected for this study. One such example from my study in respect of the accuracy of the data was the claim by some of the disciplinary specialists that I had interviewed that they have made specific changes to their teaching practices where they incorporated strategies to improve FP students' reading and reading comprehension in science. I used observation to locate instances where there was engagement with reading and reading comprehension strategies in science. Therein lies the benefit of triangulating data. In terms of its use in research, the concept of triangulation implies that a researcher can approach research from many different perspectives and angles to gain multidimensional understandings of the phenomenon under study.

Triangulation enables "cross-checking and verifying sources of information" (Heck, 2006: 380). It can be used to "build a coherent justification of themes" (Creswell, 2009: 191), thus contributing to validity of the study. Through triangulation, I was able to obtain "different but complementary data on the same topic" (Morse, 1991: 122) so that I could get a richer understanding of the research issue. Thus, triangulation not only assisted with the consistency and accuracy of the data collected, but it allowed me to acquire a holistic picture and understanding of the research focus in this study.

The challenge of relying on gathering data from multiple sources was that it was a rigorous and time-consuming process. I had undertaken the data collection single-handedly, i.e. conducting, transcribing and analysing interviews; engaging with documentary evidence; and observing lessons, tutorials and laboratory practicals in each of the science modules offered in the FP. This included field research on the campus site (UKZN) and a field trip to the rocky shores and the Ushaka Marine World[46] undertaken in the discipline of the foundation biology module offered in the FP. I now turn to the discussion of case study as a research strategy used this study.

5.3 Case Study Research

One of the sources of acquiring research data in educational research is with case studies. There have been several descriptions of case study by various researchers. A case study, according to Cohen *et al.* (2011), "provides a unique example of real people in real situations" (289). For Yin (2009), "a case study is a study of a case in a context" (18). For Hitchcock and Hughes (1995), case studies are set in temporal, organisational, institutional

[46] The field trip was undertaken in the rocky shores of the Isipingo beach, which is in the south-coast of Durban, South Africa. Students' theoretical knowledge of marine organisms; laboratory practical sessions involving the examination of preserved species; and sampling techniques learnt on the campus site are consolidated with these outdoor field trips where live marine organisms are examined/viewed, after which students compile and submit a scientific report on 'Species diversity/richness in the inter-tidal region of the rocky shores'. The Ushaka Marine World is an aquarium/oceanarium and an amusement park in KwaZulu-Natal, South Africa.

and other contexts that enable boundaries to be drawn around the case. Stake (1995) describes it as a strategy of inquiry in which the researcher explores in depth a program, event, activity, process, or one or more individuals. According to Hitchcock and Hughes (1995), "the case study is particularly valuable when the researcher has little control over events, i.e. behaviours cannot be manipulated or controlled" (322). Indeed, in the context of this study I had no control over the way in which the RPs conducted their lessons or the science-based tasks and activities they had assigned to students in the FP. One of the reasons for this was my status as non-participant observer as the dominant mode of enquiry. In this way, I merely acquired an overview of the observation situation, thus allowing for a sense of objectivity. In any event, except for the outdoor field trip, all the observation took place in the natural environments of the lecture venues laboratories and/or the field within the FP at UKZN. Even when I was collecting data by means of semi-structured interviews, as much as there was a list of pre-determined questions to pose to the RPs, I had little control over their responses; I had to see the research situation through "the eyes of the participants" (Cohen *et al.* 2011: 293).

As with this study, in case studies, researchers collect detailed data "using more than one tool for data collection and many sources of evidence" (Cohen *et al.* 2011: 289). This strategy allowed me to grasp a holistic understanding of the phenomenon under investigation (Creswell, 1998; Eisenhardt, 1989). The range of research instruments for data collection used, as explained in the preceding sections in this Chapter, included semi-structured interviews, observation and documentary evidence. The reliance on the various data collection research instruments in this study had enabled me to "collate and synthesize data from different sources, to make inferences and interpretations based on evidence" (Cohen *et al.* 2011: 296). The data yielded through various data collection methods can be efficiently used in case studies to "explain, describe, illustrate and enlighten" (Yin, 2009: 19).

In this study, case study has been useful for "descriptive purposes" (Conrad and Serlin, 2006: 378) that provide narrative accounts (Yin, 1984) for acquiring "descriptive and detailed data" (Cohen *et al.* 2011: 290). The reliance on case study as a research strategy in this study has been consonant with the interpretive paradigm which "sees the situation through the eyes of the participants" (Cohen *et al.* 2011: 293). The case study is ideally suited to the interpretive paradigm where "the concern is with sense making or the social construction of reality" (Conrad and Serlin, 2006: 379). The case study fits in with the interpretive paradigm that allows for the interpretations about a phenomenon.

The data was analysed by searching for patterns and explanations as they emerged. I then had to collate and synthesize these to make inferences and interpretations. These patterns and explanations were identified using the tool of coding which Cohen *et al.* (2011) describe as the "process of disassembling and reassembling the data" (599). In this study, the "disassembling" involved fragmenting the data (e.g. in the case of the transcripts of the interviews) into lines, paragraphs and sentences. This way of deconstructing the data into little pieces that were easier to engage with, enabled me to code for specific meanings, actions, perceptions, attitudes, experiences, thinking, events and practices in relation to the research problem. By exploring the data in this way, I was able to look for the emerging patterns and explanations; and find links and contrasts. This iterative process enabled me to understand the research issue more clearly.

This "building up (i.e. reassembling) of categories and themes from the bottom up, by organizing the data into more abstract units of information" is what Creswell (2009: 175) refers to as inductive data analysis. Inductive reasoning is associated with qualitative research. Babbie (2001) states that inductive reasoning "moves from the particular to the general, from a set of specific observations to the discovery of a pattern that represents some degree of order among all the given events" (34). Through inductive reasoning, researchers draw conclusions from specific instances or occurrences. In analysing data from the foundation students' laboratory practical workbooks, laboratory reports, field reports and tests, I had to rely on deductive reasoning which "moves from the general to the specific" (Babbie, 2001: 35). One such example pertinent to this study is the claim by RPs that the use of non-technical and everyday words used in the context of science can be challenging for students in the FP. I had to rely on the data from students' answers in their tests and observation in the classroom to find out whether such challenges emerge. In terms of this study, I had to engage with data in a manner that enabled me to explore patterns that revealed situations and explanations that illustrated the RPs' views, understanding and perceptions of the science discipline-specific literacies required by the students in the FP.

This study entailed a personal journal of copious writing related to data collection, data analysis, research writing and reporting. In research, this is referred to as memo writing.

“Memo writing refers to the analytic thoughts about the codes; they provide clarification from coding to reporting” (Gibbs, 2007: 31). I used the memos to identify the emerging patterns and explanations. Richardson (2004) states that “researcher’s memo writing can be organized into different categories of note taking such as observational notes (what the researcher saw, heard); methodological notes (on how to collect data); theoretical notes (notes to yourself on hypotheses, connections, alternative interpretations) and personal notes (your own anxieties, pleasures, doubts about the research)” (489).

5.4 Research Context and Research Participants

The study was undertaken in a natural setting and environment: the FP in science at the University of KwaZulu-Natal (UKZN). UKZN arose from the institutional merger on 1 January 2004 between University of Natal (UN) and University of Durban-Westville (UDW). UKZN is located in the province of KwaZulu-Natal, South Africa. It has five campuses, four of which, viz. Howard College, Westville, Edgewood, and Nelson Mandela School of Medicine are located in Durban; while the Pietermaritzburg campus is located in the midlands city of Pietermaritzburg. UKZN is structured on a College model with four Colleges: Agriculture, Engineering and Science; Health Sciences; the Humanities; and Law and Management. The FP in science within the CSA is located in the former Faculty of Science and Agriculture (which is now, upon internal restructuring, the College of Engineering, Agriculture and Science) at UKZN.[47] I have been employed at UKZN since 2005 to teach the Academic Literacy course called Communication in Science (SCOM) offered in the FP.

To select the RPs, purposive sampling was used. This study relied on the use of purposive sampling “This type of sampling is based entirely on the judgement of the researcher” (de Vos *et al.* 2005: 202). According to Cohen *et al.* (2011), “researchers hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought. In this way, they build up a sample that is satisfactory to their specific needs” (156).

[47] A comprehensive discussion on the nature of the FP at UKZN and the institutional merger that lead to the creation of UKZN, a HE institution has been provided in Chapter 1.

The purposively sampled population for this study comprised both the disciplinary specialists and the academic literacy specialists teaching within the FP in science. All these RPs were selected because of their involvement in the teaching of the foundation modules offered in the FP. The disciplinary specialists taught one of the following foundation modules in science, i.e. biology, chemistry, mathematics and physics, while the academic literacy specialists taught Communication in Science (SCOM). It was on the bases of their professional roles as educators and because of their expertise and/or experience in teaching students at foundation level that they were selected as RPs. I selected them for this study with the assumption that they might be able to provide in-depth data with regard to the focus of this study: to understand what discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the foundation programme believe are required by students to learn science. This assumption was because these RPs by virtue of being employed within the CSA, have had accesses to discussions of FP students' understanding and competencies of discipline-specific literacies in science. These discussions were, over time, raised at formal forums, i.e. staff meetings; disciplinary/inter-disciplinary/planning/teaching and learning committee meetings; as well as examinations/CSA Board of Studies meetings.

At the time this study was undertaken, thirty-seven academics[48] were involved in the teaching of students within the CSA. Twenty-eight of these academics were employed to teach students in the FP in science. Of these, eight taught SCOM while twenty taught one of the following foundation modules in science offered in the FP: biology, chemistry, mathematics and physics. The purposively sampled population was made up of twenty RPs. There were sixteen disciplinary specialists teaching in the foundation disciplines of biology, chemistry, mathematics and physics, as well as four academic literacy specialists teaching SCOM. Due to the majority of the FP staff being employed on fixed-term contracts, there existed a high employee turnover rate within the CSA. It is because of this that some of the teaching staff only had short periods of three months to a year of teaching experience in the FP. Over and above this, some of them had very little experience and exposure to teaching students in science access programmes.

[48] Twenty eight academics taught in the BSc4 (Foundation) programme while nine academics taught in the BSc4 (Augmented) programme.

Given the nature of the research problem in this study, the qualitative approach was necessary as the responses from the RPs was one of the ways in which I aimed to acquire a holistic account to engage with the research problem. Lincoln and Guba (1985) state that "purposive sampling enables the full scope of issues to be explored" (220). In respect of this study, this meant that for RPs to be able to contribute to the study, they would have had to have some knowledge of the philosophy of the science access programme. It was because of this that I had isolated teaching experience (two years and above) within the FP as a criterion for participant selection in the research. The RPs' teaching experience in the FP ranged from two to ten years. The sample was homogenous in that all the RPs only taught within the FP at UKZN and they were employed as either tutors or senior tutors or lecturers. The sample was representative in that there was an equal number of RPs per module in the FP. Table 3 below presents the RPs in the various disciplines in the FP in science who were part of the sample in this study.

Name[49] (Research Participant)	**Foundation Module**
Shane	Physics
Cindy	Academic Literacy
Raj	Mathematics
Lara	Biology
Seema	Chemistry
Siva	Mathematics
Dennis	Chemistry
Annah	Physics
Iqbal	Academic Literacy
Lisha	Biology
Vusi	Mathematics
Sudeer	Academic Literacy
Kenneth	Mathematics
Nancy	Chemistry
Josh	Biology
Petrus	Physics
Rabia	Academic Literacy
Teresa	Biology
Jessie	Chemistry
Susan	Physics

Table 4: List of Research Participants (RPs) in the study

In respect of the above sample, there were four RPs in each of the following foundation modules offered in the FP: biology, chemistry, mathematics and physics as well as four RPs who taught SCOM. In this study, the RPs who taught the science modules in the FP

[49] On condition of the ethics of anonymity and at the request of the majority of the research participants in this study, the research participants' names have been replaced with pseudonyms.

are referred to as Disciplinary Specialists, which has been abbreviated as DSs[50]. In this study, the RPs who taught the academic literacy module are referred to as Academic Literacy Specialists, which has been abbreviated as ALSs[51]. The RPs' academic qualifications were in one of the following fields of tertiary study: pure sciences, social sciences, education and English literature. To assure participant anonymity, I assigned a pseudonym to each RP selected for this study. Since all the RPs taught one of the modules offered in the FP, I was keen to identify similarities and differences among the RPs' views in response to the research problem and the research questions.

5.5 Research Instruments

Data collection for this study commenced in early February 2011 and continued until the end of October 2011. The sources of data for this study required that semi-structured interviews, observation and documentary evidence be used as research instruments. The reason for selecting a variety of research instruments was that I intended to ensure the validity of research findings, i.e. to test the extent to which data obtained through one research instrument can be correlated with the data obtained through the other two instruments. For example, responses by DSs in interviews were validated through data from either (or both) observation and documentary evidence.

This study involved the use of semi-structured one-to-one or face-to-face interviews as a mode of data collection. According to Cohen *et al.* (2001), "interviews enable participants to discuss their interpretations of the world in which they live and to express how they regard situations from their own point of view" (267). Interviewing involves both the interviewer and the interviewee. As expressed by Manning (1967 in Holstein and Gubrium, 1995) "all interviews are interactional events and interviewers are deeply and unavoidably implicated in creating meanings that ostensibly reside within participants" (3). "Both parties, the researcher and the participant, are thus necessarily and unavoidably active and involved in meaning-making work" (Holstein and Gubrium, 1995: 4). This point is further substantiated by Lichtman (2006), who draws attention to the role of the researcher (as interviewer):

[50] Where necessary, DS in this study refers to the singular form, Disciplinary Specialist.

[51] Where necessary, ALS in this study refers to the singular form, Academic Literacy Specialist.

> In qualitative research, each idea, interpretation, and plan is filtered through your eyes, through your mind, and through your point of view ... You will take the role of constructing and subsequently interpreting the reality of the person being interviewed, but your own lens is critical ... You, as the researcher, serve as the filter through which information is gathered, processed, and organized (117).

Conceptualising the interview is particularly relevant in this study, especially with the way in which it relates to the interpretive paradigm that involves an understanding of the subjective world of human experience. The semi-structured interviews were used as an instrument in this study in order to gather detailed data from the RPs "to understand beliefs, perceptions or accounts of the research focus" (de Vos *et al.* 2005: 296), viz. the acquisition of discipline-specific literacies in science in the FP. After I had decided that the semi-structured interviews was one of the suitable research instruments that will yield the relevant data designed to understand the phenomenon, I formulated a set of questions that I intended to pose to the RPs (the interviewees) (See Appendix 3 for the questions posed to the RPs).

I then engaged in the piloting of the questions. The initial questions that were devised were piloted among some colleagues, many of whom were involved in post-graduate research themselves. The main purpose of piloting the questions was to assess whether the questions would yield the kind of data required for this study and to ensure that the questions were clear, unambiguous, valid and relevant.

Amendments were made to the questions that contained specific terminology e.g. 'literacies' and 'genres', which were clear to me but opaque to others. This was done because the clarification of concepts peculiar to this study was necessary in the interview. Questions that yielded bias or were considered as leading questions - especially where the questions could influence the responses of the RPs had to be rephrased.[52]

I interviewed all RPs myself, mainly at a time and day that was convenient to them. This was done to ensure that the RPs were not inconvenienced from their activities. By personal

[52] Examples of the initial questions that had to be rephrased: The following question was changed as it conveyed some degree of bias: *"As an AL, do you think that the DSs expect the teaching of literacies needed for science to be your task?* Questions that did not allow for elaboration such as *"Are you content with the changes made to the module?"* had to be subsequently rephrased to *"What change/s were made to the module?"* In other instances, follow-up questions were included to allow for further elaboration, e.g. "*Why was/were this/these change/s made?"* or *"Have this/these change/s been effective?*"

choice, all the interviews were conducted in the RPs' offices at UKZN. The purpose was to ensure that they were comfortable in their own personal space. Before commencing with the interview, I informed each RP of the purpose of the interview and the need to have it recorded. With the consent of the RPs, interviews were recorded by means of a digital voice recorder. This enabled verbatim transcriptions of verbal data.

The added advantage of doing it this way by myself was that it allowed me to become entirely familiar with the data. The process of interviewing was time-consuming and scheduling them had to be planned well in advance in consideration of the RPs' own teaching and research commitments. The duration of the interviews was from forty minutes to an hour. This meant an enormous amount of time spent on transcribing verbal data.

The interview questions guided, rather than dictated, the way in which data was collected. I tried to keep to a logical sequence in the interview by arranging questions from the simple to complex; and from the broad to the more specific. Participants were also given the opportunity to provide further data that the interview questions probably failed to elicit. I wanted to make the interview process flexible and exploratory so that the RPs would feel more comfortable and less pressurized, and I also intended to give them an opportunity to determine how the interview proceeded. This also cast me as a researcher in a less-controlling light.

The interview schedule (Appendix 3) included open-ended questions and, in some instances, I had to probe the RPs to tease out meanings and clarify certain issues which meant that I had to be particularly attentive and needed to listen actively. Where the RPs were not particularly articulate or forthcoming with data, I had to rely on the strategy of "probes" to "stimulate a respondent to produce more information" (Bernard, 2000: 196). Probing enables the interviewer to ask respondents to "extend, elaborate, add to, provide detail for, clarify or qualify their response thereby addressing richness, depth of response, comprehensiveness and honesty" (Cohen *et al*. 2011: 420) that characterize successful interviewing. For example, in response to exploring in this study whether the DSs had any notion of the nature of SCOM and its role in FP, especially in respect of science discipline-specific literacies, one of the DSs dismissed the question by stating that he had absolutely no understanding of the nature and/or the efficacy of SCOM. Through probing, I was able to elicit a verbal response, specifically in respect of the existence and nature of inter-disciplinary engagement within the FP. I also used the technique of 'funnelling' (de Vos *et al.* 2005: 297), especially when I had to elicit, not only the RP's general views, but his/her response to more specific concerns as well. In this study, for example, I explored the RPs' views of the rationale of the FP in general, the students they taught and more specifically, the way/s in which the discipline that he or she taught satisfied the philosophy of the FP and the student profile in the FP.

Observation was another research instrument used to collect data in this study.[53] This entailed direct, overt observation that I personally undertook at lectures, tutorials, laboratory practicals and field trips. Once again, sole observation by the researcher allowed for consistency in terms of the purposes of such observation. My role in each of these natural settings was made clear to the FP students: I was undertaking research at higher education level. The appropriate ethical considerations of students' consent to being observed had been undertaken[54]. In the initial observation sessions of the lectures, tutorials and laboratory practicals that I had attended my presence was fairly noticeable by students, many of whom constantly glanced in my direction as the lessons proceeded. With the progress of time – in fact, by the third observation session, I had become a very familiar face within the context of the science 'classes' and I noticed that after a period of time, my presence was more easily accepted. Observation, as a research instrument, yielded data within an interactional setting where actions and behaviour of the RPs within context were easily accessible and available. Data from observation were merged with those obtained through the semi-structured interviews and from documentary evidence. In relation to this study, observation of lessons, tutorials, laboratories practicals and field trips was a necessary facet of the study. It is through the observation of these in natural settings that I was able to collate data based around the critical research questions formulated for this study: the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the foundation modules in the foundation programme; and, whether the DSs assisted the FP students in the acquisition of discipline-specific literacies required for science discourse. I looked for evidence of focus on (or the absence thereof) on discipline-specific literacies in science and the ways in which the DSs, in particular, alerted the FP students to the language in science.

[53] See Appendix 4 for a sample of an observation schedule.

[54] See Appendices 5 for Student Consent to Participate in Research.

I used the semi-structured observation to gather data for this study. This type of observation is "hypothesis-generating; the researcher has an agenda of issues but will gather data to illuminate these issues in a far less predetermined or systematic manner" (Cohen *et al.* 2011: 457). I found that with this type of observation, I had to gather key elements as they emerged or flowed from the situation, which I later linked to or compared with other elements that emerged from the other research instruments used (viz. semi-structured interviews and documentary evidence). For Cohen *et al.* (2001), this is "enabling the elements of the situation speak for themselves" (305). Observation necessitated comprehensive field notes that formed part of my memo writing, the purpose of which has already been outlined earlier in this Chapter.

On the advantage of observation, Cohen *et al.* (2001) note that "it affords the researcher the opportunity to gather 'live' data from 'live' situations ... *in situ* rather than at second hand" (305). On this note, observation allows the researcher "to see things that might otherwise be unconsciously missed and to move beyond perception-based data (e.g. opinions in interviews) (Cohen *et al.* 2011: 456). On the significance of observation and how it contributes to credibility, Conrad and Serlin (2006) state: "Observation can be an important part of the empirical process of triangulating what people say they do (as in interviews) and what they actually do (as in their observation of their behaviour)" (381). This means matching the responses given in interviews to observed behaviour or, what Heck (2006) calls the provision of "evidence about the extent to which something is in fact being implemented" (381). Furthermore, "observational data enables the researcher to discover things that participants might not freely talk about in interview situations" (Cohen *et al.* 2011: 456). These points tie up with the earlier reference to how triangulation can contribute to ensuring validity and reliability of findings.

A limitation of observation was the issue of simultaneously making comprehensive field notes and actively observing. Another limitation of observation is the issue of "reactivity where participants may change their behaviour if they know that they are being watched" (Cohen *et al.* 2001: 305). As much as I had no proper method of controlling or avoiding this, I attempted to convey to the RPs the expectancy of natural behaviour by asking them to 'pretend I was not there'. Having informed the RPs of my intention to observe and having had them voluntarily sign consent[55] to allow me to do so, I sometimes slipped unobtrusively in and out of the lecture/laboratory venue.

The third instrument for data collection used in this study was documentary evidence. In the context of this study, primary documentary evidence was discipline-based course manuals used in foundation modules in science and SCOM offered within the FP; the FP students' laboratory practical workbooks, laboratory reports and field reports, and test scripts. In addition to these, monthly discipline-based reports, compiled by course co-ordinators (which offered comments on discipline-based issues in the FP) were read and incorporated into the study. This, however, was done where it was deemed necessary.

In this study, I looked at the module course manuals in the FP to ascertain how the course content of the modules had been amended. These had to be accessed in conjunction with the RPs' comments on any amendments made to the discipline-based course manuals. The course content yielded data with regard to language of science viz. scientific discourse, science genres and scientific literacy required for the pursuit of tertiary studies in science and particularly, for students from educationally disadvantaged schooling backgrounds for whom the LoLT is their additional language. The student profile of students enrolled in the FP in science at UKZN has already been presented in Chapter 2 of this study.

In analysing students' writing and answers based on their work (i.e. documentary evidence), I looked at the discipline-specific literacies in science and the language of science that might have compromised students' understanding of science, and thus their participation in science discourse. Using inductive data analysis, I looked specifically at the elements, patterns and categories involving discipline-specific literacies (as a major criterion) that emerged from the written work and compared and contrasted them with the data on the discipline-specific literacies that had emanated from the semi-structured interviews and observation sessions. This was a type of diagnostic analysis that set out to explore the particular strengths and perceived challenges with the science discipline-specific literacies that might have featured in students' work. In doing so, I had to also explore the nature of the responses from DSs with regard to the students' use of the discipline-specific literacies needed to learn science. Written tasks accompanied by a rubric

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[55] See Appendix 6 for Consent Form for DSs.

or marking criteria/guide were looked at, for evidence of any focus on assessment of language usage in science (See Appendix 7). Documentary evidence formed part of the triangulation of data from the other two forms of obtaining data, i.e. the semi-structured interviews and observation, thus ensuring validity. This enabled me to gain a holistic picture of the research problem.

Documentary evidence required careful analysis and interpretation. In this study, data collection from documentary evidence was labour intensive. I spent many hours either scanning and/or photocopying volumes of students' work. All documentary evidence used in this study required me to acquire memoranda. I had to work at a feverish speed because I had to meet specific deadlines, especially those for each of the science modules in the FP. For example, laboratory practical workbooks were used each week and had to be returned promptly, as were tests that had to be reviewed within a week of having been written and marked. Access to students' work was dependent on the students' own personal and academic schedule.

The use of multiple data sources in this study yielded copious data. I analysed the data inductively. This meant comparisons within data of RPs views, actions, responses, accounts and experiences. I coded the emerging data as I collected them to gain a firmer understanding of the research problem. Cohen *et al.* (2011) define a code as "simply a name or label that the researcher gives to a piece of text that contains an idea or a piece of information" (559). According to Strauss and Corbin (1990), coding is defined as "the process of breaking down segments of text data into smaller units (based on whatever criteria are relevant), and then examining, comparing, conceptualizing and categorizing the data (61). Strauss and Corbin (1990) divide coding into three stages that are open coding, axial coding and selective coding[56].

I began the data analysis by first implementing open coding where I read the text/s "reflectively to identify relevant categories" (Strauss and Corbin, 1990: 69). With this type of coding, I went through the text in stages: line-by-line, phrase-by-phrase, sentence-by-sentence and paragraph-by-paragraph. This type of open coding generated categories.

[56] This type of coding is commonly used in Grounded Theory (Glaser and Strauss, 1967). I have used the elements of open coding, axial coding and selective coding here as a way of assisting with the categorising of the data gathered in this study. For information on this type of coding, see Cohen *et al.* 2011: 559-563 and Charmaz, 2000.

Open coding enabled me to "remain attuned to [the] [participants'] views of their realities" (Charmaz, 2000: 515), letting me make meaning of the data by asking questions such as "What is this about?" or "What is being referred to here?" I did this by grouping and naming the general categories that arose from the data, e.g. 'the issue of schooling'. Thereafter, I implemented axial coding, which meant that the categories had to be "refined, developed and interconnected" (Strauss and Corbin, 1990: 69). With this type of coding, the general categories that had emerged from open coding are recombined into a larger category. I had to look for connections and interconnections between categories. For example, linked to the open category of 'students' schooling', I interconnected categories of 'teaching methodology' and 'learning strategies'. The data was becoming more interpretive. I then worked through the stage of selective coding, which Strauss and Corbin (1990) define as "identifying the core category around which all the other categories that have been identified and created are integrated" (116) to acquire a deep understanding of what is identified as "the main story line" (117). Interpretation of the data enabled me to find patterns and themes; providing the evidence needed to draw conclusions with regard to the research focus of the study.

All three instruments of data collection used in this study were essential in answering the critical questions of this study which focused on the discipline-specific literacies required for science, viz. reading, writing, talking and doing science. These research instruments also assist in isolating any perceived challenges that these literacies could present, especially for students who formed the FP cohort, i.e. students from disadvantaged schooling backgrounds (who gained entry into higher education through access programmes); and for whom English, the LoLT at UKZN, is not their home language (At the time of data collection for this study, the student distribution by home language in the FP was: isiZulu: 86.04%; Xhosa: 5.81%; Swati: 2.32%; English: 1.93%; Sotho: 1.93%; Tsonga: 0.77%: Other Black Language: 0.77%; Ndebele: 0.38%). Another significant component of the research problem that was explored was the ways in which discipline-specific literacies are conveyed in the foundation modules in science in the FP, i.e. biology, chemistry, mathematics and physics.

5.6 How the theory informs the method in this study

NLS (Street, 1985) takes on a sociocultural view of literacy, i.e. literacy as a social practice. In other words, literacy is situated in the interactions between people in the context in which they engage with literacy. The concept of literacy goes beyond reading and writing, incorporating "multiple activities such as listening, speaking, viewing, and symbolizing" (Draper, 2002: 359). It is from this framework that this study has understood the way in which the FP students are apprenticed into the literacy practices needed for science. This was done through the responses from the RPs in the semi-structured interviews, the observation of lectures, laboratory practicals and field trips as well as through the perusal of documentary evidence in the form of discipline-based course manuals.

NLS (Street, 1984; Gee, 1990) distinguishes between the autonomous and ideological models of NLS. While the autonomous model views literacy independently of its social context; the ideological model sees "literacy practices as being embedded in social practices" (Street, 2003: 78). This study was done from the position of the ideological view of literacy primarily because it, like this study, does not view literacy as either neutral or universal or the acquisition of skills. Since the ideological view emphasizes the contextual nature of literacy practices, it has been pertinent to this study which was undertaken in the specific context of science-based modules in a foundation programme in science. It is from this framework and within this context that this study explored the discipline-specific literacies required by the students in the FP to learn science. This was obtained through the responses from the RPs in the semi-structured interviews; through the perusal of documentary evidence and observation.

Gee (1990) has argued for a contextual view of literacy, seeing literacy as Discourse. According to Collins (2000), Gee's (1990) Discourse does not refer solely to talk or text, but more broadly to configurations of values and practices, modes of conduct as well as communication specific to groups and institutions. Discourse, thus, does not only include ways of speaking, reading and writing, within particular contexts, but also ways of behaving, interacting, valuing, thinking and believing that are acceptable within specific groups of people in particular contexts.

It is from this understanding of literacy that this study seeks to understand if (and how) the students in the FP are socialized into their science disciplines. One of the ways to establish this was through the use of semi-structured interviews. This research instrument was used to understand ways in which the FP students are apprenticed into the discourse community of science; and to ascertain whether the DSs who teach the science modules offered in the FP assist the FP students to acquire an identity in science. This study explored the type/s of academic reading and writing needed in the foundation modules in science; how students coped with the academic discourse of scientific texts; and writing science.

According to Collins (2000), the field of NLS (Street, 1985) shares with Bernstein (1971) and Bourdieu (1977) a political and sociological conception of the relations between language, identity, and institutional orders (70). The necessity of understanding the reliance of secondary discourse in reading, writing, and speaking science discourse is linked to Bourdieu's (1977) 'cultural capital' which is explained as familiarity with the dominant culture in a society, and more especially, in this study, the ability to understand and use 'educated' language as per the dictates of the foundation modules of science offered in the FP. This was explored in this study by means of observation and documentary evidence; data from which has been corroborated with the verbal responses to questions posed to the RPs in the semi-structured interviews. The 'cultural capital' needs to be seen in light of institutional expectation – the ability to understand and communicate in the LoLT, English, the 'educated language' (Bourdieu, 1977) used in the research site. Since science texts rely on the 'elaborated code' (Bernstein, 1971) to convey science knowledge, the study shows whether this type of code has any impact on the FP students' use of the language of science in the foundation modules offered in the FP.

The language of science uses two kinds of resources to convey knowledge – lexical and grammatical. The lexical resource includes technical terms (for science has its own specific register); and grammatical resources include nominalization (which includes complex nominal phrases, nominal compounds and grammatical metaphors); and lexical density. By way of access to documentary evidence in the form of course manuals, this study explored the way in which the FP students engaged with these specific resources. This study also focuses on Grammatical Metaphor (GM) (Halliday and Martin, 1993). This study shows how GM functions in terms of presenting processes as things and the packaging of complex phenomena in texts. Understanding how GM functions in science is one of the directions of this study which is undertaken through access to documentary evidence in the form of course manuals. Halliday (1978; 1985a) considers nominalization from a systemic functional perspective and proposes the idea of GM. His systemic theory is a theory of meaning as choice, by which a language is interpreted as networks of interlocking options.

In this study, the SFL (Halliday 1978; 1985a) model of language was used to explain how language works within the context of science; i.e. to understand the relationship between language and context. The focus on the relationship between language and the context means that the theory can account for language variation across different registers and across the different genres that students need to speak, listen to, read or write. It treats language at the level of text rather than simply at the level of sentence. SFL is functional because it is designed to account for how language is used and the way it is organised to fulfil communicative functions. It was from this point that this study explored the way in which language was used in science. This was ascertained by means of observation and the responses from the semi-structured interviews. This involved an understanding of the nature of the communicative activity/event that was taking place (i.e. the field) (e.g. a science practical); the social roles of the interactants in the communicative activity/event (i.e. the tenor) (e.g. the interactive relationship between the DS who teaches foundation biology and a group of students in the FP); and the role of language in the communicative activity/event (i.e. the mode) (e.g. making sense of a science text by way of reading, discussion, diagrams/visuals).

This study used SFL to understand the lexicogrammatical choices needed to write science. Scientific language has specific grammar and relies on specialized register to communicate science knowledge and differs from the way in which language is used in everyday casual conversation or spontaneous speech. This study relied on documentary evidence to understand how the students in the FP engaged with the language of science, especially the technical, abstract, dense and impersonal ways that characterise science writing/reading. This study, through the research instrument of documentary evidence, explored the ways in which the students in the FP were able to engage and/or cope with the unique linguistic forms and structures that construct and communicate scientific principles, knowledge, and beliefs.

Genres have been described as “socially recognised ways of using language for particular purposes within particular contexts” (Hyland, 2003: 21). Genre links language, purpose and context. The relationship between language and context is seen in the way language is used, with genres being the configuration of what texts are about - which explains what is going on; who is involved; and, demonstrates the role language plays in such texts. This genre perspective to language enabled the study to understand the genres needed in science, the linguistic resources used to express meaning in context, which, in this study, is scientific knowledge/meaning in the context of the modules offered in the FP. As shown by the data analysis this study revealed whether the DSs who teach the foundation modules in science made any effort to make explicit what was to be learnt, understood and practised in scientific genres. In terms of the advantages of genres, this study offered an understanding concerning the extent to which research participants were explicit about what was needed in science genres to help students respond to texts – the content from which they would need to construct genres, to be able to learn and acquire acceptable writing strategies required in science. This is also related to ways in which the FP students are apprenticed into acquiring the discourse applicable to genres; and if the DSs made any attempt to scaffold students’ learning of the genres in science by addressing the structure and language of the genre. Semi-structured interviews and documentary evidence were helpful to understand these dynamics.

The research instrument of observation was used to explore if Vygotsky’s (1978b) pedagogical approach of interactive collaboration between the learner (who, in the context of this study, is the FP student) and the’ teacher’ (i.e. the DSs and/or the ALs in the context of this study), where the latter helps to support or scaffold the former’s learning does take place in the context of the FP in science; and if so, the way/s in which this is facilitated. Scaffolding, as a supported teaching/learning strategy, helps the learner to move towards his/her potential level of learning. Documentary evidence, i.e. the discipline-based course manuals were used to find out if any of the reading texts with which the FP students had engaged, were scaffolded. Scaffolding, in the context of this study, referred to assistance provided by the RPs to the FP students with regard to classroom tasks/exercises, reading and writing. Research findings from this study illustrated whether there was any evidence of the RPs using the strategies of micro/macro scaffolding; modelling; providing guided practice; and/or the contextualization, deconstruction, analysis, discussion and joint negotiation of text/s to “help bridge the gap between what [the learner] know[s] and can do and what [he or she] need[s] to accomplish in order to succeed at a particular learning task" (Graves and Braaten, 1996: 169).

5.7 Ethical Considerations

Due cognisance was taken of the ethical issues with regard to this study. Upon being granted ethical approval to undertake this research on 29 March 2010, a written letter seeking permission to undertake research in the BSc4 (Foundation) programme within the Faculty of Science and Agriculture at UKZN was despatched on 5 March 2010 to the then Head of School of CSA, Dr Neil Koorbanally, and the Dean of the Faculty of Science and Agriculture, Prof. Deogratius Jaganyi[57]. Approval for the research was granted on 3 April 2010.

Upon being granted ethical clearance by the then Deanery of the Faculty of Science and Agriculture to engage in this study within the faculty, I formally informed the DSs and the ALSs teaching in the FP, via written correspondence, of the purpose of my study and the research instruments that I had selected to use to elicit data. I enquired if they would be willing to participate in the study[58]. I received favourable responses from all the DSs and the ALSs, except one who was not keen to participate or contribute to this study due to teaching and research commitments. The RPs agreed to sign consent forms, allowing me to interview them; observe their lessons, tutorials practicals, and field trips; and have access to the module course manuals, assignments, projects, tests and test memoranda[59].

All the RPs were informed of the nature, scope and purpose of the study, as well as their participatory role in the study. This involved getting their consent to be interviewed; to have their lessons, tutorials and laboratory practicals observed; and to be allowed access to documentary evidence. The RPs voluntarily signed informed consent forms; indicating willingness to participate in the study. The consent forms also gave the RPs the freedom to withdraw from the study at any stage should they wished to do so. All the RPs were informed of the measure of confidentiality in the write-up of the research. As with this study, in face-to-face interviews, anonymity can be ensured in the research by "not using

[57] See Appendix 8 for Request to Conduct Research in CSA (FP).

[58] See Appendix 9 for Request to Participate in Research.

[59] See Appendix 6 for Consent to Participate.

names of participants or any other personal means of identification" (Cohen *et al.* 2011: 91) which "can be achieved by use of aliases or codes (Frankfort-Nachmias and Nachmias, 1992).

In the write-up of the study, pseudonyms were therefore used to protect the identity of the RPs. Since the documentary evidence included students' work, consent from them for the use of their work was sought. This consent form outlined the purpose of the study and informed students that, as a measure of confidentiality, their identities would not be revealed in the write-up of the study[60]. In the write-up of the study, pseudonyms were used for transcripts from the data collection instruments involving students. Confidentiality was maintained throughout the undertaking of this study through various ways:

- I conducted all interviews with the RPs myself;
- I transcribed all audio-recorded interviews myself;
- I observed all lectures, tutorials and practicals myself; and,
- I had sole access to documentary evidence in the form of students' tests and class-based exercises (scientific reports) and laboratory workbooks which I personally scanned and/or photocopied and analysed.

Conclusion

This Chapter presented the methodological choices undertaken to address the research problem identified in this study. It offered the rationale for the choice of the interpretive research paradigm in exploring crucial issues explored in this study. This Chapter substantiated the choice of case study as a research strategy to analyse and evaluate the data collected in this study. The Chapter offered a discussion of the research instruments which were the semi-structured interviews, observation and documentary evidence that were used to collect data in this study. The natural setting, the FP, where this study was undertaken, as well as the choice of the RPs selected for this study were outlined. Included, too, were the ways in which the data was analysed and the way in which the theory informed the method. The Chapter concluded with a discussion of ethical considerations involved in undertaking this study.

The next Chapter discusses data yielded as a result of research methodological choices made in this study.

[60] See Appendix 5 for Student Consent to Participate in Research.

CHAPTER 6

DATA ANALYSIS: UNDERSTANDING RESEARCH PARTICIPANTS' WORLDS

Introduction

Chapter 5 discussed the research methodological choices made to conduct this study. The choice of research paradigm, methodology, design and research instruments was commensurate to the broader purpose of the study. The strength in selecting interpretive paradigm, for example, lies in the fact that it enables the researcher to "understand the subjective world of human experience" (Cohen *et al.* 2011: 17) and the interpretive researcher aims to understand how individuals interpret the world around them - in line with the broader purpose of this study, the discipline-specific literacies needed by FP students for science discourse. The research methodological choices enabled the study to gather data that responded directly to the three research questions:

- *What discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by the students to learn science?*

- *What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation)* programme?

- *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

This Chapter analyses the data in respect of critical research question 1: *What discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by the students to learn science?* Chapter 6 begins with engagement with the data obtained primarily from the semi-structured interviews with the RPs. The interpretive paradigm was used to interpret the verbal responses from the RPs to understand their perceptions of the students that they teach. This was necessary in this study since entry into the FP is for students who have had a disadvantaged schooling background.

The introductory section of this Chapter draws attention to the RPs' interpretation of the student profile that comprised the FP. The interpretive paradigm provided the space for the perceptions of the RPs to be heard; to understand how they perceived the FP students whom they taught. Being fully aware that the responses gathered from the RPs in the semi-structured interviews are subjective in nature, I relied on this form of data collection to ascertain "the participants' thoughts about and feelings for a situation" (Cohen *et al.* 2011: 290) which are engaged with critically in this Chapter. This was particularly applicable to this study because all the RPs only taught modules within the FP. As a case study, this study provided an example of real people in a real context. This Chapter also explores whether there were any changes to the modules offered in the FP and, if so, to ascertain the reasons that contributed to such changes. This is particularly relevant to this study since the FP is an alternative tertiary education access route for students from disadvantaged schooling backgrounds. Another issue explored in this Chapter are the views of the RPs in respect of the factors that could have contributed to the perceived challenges with discipline-specific literacies that feature in the science modules offered in the FP. The responses from the RPs were considered significant in light of the issues of transformation at HEIs in South Africa post-apartheid; and the call for redress, equity and the access to higher education for those who were previously marginalized. (These issues were discussed in Chapter 1 in this study).

6.1 Research Participants' (RPs') perceptions of the changing students

One of the issues that had surfaced in the analysis of the data is the fact that the RPs are aware that the student body at HEIs in South Africa has changed (the issue of the transformation in HE as a result of the institutional merger has been outlined in Chapter 1) but, a factor of concern is some measure of disinclination to embrace change as revealed in the following comment by Kenneth, a RP teaching in the FP:

> [61]"*We have certain expectations of the kind of students we want but with the situation that we have in our country, the educational disparities, the history* [apartheid] – *we are not getting the type of students we want. We're hoping that when students get here they would adjust to the system and eventually reap success in their learning. But, we are not necessarily dealing with the same type of students that we had say 12 or 15 or 20 years ago. The university was not really established for the type of students we are getting now*".

[61] As stated in Chapter 5, on condition of the ethics of anonymity and at the request of the majority of the research participants in this study, the research participants' names have been replaced with pseudonyms. The verbal responses from the research participants selected for this study have been italicised and are reflected within inverted commas in this dissertation.

Kenneth's reference to 'we' appears as an attempt to distance himself from the perception of the type of students who enter the HE environment, shifting responsibility from expressing his own view, choosing instead to rely on voicing a collective view of the teaching staff. The response he offers is loaded with the expectations of the teaching staff as denoted by several references to 'we'. The response conveys some measure of diminished interest in accommodating the type of students most HEIs in South Africa admit. His entire response is staff-centred in terms of what they expect from the students and the type of students they want. The contradiction in Kenneth's response is that despite being aware of the *"educational disparities"* prevalent in South Africa; its "[apartheid] *history*"; and the fact that the student cohorts have changed (*"we are not necessarily dealing with the same type of students that we had say 12 or 15 or 20 years ago"),* the expectation of teaching a 'certain type of student cohort' seems to persist (*"we are not getting the students we want").*Giannakopoulos and Buckley (2009) make reference to the fact that with the demise of apartheid, student numbers at universities increased dramatically. Universities were not prepared for this influx in two ways: firstly, many of the learners were ill prepared and secondly due to years of apartheid many lecturers could not cope with the "new type of learner" (Giannakopoulos and Buckley, 2009: 3). In light of the transformation at universities in South Africa (discussed in Chapter 2); the research that supports the inclusion in the HE sector of those who were traditionally excluded (Akoojee and Nkomo; 2011); and the numerous references to the diverse student population at South African universities (Fraser and Killen, 2003; Frick, 2008; Smit, 2010), Kenneth's statement is flawed.

It may be argued, however, that with massification of universities, the university has changed from being an "elitist to a mass system" (Reddy, 2004: 35). Universities are now characterized by a heterogeneous body of students whose socio-economic status, race, ethnicity, culture, language, level of preparedness for tertiary studies and schooling experiences differ. This means that HEIs and/or the academic staff are not going to get the students they *"want"* or prefer or expect. With the advent of democracy and transition, and the emphasis on equity, redress and access, HEIs are no longer demarcated by race, language and social class. They are no longer serving a homogenous student body or "their historical clientele" (Richardson and Fisk-Skinner, 1991: 14). In South Africa, university study is no longer the privilege of the elite; it is now the right of those who qualify for academic admission and universities now seem to be more reflective of the demographics of the country. Even though "[t]*he university was not really established for the type of students we are getting now"* (Kenneth), the mindset needs to be changed and transformation needs to be embraced. Admitting a diverse group of students is one of the transitions that universities in South Africa have undergone. "All higher education institutions need to value [this] diversity, tap into its riches and work out how to make differentiated learning possible" (Smit, 2010: 5). Since the student profile at tertiary institutions has changed and reflects diversity, measures such as changes to the curricula, and teaching and learning practices need to be undertaken by those entrusted to teach the students.

In terms of this study in particular, the point *"We're hoping that when students get here they would adjust to the system*" conveys the notion that the HEIs remain unchanged while students need to adapt to its existing culture and identity. This is the type of view that has been previously opposed. Mphahlele (1994), for example, argues that the university should attempt to socialize students into the new higher education culture. When students enter university, they need to acquire the Discourse and discourse practices (Gee, 1990) to help with epistemological access and the chance to forge an identity within a discipline in the university. They need to be able to gain membership into the discourse community. This can be achieved if they are "socialize[d] into the kinds of Discourse associated with academic learning" (Gibbons, 2007: 704). For this to happen, the Discourses (Gee, 1990) need to be made explicit. Students do not just *"adjust to the system"* as assumed by Kenneth. They do not just acquire knowledge through "intellectual osmosis" (O'Toole, 1994 cited in Barker, 2000: 2). They need to be assisted in the adjustment process, more especially in cases where their educational backgrounds might not have prepared them for enculturation into the tertiary environment. In any event, students do not just *"reap success in their learning"* (Kenneth). If the HEIs expect students' performance and throughput rates to improve, they would have to factor in suitable learning and educational support mechanisms and the teaching staff would have to implement specific pedagogical practices to accommodate students through the learning process.

Responses in respect of the type of students that enter the tertiary institution have been more specifically directed at FP. According to the RPs, some of whom have been teaching in the FP in science since 2001 (prior to the institutional merger of higher education in South Africa), the former FP students were able to cope with content and curriculum despite its intensity and volume. Lara, who has been involved in the teaching of foundation students for almost a decade, illustrates this point in her comment regarding a biology module that was offered in the previous Science Foundation Programme at UDW from 1999 until 2004, a year before the institutional merger:

> "*From 1999, UDW operated its own Science Foundation Programme. It was open to any student who did not meet the criteria for mainstream study. Since the biology module was only offered in semester 2, the biology tutors taught a language module in semester 1 which serviced that SFP. The language module was compiled by the then Department of Languages, with the focus being on writing and reporting skills. The content of the language module was based on physics and chemistry and some language tasks. Students attended these courses for extra tuition in the subjects and to gain writing/reporting skills needed for science. They did not necessarily have difficulties with expressing themselves in English. The content material was from science texts and were not scaffolded*" (Lara).

In respect of the module described above, Lara explains that " *... the pace was a bit faster. I mean they could manage a whole lot of content. Our teaching then was different from how we teach now but owing to the kind of students we had then, they coped".* A significant point in Lara's response is the biology module she refers to was not exclusively for students from a disadvantaged educational background, or black students or exclusively for South African students. According to Lara, *"the landscape of students* [then] *was different ... we had a lot of Indian students to start with, we had a lot of black students that came in from ex-model C schools*[62]*, students from privileged schooling backgrounds* [which are schools with access to an abundance of resources and more than adequate infrastructure], *international students, some whose language was really very good".* In light of this – especially in terms of educational experience – it should thus be less surprising that such students were able to cope with both the pace of teaching and content material. The changing student cohort that Lara refers to has also been a consequence of the admission of students into the university sector through alternative access routes, as such students would not have "normally qualified for entry into the Faculty" (UKZN *Faculty of Science and*

[62] "'Model C' is generally used to describe the former white schools as they existed under apartheid. Former Model C schools are adequately resourced. They are equipped with modern computers; well-resourced libraries and laboratories; and well-qualified teachers In April 1992, Piet Marais, the then Minister of Education announced that all white schools would become Model C status schools. This meant that these schools would be converted into state-aided schools managed by the principal and a management committee. The state paid the salaries of a set number of teachers whilst the rest of the costs at these schools became the responsibility of the parents. The management committee had the power to appoint teachers, determine admission policy and impose fees. Although, in theory, white schools could admit black pupils as from October 1990, many black learners were barred access to these schools due to high school fees and inability to meet certain selection criteria." (Arendse, 2011: 343).

Agriculture Handbook, 2011: 60) due to their low matriculation points. Kenneth and Lara seem to feel the same way about the students then and now.

The student cohort Lara refers to is the [former] SFP which was launched in the former UDW in 1999, where the student number in each of the campuses started with very small numbers and increased each year "up to 572 students alone in 2003 in the former UDW" (Kioko, 2009: 17). However, following the institutional merger, and the launch of the CSA in 2005, enrolment requirements into the access programmes in science had changed (as discussed in Chapter 1); enrolment was capped at 500 across the two UKZN campuses, i.e. Westville and Pietermaritzburg. Students accepted into CSA would have had a disadvantaged school background determined by the quintile of the school from which they had matriculated.

All South African public ordinary schools are categorised into five groups, called quintiles, according to their poverty ranking and availability of resources in the schools. The poorest schools are included in quintiles 1 and the least poor in quintile 5. Hall and Giese (2009) explain the two steps in the classification of schools. First, a national poverty table, prepared by the Treasury, determines the poverty ranking of areas based on data from the national census including income levels, unemployment rates, dependency ratios and the level of education (literacy rates) in the area. Provinces then rank schools from quintile 1 to 5, according to the catchment area of the school. The quintile ranking of the schools is relevant to this study as students accepted into the CSA (including the FP) come from quintiles 1-3 schools. Besides this criterion, the students would have had to satisfy the minimum criteria required for entry into the access programme based on their NSC results (these requirements have been explained in Chapter 1 of this study).

Apart from the minimum criteria discussed above, selection into the CSA was, prior to 2011, based on performance in internal selection tests in Mathematics and Science. The tests were designed and refined by the former CSA and tested the students' aptitude to be successful in a science degree. Students who performed satisfactorily in the selection tests were admitted into the FP (Appendix 10 has a sample selection criteria that was used to admit students). From 2011 onwards, students' aptitude for the science subjects was gauged from their NSC Mathematics, Physical Science and English marks. Once accepted into the CSA, students had to write an internal [English] language test, the Standardised

Assessment Test for Access and Placement (SATAP), which was used to test students' language proficiency for placement into one of the two AL modules[63] offered in the CSA[64]. The SATAP test (of 2½ hour duration) comprised reading texts based on a specific topic (e.g. eco-tourism); comprehension questions; multiple choice question types and a writing task based on extracting and interpreting information from the reading texts. The majority of the students accepted into the FP are black African. At the time of data collection for this study, the student distribution by race in the FP comprised 98.83% black African students and 1.16% Indian students. Unlike the former SFP (offered before 2005) which Lara referred to, the current tutor to student ratio in the FP is small (1:35 at most) to ensure that students are given almost individual attention.

The current FP offered at UKZN cannot operate within the framework of the original approach of its predecessor (the SFP) (discussed in Chapter 1) which was a "vehicle for the development of useful scientific skills" (Grayson, 1997: 107) or as a mechanism to "try to build up students' stamina by increasing the amount of work they do continuously over the year, until by the end of the year the workload is nearly up to that of a first year student ... and over the year most students learn to work faster and to cope with more work" (Grayson, 1997: 109). To work along such a framework is to then relegate the FP as a skills-based science programme when it needs to be used as a mechanism to allow students access into the science community by engaging them in discourse participation. In addition, the learning environment of the FP should optimize learning of science and the pace at which students in the FP work should be an attempt at "epistemological access" (Morrow, 1994) and acculturation. These are vital to help the students achieve reasonable outcomes at the end of the foundation year, rather than having them cope with the work load equivalent to first year students, especially since they are not in first year but in the transition between matriculation and first year (the objectives of foundation programmes offered at HEIs have been explained in Chapter 1 of this study).

[63] "Based on their performance in a language test at the beginning of the year, FP students will be provided with a language module that is most appropriate for their needs: SCOM or Scientific Writing and Reporting (SWR)" (63) Aim of SWR: "To develop students' ability to access and read scientific sources, and their ability to write and make oral presentations in science" (UKZN, *Faculty of Science and Agriculture Handbook,* 2011: 63; 258). Students who scored <65% in the SATAP test were registered for SCOM (Communication with the ALSs). The nature of SCOM has been explained in Chapter 1 of this study.

[64] Since versions of the SATAP tests were used for assessment/placement, it was not possible to include these in the appendices. Similarly, since the internal selection tests in Mathematics and Science were previously used for admission into the CSA, it was not possible to include these in the appendices.

6.2 Changes to the Foundation Modules in Science

From the interviews, the RPs indicated that changes were implemented in the modules offered in the FP. I used the technique of probing for reasons behind such changes and the type of changes that were implemented. The reasons presented by Lara were:

> "*But when we started with teaching with the new curriculum* [65] [for foundation biology*] in 2005 the students were just not coping, we were dealing with a lot of content and some of the content was ... somewhat dense. And we* [the DSs] *did not get time to concentrate on writing and many other language skills because we were dealing with a lot of content*" (Lara).

Lara's response illuminates several salient issues. From the response, I had ascertained that one of the main, initial reasons that students were *"not coping"* was on account of the 'density of content' in the course (which Lara clarified to be the *"...reading matter and content that was not easy to go through"*). The previous course manuals in foundation biology showed examples of the inclusion of dense texts, an example of which appears in Appendix 11. The text cited has a large number of abstract concepts and terminology. At that time, students were expected to read such texts without the support structures of scaffolding and/or guiding questions to help them unpack meaning. If Lara's concern is about the students not coping with dense content, then an important point that needs mentioning is such a challenge is not necessarily unique to students at foundation level. Research by Pretorius (2005), for example, showed how students who had to "wade through conceptually dense texts were left exhausted, demotivated and largely uninformed" (798). Similarly, a study profiling first year [mainstream] students undertaken by Frick (2008) found "the prescribed textbooks difficult and therefore inaccessible and found the volume of work daunting and as a result [students] could not easily keep abreast with their studies" (iii). Students entering university need to adjust to the transition; dense and voluminous course content can be overwhelming and stressful; and obstacles to accessibility could mean that students could struggle to keep up and could lag behind. Dense and voluminous content can hamper student engagement with it, especially if these are written in a language that is wholly different from the students' home or native language (as was the case in this situation). If they have trouble understanding such content, then they rely on surface learning approaches such as reading just so as to

[65] When the Science Access Programme was launched at UKZN in 2005, the year-long foundation biology course that was implemented had been originally devised by the biology team in the former SFP at the UN (Pietermaritzburg campus) which is the 'new' curriculum to which reference here is made.

complete a task or to rely on memorisation of information. As stated by Kember (2004), heavy workload has been positively correlated to 'surface' learning approaches.

Lara's response highlights two other issues. The first is her view of discipline-specific literacies as being autonomous, independent of content, thus the reference to "*we did not get time to concentrate on writing and many other language skills because we were dealing with a lot of content".* The second issue is her view of the literacies needed for foundation biology as *"language skills" or "skills".* Through probing, Lara included 'reading' as another example of a 'language skill'. DSs, like Lara, need to realize that for students to gain mastery of disciplinary discourse, they need to be acculturated into the discourse as "language should not be taught in isolation" (Mohan, 1986) because "authentic content provide[s] the richest and most natural context for language teaching to occur" (Brinton and Holten, 2001: 239). As stated by Moore *et al.* (1998), "linguistic competence [should not] be separated from the cognitive demands" (11). Within NLS, the ideological model views literacy as a social practice rather than the acquisition of skills (Street, 2003: 78).

Some the verbal responses from the DSs indicated FP students being perceived as having a form of deficit. Teresa, for example, is highly critical of the students' ability to cope with foundation biology when she states that "*their reading pace is extremely slow; their comprehension is very low and it precludes any other higher skills development without those basics being in place".* Teresa's response is contentious. Firstly, in the absence of a standardized reading test administered to each new cohort in the FP (or within foundation biology itself) to test students' reading pace and/or comprehension capabilities, Teresa's claim about the students' reading pace and comprehension level is unsubstantiated. This study has shown that students admitted into the FP had to write the SATAP (English language) test, the purpose of which was only for placement into one of the two AL modules offered in the FP[63]. Secondly, Teresa's claim is problematic in light of the students' disadvantaged educational backgrounds; and research on minimal exposure to print media (Nyamapfene and Letseka, 1995; Kapp, 2004; Mgqwashu, 2009). Studies (Evans, 2002; Nel *et al*. 2004; van Wyk and Greyling, 2008) have cast light on the challenges encountered by university students in making sense of academic texts. Difficulties with understanding and interpreting academic texts can present difficulties for inexperienced readers. Rose *et al.* (2003) offer reasons for this: the subject matter, including terms used in the academic field, is likely to be unfamiliar even if learners read it fluently; and the patterns of language in academic writing differ from those used in everyday speaking or writing. Scientific academic texts are complex, dense and abstract (The problem of students not being able to cope with dense content in foundation biology has already been alluded to in the analysis of the response from Lara in the previous paragraph). Scientific texts convey discourse through the use of secondary discourse (Gee, 1999) and the elaborated code (Bernstein, 1971) and are therefore more cognitively demanding which requires CALP. For students to be adept at reading and comprehension, they would have had to master academic discourse. Reading involves both decoding and comprehension[66]; and limited reading proficiency can impact on comprehension and consequently, learning. Another salient issue that needs to be taken into consideration here is that the students in the FP are forced to read texts that are in a language that is 'non-native' to them. The texts that they are engaging with are in English, which in this situation represents the 'educated language' (Bourdieu, 1977). The LoLT at UKZN is English. This, in itself, can seriously disadvantage the students' engagement with the reading texts. (Chapter 7 offers excerpts of reading text types that the FP students are forced to engage with in foundation biology. In addition, Appendices 11 and 22 offer other samples of dense reading materials extracted from foundation biology).

In attempting to probe the reasons for changes to the foundation chemistry module post-institutional merger, Seema explained that *"It* [the foundation chemistry module] *has become simpler because in the past when the course was offered at the former UDW* [in the former SFP, prior to the launch of CSA], *it was more in line with mainstream – first year and not so much high school or secondary level work. But now, we've dropped the level"*. A perusal of the content in the foundation chemistry course manuals over a period of time (from 2008 until 2011) has shown no evidence of the level being dropped. The content (i.e. topics) as shown in the textboxes below done from year to year has been exactly the same and the manner in which the content was presented had not changed:

Content: Semester 1: Energy and Matter; Pure Substances and their properties; Compounds and Mixtures; Pure Substances and their Changes; Chemical Reactions; Concentrations of Solutions; Solubility.

[66] *Decoding* refers to the deciphering of printed symbols into language, and involves the oculomotor, perceptual and linguistic parsing aspects of reading activity relating to letter-sound correspondences, word identification and lexical access. *Comprehension* refers to the understanding process whereby meaning is assigned to the text as a whole (Pretorius, 2000a).

Content: Semester 2: Measuring the Mole; The Mole and Formulae; Mole Calculations, Limiting Reagent Calculations; Atoms, Isotopes and Ions; Electronic Configurations and the Periodic Table; Chemical Bonding and Nomenclature; Electronegativities; Common Citations and their Charges; Common Anions and their Charges.

There was only one example that seemed to fit into Seema's notion of the "level being dropped", an explanation of which follows. The question below appeared in both the 2009 and 2011 foundation chemistry course manuals.

Question 17: The concentration of a dilute hydrochloric acid solution, $HCl_{(aq)}$, is 0.020 mol.dm^{-3}.

a) What volume of the hydrochloric acid solution would react fully with 10.0 ml of a 0.100 mol.dm^{-3} sodium hydroxide, $NaOH_{(aq)}$, solution?

b) How much product will be formed?

To answer this question we must start by writing the balanced equation for the reaction.

$$\mathbf{NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)}$$

(*Foundation Chemistry*, Semester 2, 2009: 30; 2011: 36)

In both course manuals, students were expected to answer the question by means of step-by-step calculations, each with a short set of instructions. In 2009, the instructions for '*Part a'* were a 2-line sentence illustrating a brief overview of what was to be done in the question. The space for the answer was half a page long. Students were thus expected to answer the entire question at once in one long step as shown below:

(First find the number of moles of NaOH present. Use this to determine the moles of HCl present. Finally use the moles of HCl to calculate the volume of HCl.(

(*Foundation Chemistry*, Semester 2, 2009: 30)

However, in 2011, the same instruction for the same question was sub-divided into three detailed steps, with each instruction having more detail than in 2009 (see below).

Step 1 *Find the number of moles of Reactant 1 (NaOH)*

Step 2 *Relate number of moles of Reactant 1 (NaOH) to number of moles of Reactant 2 (HCl) using the mole ratio. Find the number of moles of Reactant 2 (HCl).*

Step 3 *Find the volume of Reactant 2 (HCl)*

(*Foundation Chemistry,* Semester 2, 2011: 37)

The extended detail in 2011 (above) gave students a precise idea about what to do in each step to eventually arrive at the answer. In this way, students were guided from one step to the next. They had to merely follow instructions without having to think about what to do to eventually arrive at the answer, as the entire algorithm was given to them. Sub-dividing each step deprived students of the chance to figure out how to solve the problem on their own.

In respect of foundation mathematics, Raj claims that students admitted into the FP had *"lower levels of knowledge and skills in maths"*. Raj's comment is made in light of student performance in an essential skills test administered to students at the start of each academic year. (Appendix 12 contains a sample skills test; and relevant graphs outlining student performance in the skills tests to support Raj's claim). This is further supported by the following comment in an academic module report on foundation mathematics:

> "In the first few lectures basic skills were covered; and a test was scheduled. The results were very disappointing (average below 50%) and there has been a steady decline in numeric skills. We had to do some remedial work and students will be required to write a second basic skills test in February" (2011)

According to Siva, the foundation mathematics module had been revisited; "*linked to the Grades 11 and 12 school syllabi so that the skills that students should have brought into university are thoroughly reinforced in their foundation year"*. One of the ways whereby essential skills in foundation mathematics was reinforced was to provide the students with a 'Basic Skills' booklet which students were encouraged to work through, without the aid of a calculator (unless specifically asked to do otherwise). Students were informed that the topics in the booklet would be repeatedly applied and tested throughout their foundation year. The topics in the skills booklet are shown in the excerpt on the following page. Each of the topics was accompanied by a diagnostic test which students took on their own, within a stipulated time limit. The objective of the diagnostic test was to determine the extent to which the individual student needed to focus on a particular topic. Each topic was explained in detail, accompanied by examples and exercises to complete (Appendix 13 has a sample exercise based on a Chapter).

(*Foundation Mathematics*: Basic Skills, 2010: 2)

In consideration of Siva's response in the previous paragraph, restructuring the foundation mathematics syllabus to reinforce the mathematical 'skills' that students should have acquired in grades 11 and 12 can equate the course to a "backward-looking" (Rollnick, 2010: 18) bridging course that focuses on content that had been done at school or which Pinto (2001) describes as re-mediating and revisiting gaps in school experiences before selection for degree programmes. This notion contradicts the DoE (2006) description of foundation programmes as alternative introductory courses or modules aimed particularly at strengthening conceptual understanding and providing academic literacy skills. Courses offered in the FP should be "forward-looking" (Snyders, 2003) basically laying the foundation for subsequent learning, rather than offering a revision of the high school curriculum. If students in the FP are marginalized or stigmatized by being in such programmes designated for a certain sector of students (i.e. educationally disadvantaged and primarily for Black students who did not meet the formal entrance requirements for mainstream university study) and, who need special programmes to remedy their underpreparedness, then being subject to secondary school mathematical skills in a foundation module can run the risk of perpetuating any feelings of inadequacy. At the time of data collection for this study, the FP comprised 98.83% black African students.

In assigning initial reasons for the changes effected in foundation physics, Petrus claimed that it was an attempt at *"... upgrad*[ing] *the content every now and then; ... and putting in more relevant examples. We take out content that we found may no longer be necessary now".* According to the academic module report on foundation physics (2009), "the syllabus was reduced: the topic, 'Equations in 2-dimension' was omitted; 'Astronomy' was cut down to a brief mention in relation to 'Newton's Law of Gravitation'". At the end of semester 1 in 2011, one of the module reports in foundation physics indicated the following changes:

> "To provide a curriculum which will better serve the needs of mainstream physics and to increase the ratio of students entering physics major courses, there was greater focus on developing excellent understanding and skills by the incorporation of more conceptual type questions in notes, tests and exams. We [the DSs teaching foundation physics] have cut down on any repetitive areas in 'Electrostatics' and 'Circuit Electricity' and introduced more questions requiring reflection about principles and intend to do the same with 'Newton's Laws and 'Optics'" (June, 2011).

According to Shane, some of the amendments to foundation physics were on account of the topics done at school. He elaborated on this: *"We* [the DSs teaching the course] *dropped the whole of "Heat" which was a term's work, it was a lot of work and very good for them that we did so, I think. It was quite difficult, something they've never seen at school".* This was verified in the foundation physics module report: "In 2010, one of the sections omitted was 'Heat'" (Semester 1: 2010: 2). In addition to trimming some content, Shane commented on reinforcing of basic skills that students were expected to learn, know and apply (a situation similar to that in foundation mathematics):

> "*We start off right at the beginning with the very basics of physics which is not done at schools and that is measuring mass, length, volume, density* [er] *uncertainties* [pause] *are not done at school at all. Percentage, areas, significant figures. Those things are never done at school but they're an important part of physics so the first term is called 'Properties of Matter' and it is very much an introduction to give them the basic skills which they need to then apply*".

The section on 'Properties of Matter' has explanations, examples and questions that students answer independently and/or in groups, in orally and/or written form (Appendix 14 cites some relevant examples of these). Petrus' views cited in the preceding paragraph were further supported by the other DSs teaching foundation physics who maintained that initially, major changes were made on account of the institutional merger[67]; followed by changes each year. *"The changes were based on our teaching experience"* (Susan) and *"involved minor changes to facilitate student understanding – like modifying and rewording an existing example"* (Shane). (In terms of teaching experience in foundation

[67] Prior to the institutional merger in 2005, SFP on each campus implemented its own course content, but adopted a common curriculum post-merger. This involved discarding some content while retaining others. Some content in the modules had to be reorganized, revised or rewritten (communication with Petrus and Susan).

physics referred to here, Petrus has been teaching the module at UKZN for 5 years while both Susan and Shane have been doing so for 9 years each, prior to the institutional merger). One such example where a question in foundation physics had been modified particularly for clarity is cited below:

Question 1

Zipho is walking to school, which is 5.2 km east of where he lives. His watch falls off his wrist after he has walked for 1.6 km. He only realises that his watch has fallen after he has walked a further 0.5 km, and he has to walk back to where he dropped it. After he has found his watch he continues on his way to school. The whole journey to school takes him 40 minutes. (*Choose the easterly direction to be positive*).

Question 1 [14 marks]

Zipho is walking to school, which is 5.2 km east of where he lives. His watch falls off his wrist after he has walked for 1.6 km. He only realises that his watch has fallen after he has walked a further 0.5 km, and he has to walk back to where he dropped it. After he has found his watch he continues on his way to school. The whole journey to school takes him 40 minutes. (*Choose the easterly direction to be positive*).

e) If, on a usual day (in other words, a day where Zipho does not drop his watch), Zipho walks with the same average speed as he has on this day, how long would his journey to school normally take? [3]

(*Foundation Physics:* Kinematics, Semester 1, 2011: 8)

An example of an amendment to foundation physics *"to facilitate understanding"* (as expressed by Shane) which is shown on the following page, relies on visual literacy to facilitate and demonstrate conceptual understanding in the discipline:

There are several situations described below. For each situation, indicate which forces are present (circle P) and absent (circle A). Draw a corresponding labeled free-body diagram of for each situation. [25 marks]

Description of Situation	Force Present (P) or Absent (A)	Free body diagram
 1. A block hangs at rest from the ceiling by a piece of rope. Consider the forces acting on the block only. [4]	**Gravity:** P or A? **Tension:** P or A? **Normal:** P or A? **Friction:** *Static:* P or A? *Kinetic:* P or A? **Air Res.:** P or A?	

(*Foundation Physics:* Newton's Laws, Semester 1, 2011: 3)

The changes to foundation physics were meaningful, especially since they were attempts at facilitating student understanding. This implies that attention was paid to the limitations of the course curriculum rather than the reference to the students who enter the FP being perceived as deficient. The explanation by Shane of *"rewording an existing example"* indicates that content and literacies go hand in hand – revisiting and modifying the foundation physics module with a closer look at helping students to acquire the discipline-specific literacies in science and to help facilitate understanding of content.

6.3 Changes implemented in Communication in Science (SCOM)

One of the specific changes implemented in SCOM in 2010 was to change from teaching the students the mechanics of composing a full-blown academic scientific essay in the first term of semester one (as is usually done) in favour of teaching and reinforcing paragraph construction as a preparation for essay writing in semester two (See Appendix 15 for excerpts from the course manual). The general perception among the ALSs (Cindy; Iqbal and Sudeer) for doing so was that the students experienced difficulties with coping with scientific essay writing genre, a claim that has been supported by an academic report which reflects such challenges: "superficial engagement with the essay genre and difficulties with writing sentences and connected paragraphs ... majority of the students were still unable to organize and synthesize information into a logical, coherent scientific essay" (SCOM Report, Board of Studies: 2009: 28)

This study has shown attempts made by the ALSs to change their teaching practices to accommodate students' writing in science. However, one of the major oversights by the ALSs is that scientific texts are dense and cognitively demanding and the expectation for FP students to be able to extract textual information and to synthesize the same into a "logical, coherent scientific essay" (SCOM Report, Board of Studies: 2009: 28) can be challenging in consideration of four accompanying factors. Firstly, the vast majority of FP students had studied EFAL at school. In this study, of the FP 2011 cohort, 94% studied English as 'first additional language' at school level; while 6% studied English as a home Language. These were examinable subjects in the NSC. Thus, the greater majority of the FP students' writing experiences and genres to which they had been exposed at school were informal, descriptive, creative, narrative, and personal. The writing experiences of students who had studied EFAL at NSC level[68] were vastly different from those dictated by science. The examinations in EFAL had comprised texts "at the level of oral conversation ... writing tasks that are mainly descriptive, decontextualised, uncritical and cognitively undemanding" (Kapp and Arend, 2011: 5-6). Secondly, students in the FP at UKZN learn science in English, their non-native LoLT. Thirdly, students entering HEIs are exposed to academic language with which they need to familiarize themselves and which requires CALP. Fourthly, science texts are cognitively demanding, with extensive use of nominalisation and lexical density. Considering all these factors, this "superficial engagement" with the essay genre that has been isolated as a challenge in SCOM, is likely to feature; and writing [science] logically and coherently comes with extensive practice and mastery.

Responses gleaned from the ALSs interviewed have attested to the scientific laboratory report as being a fundamental genre in science. Responses from the interviews with the ALSs showed "[students'] *recurring difficulty with the ability to structure the discussion aspect of scientific reports"* (Cindy) and "[inability] *to integrate theory and experimental data"* (Sudeer). This data is triangulated with excerpts from two students' SCOM scientific reports below which illustrate such challenges as highlighted by the markers.

[68] "In EFAL, in line with the learning outcome of writing and presenting, the candidate should not only be able to write creatively and as form of communication, but also for specific purposes, for instance to present language ability. Candidates should be able to write a narrative, descriptive, reflective or argumentative essay of 250-300 words. Apart from creative writing, candidates should also be able to write longer (curriculum vitae, editorial, brochure, formal and informal letter, etc.) as well as shorter (advertisement, diary entry, postcard, etc.) transactional texts" (Grussendorff *et al.* 2010: 135).

Excerpt 1 from Nomfundo's[69] scientific report

delete space

move to the end of your discussion. First explain the results with the help of your readings

DISCUSSION: The hypothesis is rejected because the yeast and sugar does produce alcohol fermentation in red grape juice, during the pre-fermentation the litmus paper changes ~~to~~ from blue ~~and~~ ~~turns to~~ to pink when it was put in the grape juice, meaning that the grape juice is acidic, ~~but it depends on the litmus paper~~ .The blue litmus paper changes to pink which is acidic and it is expected ~~and~~ because the pH is 3, 50. ~~The~~ For post- fermentation the litmus paper does not change colour meaning that it is neutral or acidic ~~but it also depends on the litmus paper and~~ the pH ~~is~~ was 3,65 meaning that the fermentation is going slowly since the pH of alcohol is 7 ~~which~~ This implies that the fermentation is not in ~~the~~ a good conditions. The three conditions that necessary for fermentation to take place are simple sugar, yeast and anaerobic conditions (Benson, 2002). The mistakes that might have made during the experiment is that, the yeast and sugar must have been too much or the pH is measured incorrectly or there is less incubation at 15-17 degree Celsius for 2-5 days.

In your discussion you should not only say what the results were, but explain them using the readings.
E.g. why did the pH only increase by .15? Why did the aroma change? What about the change in colour & fluidity?
What about the balloon?

Excerpt 2 from Nqobile's scientific report

* MUST HAVE MORE ANALYSIS IN DISCUSSION. EXPLAIN THE PH READINGS AND WHAT THEY MEAN. DISCUSS THE LAYERS *

MUST REFERENCE AGAIN. BRING IN YOUR THEORY FROM INTRO

DISCUSSION

STRONGER ACID   WEAKER ACID

At the beginning, the solution was a weaker acid and after fermentation, the acid was stronger because fermentation took place. At the top, the yeast started to multiply and grow, due to the presence of oxygen and the balloon started to inflate because carbon dioxide was produced and trapped int~~o~~ the balloon. At the end of the fermentation, yeast died and stopped multiplying because sugar was depited (DEPLETED) and the balloon deflated because there was less carbon dioxide present in the ~~solution~~ FLASK AS IT HAD SLOWLY ESCAPED.

The experiment was the same as was expected. Carbon dioxide was produced ~~which resulted~~ AND ALCOHOL WHICH RESULTED IN to the smell of alcohol and it was exactly the same as THE REACTION BY BENSON (2002) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$. The temperature for fermentation was quite good because the best temperatures for fermentation, especially for the wines which is also alcohol range from 21°C to 32°C and the temperature for the fermentation taken were ranging from 22°C to 24.5°C which ~~were~~ WAS between the best RANGE OF temperatures for fermentation.

69 Students' surnames and/or first names in this study have been changed to protect their identities and to conform to ethical considerations.

In SCOM, the trend has been to provide students with the format of the scientific report with a short explanation on how to write up each section of the report (See Appendix 16). This, according to communication with Cindy and Sudeer, is discussed prior to an experiment being conducted in SCOM; and is reinforced after the experiment and after the assessment of the draft reports, if the need arises (Process writing in SCOM was explained in Chapter 1 in this study). Although this had not changed, there were other examples of amendments to the focus on the report genre. The first example was the inclusion of a sample discussion, followed by hints on how to compile a discussion section, drawing students' attention the way in which integration of theory and analysis of results was undertaken. The second example was to provide students with short exercises on writing up the discussion section. These are accessible in Appendix 17 in this study. These changes adopted in SCOM are beneficial in apprenticing students into the discourse of science (in terms of NLS) and in satisfying some of the advantages advocated by genre pedagogy (Hyland, 2007). In terms of the latter, the ALSs are "making explicit what is to be learnt" to facilitate the acquisition of the report writing genre; "the course objectives and content are derived from students' need[s]"; and, "a central role [is being played] in scaffolding students' learning" Hyland (2004: 10-16). These measures help "[pull] together language, content and contexts" (Hyland, 2007: 150).

The report writing genre is common to the foundation modules of biology, chemistry and physics. Writing science in the FP differs from the students' writing experiences in science from school[70]. Writing science is ideally addressed by the DSs for whom the literacy practices of science are implicit and/or habitual. The DSs in this study have academic qualifications in pure science. The ALSs who teach SCOM can be considered "outsiders" (Jacobs, 2005: 480) to the discipline of science, especially since they do not teach any of the science modules offered in the FP. Fifty percent of the ALSs chosen as RPs in this study have no academic qualifications in science. Of the total number of ALSs teaching SCOM at the time of this study, 62.5% have qualifications in social science, education and/or English Literature/English Studies which are offered within the College of Humanities; while 37.5% have qualifications in pure science. Entering the community of

[70] In the FP, students are expected to write scientific reports. The NSC Life Sciences exam papers (2008-2010) consisted of "a number of MCQ and one-word-answer questions, followed by a section of short-answer questions, data-response questions, and an extended-response question" (Grussendorff *et al.* 2010: 64). There was in each paper a short writing task (also referred to as a 'mini-essay' (NSC 2008: 16) which carried 15 marks (3 of which were for synthesis/presentation). In SCOM students write lengthier essays (500-600 words) on a science topic.

science meant that the ALSs (without qualifications in pure science) had to assimilate literacy practices of science, replacing the writing conventions they had become accustomed to in the field of humanities. This conclusion arises from the following responses from the ALS: *"I would expect teachers* [tutors] *to make adjustments to their teaching pedagogy as and when needed because they're teaching students communication in science"* (Iqbal). *"We* [ALSs] *need to adapt our strategies, we had to sort of learn to write science" (*Sudeer).

It has already been mentioned in Chapter 4 of this study that science is written objectively. This can present difficulties for students who enter the tertiary environment having had greater exposure to narrative, personal, subjective and emotional forms of writing. Such literacy practices may not necessarily be appropriate for writing science. In order to gain membership into science, students need to be able to read and write science. One of the purposes of SCOM as outlined in the UKZN faculty handbook[71] is that students would write scientifically. In science, the FP students are exposed to scientific texts that are lexically dense and heavily nominalised (as outlined in Chapter 4). The students would have to use the content knowledge from such texts; and using the appropriate science register, compose scientific reports. The expectation of them to convey dense, accurate scientific knowledge in an authoritative manner using the appropriate science register and to ensure that they provide relevant evidence from the data as demanded by the scientific report genre, can be viewed as demanding expectations for FP students. Scientific report writing involves a combination of reading science (for theoretical knowledge); and doing science (as a laboratory practical or field research). This involves observation, interpretation and explanation. Scientific report writing is thus reliant on multiple competencies. The ALSs teaching students in the FP need to understand that due to the imbalances of education, the FP students have had to deal with lack of educational resources, such as libraries and laboratories at their schools and the lack of experience with report writing. These could have compromised their access to and understanding of science. Therefore, the technique of writing scientific reports adequately needs to be reinforced in the other science modules offered in the FP.

[71] "Communication in Science Content: Through the process of short research projects relating to science, students will be supported in their reading in order to understand the purpose of a range of scientific texts. They will test their understanding of these genres by writing lab reports, essays and posters" (UKZN *Faculty of Agriculture, Engineering and Science Handbook,* 2012: 352*).*

6.4 RPs' views on factors contributing to perceived challenges in foundation modules in science

In an effort to understand the perceived challenges in discipline-specific literacies that manifest in the foundation modules in science, I had to field responses from the RPs with regard to the possible contributory factors. Seventy percent of the RPs interviewed in this study has blamed the challenges experienced by the FP students with discipline-specific literacies in science on schooling. Lara highlights this in the statement: "*You can tell if a student comes from a background where there was almost no teaching. They come in with gaps in their knowledge which impact on their performance in the science lecture".* Lara's comment highlights the educational experience of the FP students, especially the fact that they have been victims of an inferior schooling system, where lack of quality teaching has contributed to "gaps in knowledge". Besides the impact on students' performance, these gaps have teaching implications in the FP as shown in this module report on foundation biology:

> "An analysis of the first test results showed an overall pass rate of 70%. It was thus considered not necessary to put any additional measures in place at this stage as this was considered to be a good pass rate. This was logical as the first test covered material that the students were adequately prepared for at school level, i.e. interpretation and presentation of data. However, the overall pass rate for Test 2 was lower, at 54%, but certainly much better than the 15% pass rate achieved last year for the same topics. This test covered 'Cytology' and 'Histology' which students were not adequately prepared for at school (see FET Life Sciences curriculum). The teaching staff was aware of this challenge from last year; hence, interventions were put in place prior to the teaching of these topics. Different teaching strategies were used e.g. mind maps, provision of additional handouts, and exposure to visual aids from a variety of sources" (Report, Board of Studies, Semester 1, 2010: 1).

Jansen (2005) has stated that poor student performance at school level continues due to a lack of provision of quality teachers, textbooks and time-on-task. Similarly, Lara's response makes reference to poor performance in science at tertiary level, attributing this to lack of preparation at school level. As explained earlier in this dissertation, foundation programmes are "special programmes for students whose prior learning has been adversely affected by educational or social inequalities" (Kloot *et al.* 2008: 800). If the objectives of the FP is to provide students with "a foundation for meaningful learning; a phased transition in terms of pace of work, quantity of work, background required and level of difficulty" (Grayson, 1996), then added to this should be the need to fill in gaps in [scientific] knowledge. The intervention strategies outlined in the foundation biology module report quoted above illustrate how these gaps are attended to in the FP.

On the issue of schooling, the data indicated that the DSs attributed FP students' being challenged by scientific knowledge as a result of being taught by teachers at the former DET schools whose own conceptual understanding of the disciplines of science is *"very much wanting"* (interview with Dennis). In support of this, Vusi, a tutor in foundation mathematics, felt that *"because of their* [secondary school teachers] *mathematical deficiency they have nothing to transfer to the students. So we inherit those students who have come from that background".* This view is corroborated by that of Dennis who was involved in the teaching of chemistry to a group of teachers in the Advanced Certificate in Education (ACE)[72] programme:

> "*You become shocked when you realize that they* [the teachers] *actually don't understand it at all; they have difficulty visualizing and conceptualizing. The concern is if teachers are experiencing problems with this, what about the students? It's stuff like this that we would have to re-teach*".

Dennis substantiates his comment by quoting an example[73] which shows the teachers' conceptual difficulties with comprehending a fundamental chemical principle.

In light of the educational philosophy of the foundation programme in science (as seen in Chapter 1 of this study) and the type of students admitted to study in the programme, the responses of the DSs quoted above is perplexing. The articulation gap between high school and university is more acute for students whose schools are not only under-resourced, overcrowded and understaffed, but whose teachers are unqualified or inadequately qualified to teach science courses that generally require specialists in the field (Arnott and Kubheka, 1996; Marias, 2011; Bradbury and Miller, 2011). An additional issue that research (Howie, 2001a; 2001b; Reddy, 2006; Dempster and Reddy, 2007) has highlighted is teachers' lack of content knowledge and confidence to teach science subjects. The FP students' exposure to less than ideal teaching in science subjects is sure to account for

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[72] "With the introduction of the national NSE (Norms and Standards for Educators, DoE, 2000), the Advanced Certificate in Education (ACE) became the multi-purpose qualification for teacher upgrading, re-skilling and access to higher level programmes" (Soudien and Menon, 2010: 106).

[73] Dennis relayed the following example of the teachers' misinterpretation in chemistry: *"They think when you are boiling water you are breaking the molecules into hydrogen and oxygen which is not correct because you can't do that, but you are actually* ***separating*** [participant's emphasis] *the molecules."* This demonstrates their poor understanding of the chemical (intra-molecular) bonds between atoms of hydrogen and oxygen in the water molecule.

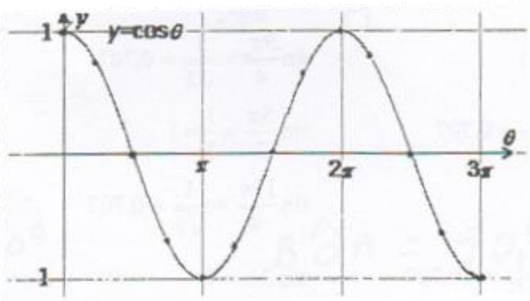
inadequate preparation for university science and if these are the students that are *"inherited"*(Dennis), then those involved in teaching them would need to create the platform for meaningful learning in the FP and induct the students into the science discourse. One of the central tenets of foundation programmes is that the students need "more time and should be provided with more tuition" (Kloot *et al.* 2008: 803). This then is likely to include re-teaching and correcting misconceptions and/or inaccuracies in science.

DSs interviewed also held the view that students in the FP relied heavily on memorisation of facts and rote learning. According to Annah, *"in foundation physics, the problem with the students is that they do not try to understand. They want to memorise. They can do the calculations but they have difficulty giving reasons".* One of the reasons for this in foundation physics, according to Petrus is that *"sometimes you* [the DSs who teach the module] *have to give them a lot of problems. In those cases they end up learning by rote memorization".* Annah explained that one of the ways in which the tendency to memorise was addressed - both orally and in written form - was to refrain from asking students for definitions, a point supported by Shane when he said: "*We don't ask them to learn definitions".* The textbox below has some examples of the way questions were framed so as to discourage rote learning and encourage students to explain/reason or even justify, adding the dimension of providing examples:

- Is the following statement true?: "Whatever characteristics *the slope of a position time graph* has, the velocity will exhibit the same". Explain your answer using examples.
- Explain your reasoning for the appearance of the graphs.
- Describe the motion of the man in words.

(*Foundation Physics,* Kinematic Notes, Semester 1, 2011: 42)

Similarly, Raj drew attention to the fact that *"with rote learning ... when a student gives an answer from memory, it's hard to tell if the student understood what they have memorised. For example, students tend to rote learn common trigonometry graphs and memorize the interpretations. However, it is unclear whether they are able to understand both the graph and its interpretation"*. Raj referred to the following graph to explain his view:



(Foundation Mathematics, Semester 2, 2011: 20)

> "*Students would tend to simply memorize the way in which the graph of "y = cosθ" appears and would thus be able to draw it if asked to. It is unclear, however, if they understand exactly what the graph means and what it shows. For this particular graph, the amplitude is "1" and the period is "2π". It is easy for a student to simply remember the answers to this question for this particular graph as these answers are constant and will never change. Hence if the students are asked to give the amplitude and period of this particular graph, there is no proof that the student understands exactly what these answers mean as they could have easily been memorized*" (Raj).

The responses have indicated that challenges associated with memorisation. However, its implications need expansion. When students rely on rote learning and memorising, it could mean that students might have had some difficulty with engaging with the subject matter. They had perhaps not internalised the material sufficiently to be able to explain, give reasons, or to show deeper understanding and learning. It is thus highly likely that students resort to rote learning when faced with subject matter that is cognitively or conceptually challenging. Although rote learning and memorising is a superficial, passive approach inappropriate for tertiary level studies, what needs to be understood is that these were mechanisms that worked for students at school, and helped them pass, almost like a survival mechanism. The persistence of the technique of rote learning as the predominant mode of learning at former DET schools has been researched (Kotecha *et al.* 1988; Rollnick and Rutherford, 1990). Students in the FP cannot automatically assimilate a different mode of conveying information in science when they enter the HE environment. If expected to do so then they need to be groomed into applying, explaining, justifying which are the higher order skills needed for higher learning.

Another issue linked to the impact of rote learning and memorising was mentioned by Kenneth, a DSs teaching foundation mathematics, who said that *"sometimes you don't know if it is a language problem where they cannot read and comprehend or if it is a maths problem – where they simply don't know the correct answer* – [pause] *because one of the* *difficulties we* [the DSs] *face is that some students just won't open up and answer or explain or justify"*. Kenneth's concern is justifiable in light of not being able to pinpoint the reason/s as to why students would not answer or explain in class. His concern, however, raises some crucial issues that can confront students in the FP: the LoLT; the literacies associated with reading; the challenges of understanding and conveying disciplinary content. The point made by Kenneth is what Bernhardt *et al.* (1995 cited in Snow and Brinton, 1997: 315) refer to as 'double jeopardy', a description apt for FP students especially since they are compelled to demonstrate scientific knowledge through a language they have not yet mastered. Learning science is essentially learning to participate in a new social practice (Lemke, 1997). This can be challenging for students for whom the LoLT in the tertiary environment is not a home language. In the context of this study, the LoLT is the English language. In this regard, Rollnick (2000) states that "the learning of a new language is itself part of another social practice, so a learner learning science through a second language is trying to become initiated into two social practices at once" (100).

In terms of lack of success in getting students to "*open up and answer or explain or justify"* RPs need to understand that for the majority of the students from the former DET schools, instruction was teacher-centred; teaching was primarily the uncritical presentation of facts, and knowledge which has been described by Haiden (2000) as uncontested and uncontestable. Moreover, explaining an answer in a science discipline in the academic environment calls for the use of secondary discourse (Gee, 1999) or the elaborated code (Bernstein, 1971) and the 'educated' language (Bourdieu, 1977). To demonstrate procedural or conceptual knowledge, the students would require CALP and they would need to explain using the appropriate academic discourse in the LoLT.

In an observation of a foundation mathematics tutorial session on 'Exponential Functions', Kenneth posed the following question to the students: "What's the answer to the question: 2^{-2} – how would you approach this question and calculate the answer?" As an observer, I, too, gathered a distinct sense of inhibition by a number of students to attempt to give the answer in front of the entire class even though many of the students made some attempt to provide written answers in their workbooks to the same questions that had been posed to them orally. (There were, however, at least four students who readily provided answers – orally – to several other questions in the tutorial). One of the ways in which Kenneth could have addressed this issue of non-participation and to probe students' challenges was to enable students to discuss the questions/answers in a group as a way of developing student confidence and helping them to support each other in interpreting questions and justifying answers. In this tutorial, students worked on their own.

There is the possibility that students are more likely to be more at ease with BICS which use primary discourse (Gee, 1999) as a means of interaction rather than CALP. The assumption here may be based on the response from Lisha that *"a number of students are very articulate and confident enough to come to a lecturer's office and explain why they might have missed a prac but are still quite nervous about standing in class and giving an answer to a biological question"*. In this regard, Cummins (1980) advises that conversational English should not be used as a guide for predicting success in the classroom because the kinds of language skills needed to learn academic subject matter and to carry out the type of assignments demanded of students are much more complex than those used in everyday conversation.

Peckett (1987: 143) explains that in mathematics, for example, where students become accustomed to accepting rules without reasons and have never been encouraged to ask questions or be curious, a 'funnel effect' is created which is depicted in Figure 7 below. This diagrammatic representation of the funnel effect is pertinent here because it illustrates how students enter a learning environment with limited understanding of concepts and are then forced to adjust to teaching and learning within a discipline that is reliant on deeper processing skills, which can be rather challenging.

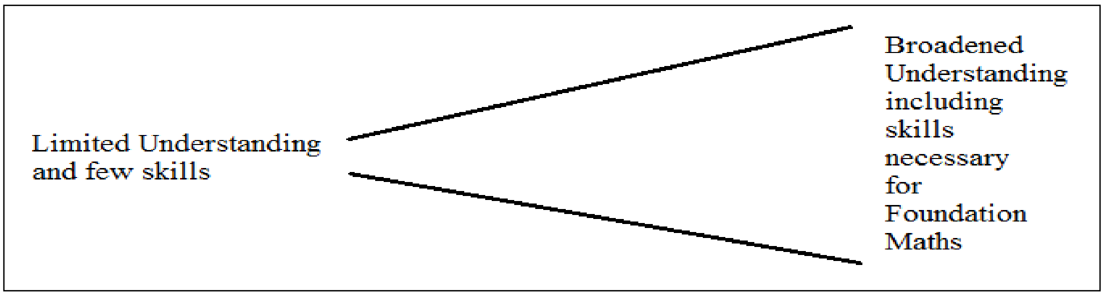


Figure 7: The Funnel Effect (Adapted from Peckett, 1987: 143)

6.5 Academic Literacy Specialists' (ALSs') views on discipline-specific literacies in science

The semi-structured interview was used to explore the discipline-specific literacies that the ALSs believe students in the FP need for science discourse and discourse participation in science. The views of the ALSs are significant in this study, considering they teach the academic literacy module, SCOM, an examinable component of the FP.

6.5.1 The focus on genres in science

Considering that SCOM is a separate language module offered in FP in science, I considered it necessary to field the views of the ALSs teaching SCOM with regard to the discipline-specific literacies needed *in* and *for* science. The purpose of fielding their views in this study was to explore the way in which SCOM caters for the discipline-specific literacies needed by students in the FP to be able to read, write, do and talk science. In response to critical question 1, two specific literacies the ALSs emphasized as being particularly crucial for FP students were reading and writing. Upon probing the ALSs on the nature of reading and writing that the FP students were expected to do in SCOM, I noted specific reference was made to the issue of science-based topics and genres in science. The following response came from Iqbal: *"We* [the AL teaching team] *are involved in regular teaching of constructive science genres ... tasks are on a science-related topic or theme*". Iqbal's implication of *"regular teaching"* is based on the fact that the genres are repeated each semester, i.e. the scientific essay, the scientific report and the oral presentation based on a science topic. Topics in SCOM are linked to the disciplines of biology, chemistry, mathematics and physics. Readings on the topics are used to teach science genres. Examples of these – which have been extracted from the SCOM course manuals – appear below:

(*SCOM*, 2010; 2011)

According to the ALSs the "*topic or theme"* was chosen by the SCOM staff and not in collaboration with any of the DSs teaching in the FP nor was it linked to the syllabi of any of the FP modules in science. Iqbal clarified his interpretation of "*science genres*" as being:

> "*writing tasks through which students displayed their science knowledge ... essay, paragraph writing, grammar skills but the most important component to this module is the scientific report – all they learn in that part of the module is to develop writing skills and to write about science and present it in a certain way*."

Iqbal's understanding of genre draws attention to the definition of genre as using language for particular purposes within particular contexts. However, the focus should go beyond writing techniques and grammar skills; and the emphasis should be on discipline-specific literacies rather than the teaching of skills. Research in academic literacy (Goodier and Parkinson, 2005; Jacobs, 2005b) has called for the focus on discipline-specific strategies, rather than the teaching of decontextualized skills. Furthermore, students in the FP need to be inducted into science discourse which is more than just writing. The essence of thinking, reading, and behaving like a scientist (Gee, 1994) is a distinct omission in the above description. Although SCOM is a separate language module, it would have perhaps been more meaningful if familiarity with the conventions of the different science genres are undertaken in the context of specific disciplines, which in the case of this study, should at least be linked to the topics/content done in the other FP modules in science. This is not happening in SCOM as communicated by Cindy: *"We choose science topics as an AL team; they're not the same as those done in the foundation science modules"*. Except for one citing of lesson/assessment collaboration between SCOM and foundation biology (which is discussed in Chapter 7), the choice of SCOM topics shows no overlap with the curricula of the other foundation modules of science.

Inter-disciplinary integration especially with SCOM would have had the added advantage of the FP students learning and using the genres in a more meaningful context (within common topics). This would also ease transfer of learning across SCOM and the FP science modules. This would then add meaning to the notion of the AL team being involved in teaching *"constructive science genres"*, as communicated by Iqbal, adding to the engaging role of SCOM. This study has shown that in SCOM students are taught to compose a comprehensive scientific report, *"the type that is usually a requirement in foundation biology"* (Iqbal). Except for the inclusion of formulating a hypothesis and listing the apparatus/materials in the scientific report taught in SCOM, the format of the scientific report parallels with that expected in foundation biology. This is written as:

- Title
- Abstract
- Introduction
- Hypothesis (a requirement in SCOM)
- Apparatus/Materials (a requirement in SCOM)
- Method/s
- Results
- Discussion
- Conclusion
- References

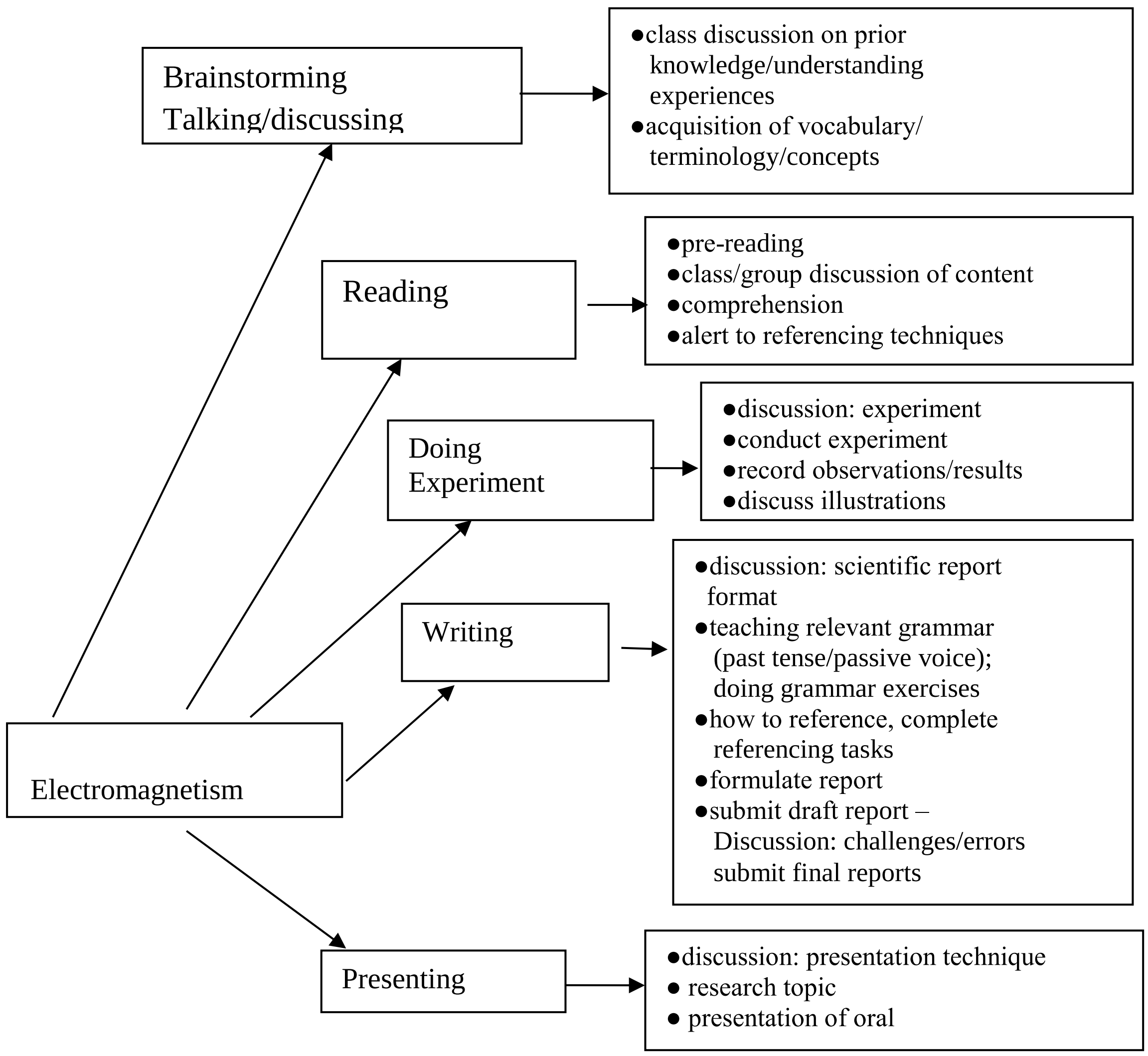
In contrast to those done in SCOM and foundation biology, the scientific report genres in both foundation chemistry and foundation physics are sketchy. Students merely fill in very brief information in a few specific sections in a set template. This is supported by the following responses of the DSs in respect of the nature of the scientific reports in foundation chemistry and physics. *"In chem we give them a report template and they just* *fill in the calculations and explanations"* (Seema). *"In foundation physics, students get a template and they fill in the method – to explain how they did the experiment, how they took their measurements, the only other section they fill in is the conclusion"* (Petrus). (Appendix 18 has these report templates in which the inclusion of blank spaces or ruled lines indicate the amount of writing required). This type of inconsistency with the scientific report indicates that Iqbal's reference to the "*constructive science genres"* done in SCOM is primarily constructive only to the expectations of the report genre in foundation biology. In a topic such as 'Electromagnetism' (linked to the discipline of physics) which was done in SCOM, the report genre satisfied the format requirements of SCOM (a sample of a student's report has been included as Appendix 19) which differed from that usually done in foundation physics (Appendix 18).

Where, on one hand, Iqbal's understanding of engaging the FP students in science was sketchy, Sudeer, on the other hand, offered a more holistic understanding of the nature and pedagogy involved in how SCOM assists students with learning the discipline-specific literacies needed by FP students studying science:

> "*We use a variety of texts that are not our own texts and are not outside of the context of the science disciplines so we try and find physics, biology, chemistry reading texts* [pause] *The idea is to teach them how to read*[74]*, how to deconstruct and understand* [these] *texts. We then use the texts to construct a piece of writing – paragraphs or a basic scientific essay. As the semester goes on we usually do a lab report. They learn to write in 3rd person, report scientifically ... on a prac. We develop communication skills by getting students to do an oral presentation on a science topic, encouraging independent research*".

Sudeer offers a methodical outline that commences with talking about the topic; reading texts in the science discipline; proceeding to doing science (i.e. conducting a practical); writing in a specific genre; and, finally presenting an oral on a science topic. The diagrammatic representation below based on the topic, 'Electromagnetism' (*SCOM,* Semester 2, 2010: 15-31) shows the type of progression Sudeer is referring to:

[74] Through probing in the interview, Sudeer stressed the reliance on 'scaffolding' as a strategy used by ALSs in SCOM to support FP students to read complex science texts and compose writing tasks based on them. In addition, the FP students were alerted to the use of the skills of skimming and scanning the scientific reading texts for information.



Sudeer's view is suggestive of SCOM being an academic socialization model of literacy as it is concerned with students' acculturation into disciplinary and subject-based discourses and genres (Lea and Street, 2006). The progression of the lesson is suggestive of SCOM satisfying the notion of reading, "talking, doing and writing science" as advocated by Lemke (1990: 1; Lea and Street, 2006). The progression of the lessons can help the FP students to become members of the discourse community of science.

The response from Sudeer addresses two important literacies that are specific to the disciplines of science. These are being able to read and understand texts on science content; and to be able to write scientifically. It was noted in Chapter 4 of this study that scientific texts were dense and heavily nominalised. Seeing that nominalisation (Halliday and Martin, 1993) has a tendency to make sentences more complex, especially since several abstract ideas are packed into one single sentence, teaching students 'how' to read science texts is specifically useful for FP students faced with reading and comprehension of science content in their foundation modules in science. The exercise below illustrates the reading hints that SCOM uses to help students to unpack science texts.

Reading and Writing Task 2

Read the following extract from a review.

Note down in keywords and phrases what you are learning as you read along; you may use the blank text boxes on the right hand side of the page to record these words and phrases.

Summarise the key issues you have gained from the article. Try to do this in complete sentences.

Proceed to answer the questions in the exercise at the end of the article.

There is a famous graph showing the fraction of carbon dioxide in the atmosphere as it varies month by month and year by year [see the graph below]. It gives us our firmest and most accurate evidence of effects of human activities on our global environment. The graph is generally known as the Keeling graph because it summarizes the lifework of Charles David Keeling, a professor at the Scripps Institution of Oceanography in La Jolla, California. Keeling measured the carbon dioxide abundance in the atmosphere for forty-seven years, from 1958 until his death in 2005. He designed and built the instruments that made accurate measurements possible. He began making his measurements near the summit of the dormant volcano Mauna Loa on the big island of Hawaii.

(*SCOM,* Semester 1, 2010: 40)

Research has pointed out that university students need to learn from academic reading (Rose and Hart, 2008). Reading academic texts requires decoding, comprehension, and knowledge and understanding of the discipline in which the reading is grounded. To be able to write scientifically, students in the FP need to unpack the language of science in the science texts used in SCOM. With science writing being concise, accurate, objective and impersonal and vastly different from everyday discourse, the FP students require CALP. Research by Angélil-Carter and Paxton (1994) and Kapp (1994) have highlighted the role of CALP in being able to cope with cognitively demanding tasks and texts. Moreover, when students enter FP they are confronted with writing conventions that are vastly different from their prior experiences at school and they are forced to switch writing practices. As expressed by Rabia, an AL academic, *"*[p]*aragraph and essay writing here are different from school where they wrote about themselves, gave their personal opinions* *or narrated stories and experiences ... here it is science-driven and we teach them how to write in science"*(This has already been alluded to earlier in this Chapter on the discussion on EFAL). Teaching and training the students to acquire the discourse conventions appropriate for the discipline of science can help ease the transition of FP students into the new, unfamiliar world of academic writing. In SCOM, one of the major literacies is to help students write science. This is done by providing the FP students with guidelines on essay writing (See Appendices 20A and 20B). Appendix 20A serves as a set of generic guidelines that could easily be applicable to differing disciplines. If students in the FP need to be apprenticed into writing science and the ALSs claim to do so, then the guidelines included in the manual need to be more specific to science. Appendix 20B is more effective as a guideline for FP students as it has been structured from the perspective of science writing, using the technique of leading questions to test if the students are adhering to the requirements of the scientific essay, for example, the inclusion of explanation of core concepts/terminology; and the provision of scientific evidence. In addition, the guidelines are directly linked to the prescribed reading texts, with the essay question as the prime object of focus.

Successful genre writing involves the use of appropriate discipline-specific literacies in specific contexts. Theorists (Martin, 1997; Hyland, 2002b; Martin and Rose, 2003) have explained that doing so involves the register variable of mode, field and tenor. If the SCOM class is where science genres are taught purposefully or constructively, then the following elements of SFL (Halliday, 1978) are satisfied: "what is going on (field); who is involved (tenor), and what the role of language is (mode)" (Hyland, 2002b: 119). Other ALSs have confirmed that *"the laboratory report is based on a science topic and uses specific language"* (Rabia and Cindy) or *"peculiar register to explain a scientific phenomenon*" (Sudeer). The *"specific language" or "register"* referred to is significant because the content used relies on both lexical and grammatical features that are used in a particular genre, to convey science epistemology or discourse, for example, "*to explain a scientific phenomenon"* (Sudeer). In SFL, the notion of linguistic register (Halliday, 1978) illuminates the relationship between language and context. The comments thus far are framed around the SFL theory which explains that language and context are integrated; highlighting the way in which "language actively construes contexts" (Colombi and Schleppegrell, 2002: 9). In SCOM, this is practised by familiarising the FP students with the appropriate register needed for science. One such example is provided here:

(a) Formulate a hypothesis that you can test in your experiment
A **hypothesis** is a tentative statement that proposes a possible explanation to some phenomenon or event. A useful hypothesis is a testable statement which may include a prediction. A hypothesis should not be confused with a theory. Theories are general explanations based on a large amount of data. Below are examples to write a hypothesis:
1. Salt in soil may affect plant growth.
2. Plant growth may be affected by the colour of the light.
3. An object that is dropped falls to the ground.

(b) Design an experiment to test the hypothesis
Designing of experiments must reflect the best procedure to test the hypothesis. Some most important aspects of an experimental design include:
Control: Comparison of treatment with the control (constant/untreated) helps us to understand the effect of the treatment in the experiment. Often the comparison against a standard or control acts as baseline.
Randomisation: Random selection of measurement must be taken which is not biased. Randomisation does *not* mean haphazard and great care must be taken that appropriate random methods are used.
Replication: Measurements are usually subject to variation, both between repeated measurements and between replicated items or processes. Multiple measurements of replicated items are necessary so the variation can be estimated and minimised.

(*SCOM,* Semester 1, 2011: 39)

6.5.2 Apprenticing students into science discourse

In attempting to understand the discipline-specific literacies needed *in* and *for* science in the FP, this study seeks also to explore the ways in which students are apprenticed into science discourse. According to Sudeer, in the SCOM class, students are told that *"we* [ALSs] *are going to teach you* [the students] *how to read, write and communicate for science and in* science" (See Appendix 21 for observation of Sudeer's lesson). One of the ways that this study has attempted to triangulate the responses from the interviews with the ALSs is to locate supporting evidence of this in the course manuals. A recurring feature in the SCOM course manuals is that the reading texts are accompanied by relevant, leading questions and exercises that help consolidate reading comprehension in science. The following textbox shows an example of how SCOM 'teaches' the students to read science:

1. Read the short extract on *'The Life Cycle of Plasmodium'*.
Underline the key words/phrases in each paragraph. Use the information in the article to fill in the missing words and complete the life cycle diagram on the next page.

The exercise cited below on how to write an abstract for a scientific report has been extracted from a SCOM course manual:

Writing your abstract Have a look at the abstract for an article by Govere, Durheim and Kunene: <u>Abstract</u> For the past five years, South Africa has had an increase in malaria cases.However, this has not happened in Swaziland, which is between the two malarious South African provinces of KwaZulu-Natal and Mpumalanga. Swaziland and these provinces share a border with Mozambique, where malaria is endemic. Using clinic attendance data, this research aimed to consider whether the change from DDT to synthetic pyrethroids for spraying of houses in South Africa may have contributed to this increase. The absence of an increase in Swaziland, where DDT continues to be used, indicates a link between change in the use of insecticide and increase in malaria cases. The findings indicate the importance of reconsidering the ban on DDT.

Which of the following appear in the abstract by Govere *et al.* (2002) above? Write the relevant parts in the space provided.

Exercise:

Motivation for why the research is important	
Purpose/aim of the research	
Brief statement of method	
Brief statement of the conclusions that can be drawn from the research	
Implications of the research	

(*SCOM,* Semester 1, 2010: 67)

The FP students are also given explicit guidelines on how to write/communicate scientific information in a comprehensive scientific report, as shown in Appendix 16. Sudeer refers to *"the integrated approach of SCOM",* explaining that *"we're giving them the academic language they need for academia in science".* The response by Sudeer highlights two specific ideas about what ALSs perceive to be the role of SCOM in helping students to learn science discipline-specific literacies. The first is that students are taught the discourses of science (the issue of pedagogical practices is explored in critical research question 3 in Chapter 7). This is significant in light of the responses in the previous part of this Chapter that drew attention to students' challenges of writing in the sciences. Secondly, this response is particularly meaningful in this study since it satisfies the framework of NLS as advocated by Street (1984) and Gee (1990).

NLS sees literacy as a social practice and SCOM appears to locate itself within this theory. By assisting students with discipline-specific literacies required in science, SCOM is conforming to the principle of literacy as a social practice. It also serves as a mechanism to prepare students for their subsequent studies in science which can help in their possible future careers in science as reflected in the comment *"we're giving them the academic language they need for academia in science"* (Sudeer). FP students' engagement with scientific readings and writing in SCOM helps create a discursive space for the students to acquire practice in science meaning and discourse enabling them to create for themselves a sense of identity and belonging in science: as science students in the science community. This was reflected in the following response:

> *Sudeer: "We're sort of trying to immerse students into the university culture and create an academic identity. Part of that identity uses language and students need to be able to communicate, they need to be able to write, read and speak and perform in this new culture, in science".*
>
> *VP*[75]*: So, how do you create this identity?*
>
> *Sudeer: "Well, by the science* topics *... the reading articles are on chem, bio and physics ...* [er] *... even maths – Like once we did a topic on Archimedes Principles. Our articles are from science journals and sometimes textbooks or the internet. In orals, students do independent research on a science topic like bilharzia or landfills or* [pause] *how a cold drink bubbles. In one semester students had to go through readings that we gave them on famous scientists like Einstein, Newton and Pythagoras ...* [er] *... the mathematician. And later we included local scientists from Africa – from South Africa – bringing science home so to speak. We even did experiments in the lab and then students write a lab report*"

The table on the following page shows a list of topics and the practical (laboratory/experimental/field research) activity linked to the disciplines of science that have been done in SCOM; as well as a list of oral topics and the nature of research associated with the topics. The *"identity in science"* (Sudeer) fits in with Gee's (1990) notion of the "identity kit" that becomes possible once students acquire the "Discourses" in science that "show them how to act, talk, and write so as to take on a particular social role" (Gee, 1990: 142). The "Discourse" in science includes too thinking and behaving like a scientist (Gee, 1994). One of the ways in which this identity in science takes place is by exposing students to the conventions of different genres within the context of specific disciplines in science; and exposure to academic science texts from authentic science

[75] I personally conducted all interviews in my capacity as a researcher and have referred to myself as VP, denoting the initials of my first name and surname.

sources. The table below based on the curriculum choices in SCOM draws attention to the notion of *"identity in science"* articulated by Sudeer.

Topic	Marine Conservation	Methods of Solid Waste Disposal	Mixing hot and cold water	*The physics and chemistry of bubbles. *Pygthagoras *How were pyramids built? *Biofuels *Acid rain
Discipline	Biology	Chemistry	Physics	Multi-discipline/ Inter-discipline
Reading Source (science)	text books; journals	textbooks; journals	textbooks	Electronic and print media
Genre	scientific essay	scientific essay	scientific report on experiment	oral presentation

Examples of curriculum choices in SCOM

As Gee (1990) states, becoming accepted as a member of a discourse community involves becoming part of the culture and taking on the values of the discourse community. In addition to this, the interaction between teachers or facilitators and students becomes a social activity. This has been communicated by Sudeer when he said, *"we* [the ALSs who function as teachers or facilitators] *teach ... and they* [the students] *learn"*. If SCOM is an attempt at helping students to become part of the discourse community in science then the crucial element are the DSs who should be part of this interaction as well.

From the verbal data, this study has shown that the ALSs seem to have a reasonable understanding of the discipline-specific literacies needed by the FP students, but were perturbed by their assumptions of the way in which SCOM is perceived by the DSs teaching in the FP. I felt it relevant to include this data in this study as it could contribute to the understanding of the discipline-specific literacies that the DSs regard as relevant for the FP in science. The verbal data conveyed by the ALSs will later be corroborated with the understanding that the DSs have of the discipline-specific literacies required in the modules that they teach.

6. 5.3 How is SCOM perceived by the DSs?

The ALSs have expressed concern over the way in which their role within the FP is perceived especially by DSs teaching the science modules in the FP. Upon being asked to clarify his response: "*We* [ALSs] *are not here just correcting the sentence structure and other stuff*", Iqbal explained that it was aimed at dispelling the notion that ALSs are *"English language teachers whose primary job is to correct students' spelling and punctuation errors and to teach them basic grammar"*. Iqbal's response indicates firstly, the conflation of AL and proficiency in English; and, secondly, that AL is being perceived as a study skills model. The study skills model, according to Lea and Street (2006), is concerned with the use of written language at the surface level and concentrates upon teaching students formal features of language such as sentence structure, grammar and punctuation.

To view SCOM within the worldview of study skills is to hold the belief that students are taught an autonomous list of generic skills or decontextualised skills that are transferable from the so-called *"language course that FP students do*" (Jessie). In response to the question on whether SCOM is skills-based, Cindy was vociferous in arguing that "*there is this belief* [by DSs] *that we* [SCOM tutors] *can fix students' work by just giving them practice in basic skills which they just apply"*. Cindy's response rejects the perception of SCOM as an add-on remedial course where students' work is *'fixed'* which frames the students in a deficit mode. Cindy's point draws some attention to how SCOM aims to integrate AL and disciplinary content in stating "*... but we don't do that – we're not a language or a grammar repair workshop, we link language and* [science] *content, and of course what is relevant to science courses even if it is a simple lab experiment on Electromagnetism"*. This idea of the SCOM classroom being a place where grammar is fixed is contrary to Sudeer's earlier reference to SCOM helping students to acquire an identity in science. The ALSs interviewed critiqued the belief by DSs that SCOM is often assumed to be a course that helps students to gain proficiency in English grammar and sentence construction. Cindy's response below shows reference to 'language' in SCOM which is actually a loose reference to literacies as noted by the following probe:

> *VP: What do you mean by language and content?*
> *Cindy: "Well, the language is like the tools that are needed for science content, like how to read science, how to make sense of the readings ... then how to write in a way acceptable to science, for example a lab report. And then maybe how to deliver a presentation in front of the class on a topic that we read through and discussed in class".*

Rabia, however, was more specific about the reference to 'literacies'. She sees SCOM as serving ideological needs by providing FP students with *"a broad exposure to different* *literacies in the various sciences – maths, chem., physics, bio. – in each semester*" which emphasizes the contextual nature of literacy practices; and "*which students take away with them, in the science lectures and later when they work ... perhaps as scientists, or chemists ... or in labs"* (Rabia), emphasizing the point that literacy is socially constructed and, by implication, a social practice. This study has thus far shown how SCOM assists the FP students to acquire the literacies needed for science. Rabia's response implies that the literacies in the science disciplines that the students acquire in SCOM should be transferable to their foundation modules in science. According to the response from Rabia, these literacies in science can be used in the workforce. To do so, they would need exposure to the elaborated code which, according to Bernstein (1971), is the type of language needed to communicate with outsiders from the wider society and which, in the view of Kelder (1996), gives a student cultural or symbolic capital that can translate into power and goods.

This point was alluded to by Rabia who made reference to students' roles in the world, i.e. first as students*"in the science lecture"* and afterwards as science graduates and as productive citizens in the country *"when they work ... perhaps as scientists or chemists ... or in labs"*. The students are then able to occupy the "social role that others will recognize" (Gee, 1990: 142). In essence, these descriptions show how SCOM contributes to literacy as a social practice and how it operates within the view of literacy ideologically as postulated by Street (1984). The literacies that are used in the context of science in SCOM can be used in meaningful and functional ways, for both "enculturation and socialization" (Gee, 1990: 67), as students of science and later, in the work place. This study has earlier highlighted (in Chapter 4) the call by NPHE (2001) which states that besides technical skills, "employers want graduates who can demonstrate a strong array of analytical skills and a solid grounding in writing, communication and presentation skills" (UNESCO/World Bank Report, 2000:85, cited in NPHE, 2001: 27).

Rabia's reference to what students *"take away"* is a reference to the discipline-specific literacies [for science] that can be transferred to new and different contexts. However, this transfer cannot occur naturally or unproblematically. On the contrary, the transfer of literacies from one context to another can only occur if the opportunities for their application and practice exist. This could have been facilitated if there was some measure of topic-overlap in SCOM and the other foundation modules in science. Students need to be reminded to actively transfer literacies, conventions and discourses across learning domains (Bassok and Holyoak, 1993; Perkins and Salomon, 1998; Boughey, 2000) or else they just would not do it; and continue to learn in a compartmentalized way. One particular area where transfer can occur unproblematically is by applying the ways in which the scientific report genre is taught in SCOM and transferring the same to foundation biology, especially since this study has already shown that it is across these two modules in the FP that the scientific report genre is most compatible.

6.6 Disciplinary Specialists' (DSs) views on discipline-specific literacies in science

The DSs in the FP teach one of the four foundation modules in science offered in the FP: biology, chemistry, mathematics and physics. I intended in this study to explore the DSs' responses to the discipline-specific literacies that they believe are required by the students in the FP to learn science. This study involved interviewing the DSs in the FP to explore the discipline-specific literacies that they consider as being necessary in each of the respective foundation modules in science that they teach. At the time of this study, all the DSs were only engaged in teaching modules offered in the FP in science.

From the responses of the DSs, I had gathered that as much as they were aware that there were *"those literacies out there"* (Shane), some of them held the opinion that the issue of conveying discipline-specific literacies for science in the FP was primarily the task of the ALSs. They believed that their job was to teach students science content. The reluctance to focus on these discipline-specific literacies and the tendency to exonerate themselves from doing so was apparent from the view held by DSs such as Shane who stated: *"I think it* [the literacies] *is obviously, primarily academic literacy's job ... it is not our* [the DSs] *job".* This type of assumption conveys the belief that disciplinary content is separated from discipline-specific literacies (an issue that is expounded later in this Chapter). Similarly, Dennis foregrounded the fact that his *"job is to teach foundation chem. When I see that students made a lot of mistakes in explaining in chemistry, then I ask myself what are these academic literacy people doing when they supposed to be attending to these problems?"* Dennis's response is exactly the type of assumption of SCOM as being a *"repair shop"* that was earlier critiqued by Cindy. The attitude conveyed by Dennis shows the tendency to shift both blame and responsibility to AL when in fact teaching and learning in the FP modules should not occur in a vacuum, rather a collaborative partnership between the AL and the DS would have been more helpful in helping students to learn and use discipline-specific literacies in science.

The responses from the DSs have shown a disinclination of some of them to pay attention to the discipline-specific literacies in the FP modules in science. This conclusion was based on two factors that emerged from the data. The first factor was attributed to the reservations of the DSs about stepping into domains or disciplines of specialization, such as academic literacy, the practices of which some of them were either knowledgeable; not entirely familiar; or completely uninformed). According to the data, 31% of the DSs were knowledgeable; 25% were not entirely familiar; and 44% were uninformed of AL practices and/or what goes on in the SCOM classroom. In support of this, the following are the some sample responses that were fielded from the DSs: "*Not a clue*." (Siva); "*I think not enough."(Susan);"I thought you were dealing with grammar."* (Dennis); *What I know is what the students have told me and the odd thing that I have heard like the teaching of summaries, science writing and so forth."* (Jessie); *"Ja, it is basic literacy."* (Kenneth); and *"You've got to teach them ordinary English, then you've got to teach them scientific English and to get them to apply it. I know they have to do reports, write essays and get about three chances to correct it and correct it and correct it and eventually they are given a mark"*(Shane).

The responses vary from one DS who has no idea about what SCOM entails; to those who assume SCOM is about grammar or literacy; and to those who do seem to have an understanding in light of the reference to reports; essays; and drafting/process writing (even though Shanes' assumption is not wholly accurate because in SCOM students submit one draft and one final attempt, both of which count for assessment). Jessie's response on understanding what happens in SCOM via secondary source, i.e. the students, shows the absence of direct inter-disciplinary engagement with the SCOM staff. This is of concern in light of the role of SCOM in the FP in conveying discipline-specific literacies needed in/for science. Shane's perception that students in SCOM are first taught conversational English and then scientific English also shows little knowledge of the focus of SCOM.

The second factor that emerged from the data was that some of the DSs distanced themselves from paying attention to the discipline-specific literacies in science as they claimed to have had hardly any academic or professional training in AL. This study has already made reference (earlier in this Chapter) to the qualifications of the ALs. According to the data, except for teaching experience in AL, none the ALSs in this study had any academic/professional qualifications in academic literacy, linguistics or applied linguistics. In this study, only one DS (with academic qualifications in science) had some experience of AL, having taught the module for a semester in 2005. All the DSs have undergraduate and postgraduate qualifications in science. Over and above this, fifty percent of the DSs have a tertiary qualification in Education (either an undergraduate degree or diploma; or a postgraduate degree or certificate).

The following conclusion drawn from the data ties up with the two afore-mentioned factors: "*... and it is not our qualification to be able to teach these literacies which you* [the interviewer] *talk about"* (Shane); and that by Raj: *"I don't know about those language skills that they teach in the communication class ... or the kind of literacies needed in science, I am not an expert"* (Raj). The reference to literacies as *"**those*** [my emphasis] *language skills that* **they** [my emphasis] teach*"* reflects an attitude of being dismissive of the need to focus on such literacies specific to science or to make an effort to become familiar with the literacies that could aid with the teaching of content knowledge specific to the FP modules in science. It is responses such as these on how the AL is perceived by the DSs that Iqbal referred to earlier in this dissertation, especially the view that the AL classroom is where **'language skills'** [my emphasis] are taught.

6.6.1 Whose Job is Academic Literacy (AL)?

According to the responses, there was fervent support for discipline specialization. Lara, for example, conveyed the belief that the primary task of the disciplinary specialists who teach in the FP was to facilitate acquisition of science content, as reflected in the response: *"I mean, language people are specialists in language and we are specialists in biology".* Similarly, the following response from Vusi (and that of Raj in the preceding paragraph) indicates some measure of absolution of responsibility for discipline-specific literacies required in science as a consequence of not being the so-called 'experts' in the field (of AL): *"If the emphasis is just on the structure of the English language, then the experts must do that. But mathematicians are not language experts ... there is somebody else there to address the broader language issues"* (Vusi). In terms of expanding on what exactly is conveyed by the perception of the *"structure of the English language",* the response by

Vusi was the typical loose reference to *"the use of grammar and sentence construction"*. Such a response ties up with the DSs' perception of AL as being decontextualised and skills-based and that *"SCOM* [is dealing] *with grammar"* (as intimated by Dennis). Similar conclusions have been arrived at in studies by other researchers (Ratekin *et al*. 1985; Stewart and O'Brien, 1989; Muth, 1993).

Thus far, the interpretation of the responses and attitudes of the DSs show the tendency to divorce discipline-specific literacies from science content as was aptly summed by Shane when he said, *"there is not enough time to teach both content and language skills at the same time"*. Literacy should not be seen in isolation; it is actually a social practice and students need to be socialized into the discourse of a discipline so they can learn ways of speaking, reading and writing, within particular contexts. Ideally, the discipline-specific literacies should be taught together with content so that students are able to understand the relationship between the two. Furthermore, registers vary and students need to become conscious of the specific register required for specific disciplines. Boughey (2000) argues the need to make the "rules and conventions of academic disciplines as overt as possible" (289) and who best to do so in FP in science other than the DSs. In terms of SFL, the science class represents a social action where field, tenor and mode interact in terms of participants (the DS and the students); activity (science) and the use of language as a means of conveying and acquiring discourse. In fact, according to Derewianka (2007), "context and language are co-constructed: the context helps to shape [the] use of language and the language choices [made] help to shape the context" (849). The theory of SFL is particularly relevant in this study involving the discipline-specific literacies in science as it highlights the relationship between language, text and context. In SFL (Halliday, 1978), language is essential as it is a resource for meaning. Meaning is negotiated through texts. Lexical and grammatical features are used to convey discourses. SFL sees language as a social meaning system where text is situated in context. Hence, "every interaction reveals some information about the situational context itself and the cultural context in which that language is used" (Polias, 2004: 3). Thus, literacies cannot be separated from content.

6.6.2 Focus on discipline-specific literacies for content

The DSs referred to the discipline-specific literacies in the foundation modules in science as 'language issues' as portrayed in the response from Annah: *"Yes, I actually do* *consciously think of language issues when I'm doing physics*". Upon being asked to clarify the interpretation of *"language issues",* Annah explained that *"it was reading and writing and* ... [pause] *maybe using isiZulu"*. In light of this study, the reference to reading and writing conveys the traditional view of 'literacy', i.e. the ability to read and write, neglecting the new and multi-faceted nature of literacy (Langer, 1987; Draper, 2002; Street, 2003; Lee, 2004). Simply interpreting specific disciplinary literacies as 'language' was also conveyed by Vusi when he stated: "*The only language they* [the DSs who teach foundation mathematics] *would emphasize is the language that affects their course*". Deconstructing Vusi's opinion reflects the ideological model of literacy which envisions it as a social practice. NLS centres on the notion that literacies are always situated within specific social practices within specific Discourses (Gee, 1996, 2001). Literacy is viewed as socially constructed practice and individuals are seen as active agents who co-construct meaning while they develop perceptions, values, goals and purposes about ways in which literacy is used (Gee, 1990). NLS posits that even the way facilitators and students interact is a social practice in itself, which, in turn, affects the nature of the literacies being learnt. So, in essence, by claiming to provide FP students with the specific literacies to engage in mathematics discourse, and if this is happening in the foundation mathematics venue, then Vusi is satisfying a crucial orientation of NLS.

Lara's response:*"We need to use those special language skills like listening, close reading and comprehension for our students to grasp biology so they can write"* hints at the importance of discipline-specific literacies that students in the FP need to understand foundation biology. As with most of the DSs, Lara, too, likens skills to literacies. Despite this, an important factor that Lara outlines about literacy is that it involves purposeful reading (in foundation biology) which enables writing in a specific context (of foundation biology). One such example of this in foundation biology is that the students are expected to read the marine theme reading texts on specific marine organisms (See Appendix 22 for a sample reading). The knowledge that they acquire from the readings on marine organisms[76] was necessary to answer questions in a laboratory practical. They would have had to consolidate this knowledge with that gained in the field trip to the rocky shores, and they would have had to write and submit a scientific report as an assessment task.

[76]The marine theme readings were on the following marine organisms: sea anemones, chiton, sea urchin, mussel, goose barnacle, hermit crab, octopus, panaeid prawn, starfish, and flatworm (*Foundation Biology*: Mode of Life Practical Handout).

Lara also drew attention to some of the multiple activities of literacy which include listening, reading and writing. One of the ways in which purposeful listening was incorporated in foundation biology was the inclusion of a half hour long documentary video on marine ecosystems as part of the marine theme topic. Students' listening comprehension skills were tested by means of a discussion of the documentary video. Students studying at HEIs need to be able to listen, read, write and talk in ways that conform to the discourse of their disciplines. From the interview sessions with the RPs, I have discerned that it was essential for the DSs to take control of the need to provide students with the literacies required for access to disciplinary discourse. Vusi explains that the need to provide students with the literacies in mathematics is to "ensure that students don't get deprived of knowledge because of the limitations of language. That gives them access to it" (Vusi). In foundation mathematics, included in the course manual are problem solving strategies (accessible in Appendix 23). Included, too, is a list and explanation of specific terminology and concepts (register) frequently used in mathematics as shown below:

assume	:	You may take what comes after this word to be true, e.g. assume $x = 5$ means you may use 5 for the value of x.
solve	:	What is the value of the unknown (the letter, e.g. x)? e.g Solve the equation $2x - 5 = 1$ means you must find the value of x which fits the equation.
simplify	:	Put into a simpler form using any methods, e.g. factorizing, canceling, collecting terms, etc. The value of the expression remains the same throughout the simplification.
evaluate	:	Find the value of. Work out.
calculate	:	Find. Work out.
determine	:	Find. Work out. Calculate.
deduce	:	Use logical steps to arrive at what is asked.
by inspection	:	Just look at it and see if you can tell what the answer is. You are not expected to have a method to work through.
respectively	:	x and y are 5 and 3 respectively, means $x = 5$ and $y = 3$.
consecutive	:	Following one after the other.

(*Foundation Mathematics,* Semester 1, 2011; ii)

These literacies can help in apprenticing students into the discourse of science. This is relevant since, according to Gee (1990), discourses govern how we talk, think, and interact as members of a culture. For students to grasp mathematical knowledge, they require secondary discourses. Since disciplinary knowledge is disseminated using the "elaborated code" (Bernstein, 1972) which is "explicit and specific" (476); "abstract, logical and precise" (Schallert *et al*. 1977: 18), some form of assistance needs to be provided so students can gain access to knowledge.

6.6.2.1 Discipline-specific literacies for foundation biology

Judging from the response to critical research question 1, the DSs who teach foundation biology in the FP have acknowledged reading and writing in the sciences as being the key literacies in their discipline. According to team members teaching foundation biology, the module is "*heavily language-dependent"* (Lara), a "*more descriptive science discipline*" (Josh), therefore [discipline-specific] "*literacies are both "essential and crucial"* (Teresa). Below are references to the various discipline-specific literacies that had been included in the course manuals in foundation biology:

1. Reading and reading comprehension

> IMPORTANT NOTE:
> YOU NEED TO PREPARE FOR THE NEXT PRACTICAL BY SPENDING ABOUT AN HOUR READING AND COMPLETING TASK 1 BEFORE YOU ARRIVE.

(Practicals, Semester 2, 2011: 5)

> Read **The Sea** on page 8 and the following marine theme readings in your files and answer the questions that follow:
> - Rocky shores 1A
> - Tides 1B

(Readings, Semester 2, 2011: 2)

2. Summarizing, with the aid of concept mapping

> Draw a simple diagram to summarise the ideas on the origins of the eukaryotes by endosymbiosis and enfolding of the cell membrane.

(Notes, Semester 2, 2011: 20)

3. Viewing an audio-visual science documentary, listening, and answering questions

> **UNICELLULAR AND MULTICELLULAR ORGANISMS**
> **1. LISTENING FOR UNDERSTANDING EXERCISE**
> **Read through the questions.**
> **Watch the video, listen carefully, and then answer the following:**

(Practicals, Semester 1, 2011: 87)

4. Integrating theory with practical work (observing)

> ***Remember you have read all about these organisms already and have made notes about them. In this practical now you are relating this information to observable characteristics of specimens of these organisms.***

(Practicals, Semester 1, 2011: 109)

> You are now going to classify the marine organisms that are on the bench in front of you.
> This task involves completing the classification diagram you have been given by using the information that is written in the two lists below.

(Practicals, Semester 1, 2011: 11)

5. Designing and conducting an experiment

> Now that you have worked through all of the stages in the scientific method, you are going to apply your knowledge by designing and performing a complete experiment in the laboratory.

(Semester 2, 2011: 39)

6. Talking: discussing/explaining orally

> **Task 2**
> Discuss with a partner what it means to classify something. Write a precise definition in your practical book. (1)

(Practicals, Semester 2, 2011: 2)

> **Task 1**
> Go through the entire process (steps 1 to 10), with each group member taking a turn as the "explainer". Answer the questions about **each** stage as you go along. Explain your answers in your own words and your own way: do not recite them by rote memory.

(Practicals, Semester 1, 2011:89)

> Test and practise your knowledge of parts of the microscope with the person sitting next to you.

(Practicals, Semester 1, 2011: 48)

7. Using visual-graphical literacy

> Use the rules above to draw up a table of the following raw data. Be sure to include a column for the means.

(Practicals, Semester 2, 2011: 17)

8. Writing the scientific report

> **7. Write the report**
> Once the experiment has been conducted and the results collected, a report has to be written. Over the next few contact sessions you will learn how to write a scientific report.

(Practicals, Semester 2, 2011: 42)

The importance of these literacies in the foundation biology module was emphasized by Teresa in her statement that *"success in biology is contingent on their* [FP students] *ability to read and write".* The foundation biology course manual contains a number of reading texts that require close reading and reading comprehension, accompanied by writing exercises, as shown in Appendix 24. In the interviews, all the DSs teaching foundation biology emphasized the importance of pre-reading around a topic as preparation for lectures, laboratory practicals and tutorials (evident in the list of literacies above). The responses from the DSs in the semi-structured interviews showed specific reference to being able to read and write. In the semi-structured interviews, there was scant mention of the literacies needed for specific science genres; for speaking; and for visual-graphical representations such as graphs, diagrams and illustrations although these literacies have been incorporated quite effectively in the foundation biology manual as a way of conveying conceptual knowledge or as a means of facilitating learning. Below are two examples of such visual-graphical representations:

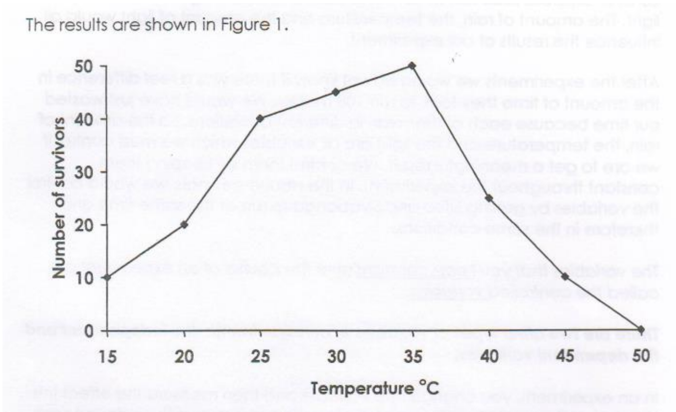


Figure 1: The number of *Amoeba* surviving in water at different temperatures

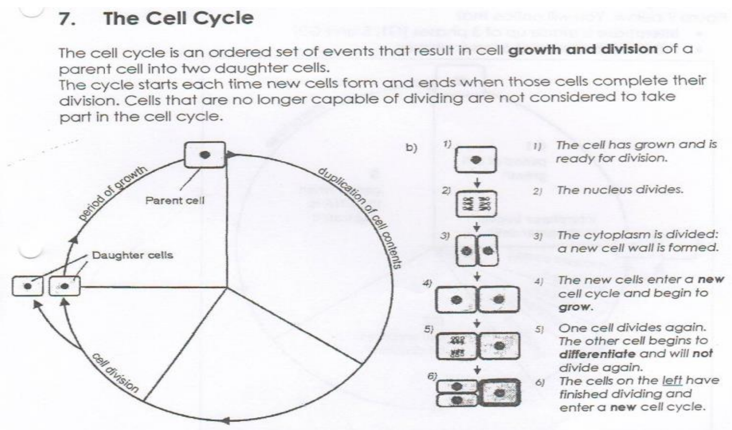


Figure 8a. The cell cycle
Figure 8b. The cell cycle is made up of growth and division phases

(*Foundation Biology*, 2011: Semester 1: 6,73)

6.6.2.2 Discipline-specific literacies for foundation chemistry

According to Seema, the *"language required for* [foundation] *chemistry is not* [as] *intense as* [that required for foundation] *biology".* The reading texts used in foundation chemistry are not as lengthy and comprehensive as those in foundation biology. Seema describes the foundation chemistry module as "*not hav*[ing] *much reading. There is a little introduction, explanation and then diagrams"* (Seema). Expanding on this description is that conveyed by Nancy when she stated: *"We do not have extensive paragraphs in our* [foundation chemistry] *notes. It's mainly tables, headings, pictures, calculations and the odd paragraph*". In this regard, the extract below from the course manual shows an example of the reading:

Atoms, Isotopes and Ions

Law of Constant Composition

A pure compound is always made up of the same elements in the same proportion

131.88g FeS	
84.40g Fe	47.48g S
0.64 g Fe	0.36g S
64% Fe	36 % S
7	4

15.0g FeS	
9.60g Fe	5.40g S
0.64g Fe	0.34 g S
64% Fe	36 % S
7	4

Dalton's Atomic Theory

- Elements are composed of atoms
- Atoms are small, individual, indivisible (cannot be broken down into anything smaller) particles
- Atoms cannot be created or destroyed
  They are indestructible
  Atoms are the smallest part of an element what can take part in a chemical reaction
- All the atoms in an element are identical*
  They have the same mass*
  They have the same chemical and physical properties*
- Atoms of different elements are different
- Chemical reactions take place by atoms joining together to form molecules/formula units. The molecules/formula units of a pure substance are identical. The atoms combine with each other in whole number ratios

Scientists have carried out many more experiments since Dalton's time and know more about the atom than they did in 1808.

(*Foundation Chemistry*, Semester 2, 2011: 56)

Judging from their response to literacies in foundation chemistry, both Seema and Nancy need to realize that the FP students are expected to engage with the course content. They would need to read their course notes (despite length and/or intensity) and their laboratory practical manuals and interpret the symbolic presentations such as tables, equations, formulae, graphs and calculations. Doing all of these requires specific literacies needed in the context of the discipline of foundation chemistry. Writing in foundation chemistry, as revealed in this study, involves very short explanatory and descriptive type of answers that the students need to fill in the course manuals which makes it akin to a workbook as shown in the example below:

Table 4.3 Comparison of Chemical and Physical Changes

	Physical changes	Chemical reactions
Properties		
Mass		
Heat energy		
Composition		
Reversibility		

(*Foundation Chemistry*: Semester 1, 2011: 55)

Jessie explained that the *"*[foundation chemistry] *tests do not have much writing - MCQs, may be just one word answers. We do give them some questions about the pracs - that is the section that has the most writing".* The foundation chemistry test 1 (2011) perused does show a greater emphasis on questions requiring calculations (55%); with the multiple-choice questions (MCQ) carrying a weighting of 16.6% and the questions Jessie referred to which could have been answered in phrases or short sentences carrying 28% of the mark allocation (Appendix 25 contains this test and marking memorandum[77]). This study in no way intends to critique the use of multiple choice questions used in foundation chemistry. MCQs, however, can involve close, careful reading. According to Case and Swanson (2001), while MCQs are expressly designed to assess knowledge, well-constructed MCQs can also assess taxonomically higher-order cognitive processing such as interpretation, synthesis and application of knowledge rather than testing recall of isolated facts. Although MCQs are useful to test a greater range of the syllabus and may be adopted for 'practical' reasons such as efficient marking time, writing in a discipline gives students a chance to explain scientific knowledge and phenomena.

[77] For the purposes of this study, only the answers that require writing/explanations in the test have been included in the marking memorandum in the Appendix 25.

In foundation chemistry there is not enough attention being paid to writing in the course. This can impede students' acculturation into the field of chemistry when they have successfully completed the one year of study at foundation level especially when they have to be able to formulate comprehensive laboratory reports (Appendix 18 offers the type of scientific reports done in foundation chemistry). With the language of science being particularly dense and conceptual and differing immensely from everyday language, it is thus imperative for students to gain sufficient practice in its disciplinary discourse to gain some measure of mastery of it. Research (Sirhan, 2007; Steenberg, 2006) has shown that while chemistry is highly conceptual, much can be acquired by rote learning. Other research has shown that difficulties in the learning of chemistry can be precipitated by a lack of chemistry language skills (Ver Beek and Louters, 1991; Danili and Reid, 2004).

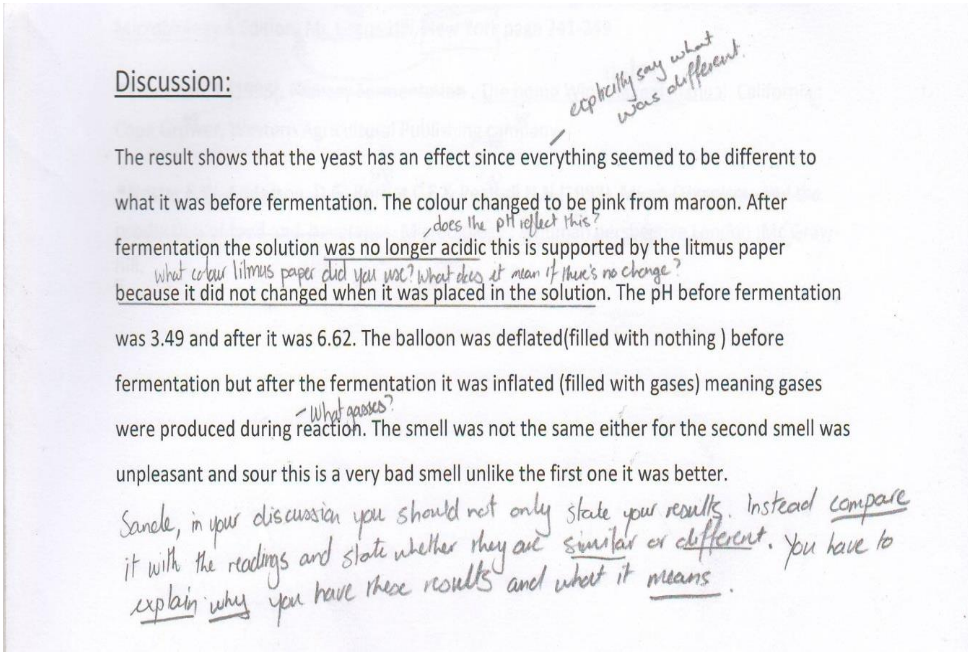
This study has shown that some of the DSs were aware of the limitations of not focusing on specific literacies that could be useful in the disciplines that they teach. One of the DSs teaching the foundation chemistry course suggested that in preparation for "*working on their own and to be better equipped when they get to mainstream level ... we* [chemistry DSs] *should perhaps after each section, get the students to write a summary"* (Jessie). Although composing a summary is a writing strategy, it can be a useful tool in light of the FP students' disadvantaged educational backgrounds where, according to researchers such as Kotecha *et al.* (1988) and Rollnick and Rutherford (1990), the technique of rote learning was the predominant mode of learning. Incorporating summary tasks in the foundation chemistry can help to engage students in content, which can in turn help in their learning of the content. It can contribute to the way in which students learn to organize and synthesize their conceptual knowledge and "can be a tool for self-monitoring of comprehension, thus creating opportunities for students to evaluate their own understandings and confusions about a topic" (Bangert-Drowns *et al.* 2004: 32). It can also assess students' conceptual understanding of the topics in foundation chemistry. With summarising being important for academic reading and writing, Jessie's reference to its (later) use in mainstream holds true, especially since it is where the students will be exposed to various other academic texts, well beyond the course manuals. There are no prescribed textbooks in the FP modules. The course manuals and the laboratory practical manuals are the dominant reading materials in the FP.

The lack of attention to more in-depth writing, a literacy in science which demonstrates knowledge, comprehension and synthesis, has also been expressed by Nancy:

> "*I personally believe that we should have more of the paragraph type answers. The problem is that it is labour-intensive to mark. We have very short answers, one word answer, definitions, we allow them to write in point form etcetera ... For example, in the first chapter of the year, there's a section where there's a typical kind of exam question which involves a long paragraph answer in depth. Besides ensuring that the students cover all that they need to in their answer, it would be a good place to test language. I believe it will help if it was marked intensely for grammar as well as chemistry and ask them to practise writing in* [foundation] *chemistry. It would need to be marked and corrected as much as possible and maybe ask them to try again.*"

According to the reference to writing by Nancy (above), the following are the types of questions that can be answered in paragraph form: "(a). Compare the physical properties of the different states of matter; and, (b). Explain the differences in state and converting between the states of matter in terms of the Particulate and Kinetic Theory of Matter" (*Foundation Chemistry,* Semester 1, 2011: ii). Nancy's suggestion that paragraph writing be included in the foundation chemistry curriculum is significant as it will expose students to the "sub-culture" (Dison and Rule, 1996: 87) and the appropriate discourse conventions and literacies needed in the discipline of chemistry. This will then satisfy the need to focus on writing in foundation chemistry that was discussed in the previous paragraph. However, it is disconcerting that such a crucial literacy as writing is perceived by Nancy as being *"labour-intensive"* to mark. Such an attitude compounds the already complex dilemmas that confront FP students: discourse conventions that were appropriate for their secondary school studies but are inadequate for HE studies; the distinct articulation gap between school and university; inadequate preparation for tertiary science; poor teaching at school level; and, being exposed to the non-native LoLT at UKZN. Writing scientifically is a fundamental literacy needed for science modules and should be explicitly taught so students are apprenticed into disciplinary discourse practices. As stated earlier, besides the fact that the "rules and conventions of academic disciplines [need to be made] as overt as possible" (Boughey, 2000: 289), FP students should be given the opportunity to practise writing in the sciences. It remains problematic though that DSs, such as Nancy, see language as 'grammar', and therefore the need for surface level correction of writing in chemistry ("*marked intensely for grammar")*

A useful suggestion by Nancy is that of process writing: *"It would be marked ... and maybe ask them to try again"*. However, there is a clear misconception of the drafting/redrafting process. Process writing is a development process that engages students in writing through constructive feedback to encourage substantial revision and is one of the practices used in SCOM. Below is an extract from a marked draft scientific report submitted by an FP student for assessment in SCOM. It has been included here to demonstrate that process writing involves feedback rather than correcting students' work.


explicitly say what was different.

Discussion:

The result shows that the yeast has an effect since everything seemed to be different to what it was before fermentation. The colour changed to be pink from maroon. After fermentation the solution was no longer acidic does the pH reflect this? this is supported by the litmus paper because it did not changed when it was placed in the solution. what colour litmus paper did you use? What does it mean if there's no change? The pH before fermentation was 3.49 and after it was 6.62. The balloon was deflated(filled with nothing) before fermentation but after the fermentation it was inflated (filled with gases) meaning gases were produced during reaction. What gasses? The smell was not the same either for the second smell was unpleasant and sour this is a very bad smell unlike the first one it was better.

Sanele, in your discussion you should not only state your results. Instead compare it with the readings and state whether they are similar or different. You have to explain why you have these results and what it means.

Nancy, however, regarded the drafting process as the marking and correcting of students' work which does not allow the students to self-correct or to learn from their writing inadequacies or challenges.

6.6.2.3 Discipline-specific literacies for foundation physics

In respect of discipline-specific literacies essential for foundation physics in the FP, all the DSs interviewed were unanimous in isolating reading and writing as being relevant. However, the data indicates that reading is minimal and writing is sketchy. Shane explained that the notes in the foundation physics module were presented *"in a rather concise manner; they consist of explanations of concepts"* so that it becomes *"easily accessible to students, like a workbook"* (Petrus). Adding to this, Petrus pointed out that *"the course manual does not offer students lengthy notes*; ... *it's not a lot of reading but it is reading of* *concepts that they need to understand and learn".* This response is supported by the following two excerpts which show the type of reading texts in the course manual for foundation physics:

Neutral vs. charged objects

The charge on a single proton and that on an electron are equal in magnitude, but opposite in sign. Any object which contains fewer electrons than protons is said to be *positively charged* and if it has more electrons than protons it is said to *be negatively* charged. An object that contains equal numbers of protons and electrons is said to be *electrically neutral.*

Charge interaction

The interaction of electric charge can produce *either* attractive *or* repulsive electrical forces. The direction of the forces is given by the **law of charges** or the **charge-force law**:

| Like charges repel each other, and unlike charges attract each other. |

Amount of charge

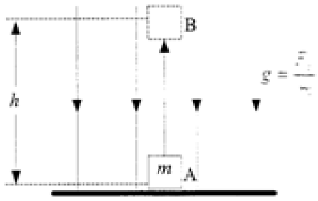
The SI unit of charge is the **coulomb (C)**. The table below shows the charges and masses of electron, proton and neutron.

(*Foundation Physics*: Semester 1, 2011: 3)

7. ELECTRIC POTENTIAL ENERGY

Gravitational potential energy analogy

Potential energy is the energy which is stored in a body. Consider the diagram at the right which shows an object of mass, m, in the uniform gravitational field close to the earth's surface. When the object is raised a vertical distance h at constant velocity, the work done by the external force is given by



$W = F_{ext}h = F_g h = mgh$

Here, F_{ext} is the external force doing work against gravity and its magnitude is equal to $F_g = mg$ since velocity is constant.

The increase in gravitational potential energy is

$\Delta E_p = E_{pB} - E_{pA} = F_{ext}h = mgh$

If the mass is released, it will fall toward the ground, because the gravitational force will do work on it. In falling (ignoring air friction), the gravitational potential energy of the mass will decrease, and this decrease will be accompanied by an increase in the kinetic energy ($E_k = \frac{1}{2}mv^2$) of the body. We say that energy changes take place when a mass moves in the gravitational field of the earth.

(*Foundation Physics*: Semester 1, 2011: 18)

Even though the readings in foundation physics were minimal, the DSs interviewed were disappointed that FP students did not read their notes. The following interesting assumptions about the lack of reading had surfaced in the interviews:

> Annah: *"I am not sure whether we explain things in class and that is why they are not reading and maybe that is spoiling them because they must be thinking that it would be done in class so they don't have to read and they must be also thinking it's hard to understand, why bother – my lecturer will explain".*
>
> Shane: *"Maybe the major problem is that they read and do not understand so they don't see the need to continue with it*".

An observation of Annah's lesson on "Position, Distance and Displacement' is an indication of her doing exactly what she had argued against in the interview. At the start of her lesson, she explained the concepts of 'Motion in 1-Dimension'; position/zero point and frame of reference. Her explanations were facilitated by drawing diagrams on the chalkboard. Although these concepts formed part of the foundation physics notes (Kinematics, Semester 1, 2011: 4), Annah chose to explain these to the students rather than questioning them on what they had read/understood in preparation for the lesson.

Students can acquire much reading practice from reading in the disciplines. MacGinitie and MacGinitie (1986) explain that "it is in content areas that teachers most effectively teach students not to read; we [teachers] destroy reading and reading comprehension when we explain the content and do not help students to understand the text" (263). To encourage reading, FP students need support and mediation. Therefore, even though reading is one of the traditional notions of literacies, it should be prioritized in foundation physics so that students do not grapple with texts which could impact on their conceptual understanding, learning and performance; or reach frustration level at reading in content areas until they are forced to abandon their attempts at reading. This can be practised, even if the readings are minimal as shorter readings in disciplines are not necessarily easier considering their focus being on conceptual knowledge.

On the issue of writing in foundation physics, Susan clarified that "*it was minimal, generally accompanied by explanations for calculations"* as a way of testing understanding. One such example of this type of question in foundation physics is: "How much of potential energy does a 1.2 kg brick have if it is raised to a height of 1.4 m above the ground? What happens to this potential energy if the brick falls to towards the ground?" (*Foundation Physics:* Work and Energy, Semester 1, 2011: 10).

On the issue of writing in foundation physics, Annah clarified why she expected students to provide explanations:

> "*Generally, in physics students have to explain concepts. I usually emphasize that once they have done their calculations they have to explain their answer at the end, in other words what does the answer mean? Students need to understand why they are doing the calculations*".

The following example illustrates Annah's expectation of writing in foundation physics: "If the dragging force decreases to 110 N, what will happen to the motion of the cement block? Give a reason for your answer" (*Foundation Physics:* Newton's Laws Tutorials, Semester 2, 2011: 15). According to Annah, impressing upon students where they *"**have to*** [my emphasis] *explain concepts"* in foundation physics has been a strategy to rule out the possibility of memorising of equations without really understanding them. This was to ensure that *"students understand what they are doing – even if they are calculating or problem-solving*". According to Petrus, students *"prefer calculating, or solving rather than explaining"*. Getting students to illustrate reasoning by explaining is a way of testing students' "conceptual understanding or procedural fluency" (Kilpatrick *et al.* 2001) which indicates the level of proficiency in the disciplinary discourse. It is also a way of giving students the opportunity to use the secondary discourse of a discipline. It is an appropriate strategy to integrate language and disciplinary content. It enables students to acquire the "disciplinary literacy" (Lee, 2004) needed to illustrate what they have learnt or understood in the subject. Questions involving explanations (only) in foundation physics were included in tests, like the example below:

Question 11: (3 marks) A scheming business man buys gold by weight at a higher altitude (height above sea level) and sells it at a lower altitude at the same price per weight. Write a brief explanation to the public protector on how the business man is making a profit. (*Foundation Physics:* August Test, 2011: 2)

In foundation physics, as was the case in foundation chemistry, students write very brief scientific reports in a template (Appendix 18). Annah explained that in foundation physics, students merely *"summarise the procedure/method* [of the experiment] *in a few sentences".* Similarly, Petrus commented on "*a brief section where they* [FP students] *have to write how they did the experiment, the method part because they have to explain and describe how they took their measurements"*.

On being asked about the rationale behind the sketchy scientific reports, Petrus explained that it was *"emulat*[ing] *what the mainstream does for the first years* [students]*".* Since the FP students are in the transition year, the idea by the foundation physics team to emulate what is done at first year level can contribute to acculturating the FP students. They can enter the mainstream [physics] environment with the appropriate discourse practices. In this way, students are apprenticed to join the wider discourse community of physics. However, as explained earlier in this Chapter, there exists the inconsistency within the FP in respect of the compilation of reports. In SCOM, if the topic and experiment are linked to physics, then the FP students are taught and expected to write lengthy laboratory reports on a physics experiment (see Appendices 16 and 19). However, the scientific report format in foundation physics differs in respect of format (i.e. headings); and the content required under each heading is sketchy (See Appendix18). Therefore, there needs to be articulation between SCOM and the foundation modules in science especially if the report writing genre features prominently in science.

6.6.2.4 Discipline-specific literacies for foundation mathematics

One of the key areas in foundation mathematics which relies on the discipline-specific literacies of reading and reading comprehension is that of word problems as expressed by Raj: "*Our students need to be able to read a word problem, understand the language used, reason, extract what is required and solve accurately by working out or writing down the answer. For this they need maths knowledge* ***and*** [participant's emphasis] *proficiency in literacy"*. The following extracts from the foundation mathematics course manual supports the comment by Raj:

Steps in Method:

- ✓ Read the question. Get a picture of what it is about.
- ✓ What are you asked to find?
- ✓ Give these things letters. Say **exactly** what the letters represent.
- ✓ Translate information into equations.

Example 1.

Three years ago a boy was 4 times as old as his sister. Four years ago he was 7 times as old as his sister. What are their present ages?

Solution:

Let the boy's present age be b years, and let his sister's present age be g years.

Three years ago:
Boy's age = $b - 3$
Sister's age = $g - 3$

$b - 3 = 4(g - 3)$ (1)

Four years ago:
Boy's age = $b - 4$
Sister's age = $g - 4$

$b - 4 = 7(g - 4)$ (2)

(1) − (2) $\quad 1 = 4(g - 3) - 7(g - 4)$

$$1 = 4g - 12 - 7g + 28$$
$$3g = 15$$
$$g = 5$$

Subst. $g = 5$ in (2), then $b = 11$

Their present ages are 11 for the boy and 5 for the girl.

(*Foundation Mathematics,* Semester 1, 2011: 15-16).

The response from Raj draws attention to the issue of literacy being purposeful in mathematics. It offers a view of literacy that goes beyond the traditional notion of being able to read and write; adding on, instead, the dimension of applying knowledge for specific purposes in specific contexts which, in the case of mathematics, is to use linguistic competence to execute mathematical applications. The response by Raj illuminates two of the dimensions of mathematical discourse: the linguistic and cognitive" (Gibbs and Orton, 1994): The need for students to "*be able to read ... and* [*write*] *down the answer"* (Raj) illustrates the linguistic dimension while the cognitive dimension involves *"reason*[ing]*"*.
In the interview, Raj stressed *"the absolute importance of logic and sequence in solving mathematical problems".* For successful application of these in the context of mathematics, students need to be able to read mathematical texts carefully, comprehend what is expected, reason logically, justify and execute the mathematical application. These activities rely on the mathematical proficiencies of "adaptive reasoning, procedural fluency and strategic competence" (Kilpatrick *et al.* 2001). To elaborate on this, adaptive reasoning relies on applying logic and being able to justify; procedural fluency is the ability to carry out a procedure (e.g. the *"sequence"* that Raj refers to); and strategic competence refers to the ability *"to solve the mathematical problem"* (as Raj mentions). However, these are achievable with adequate mediation and support from DSs teaching foundation mathematics. This is particularly important in light of the disadvantaged educational background of the FP students and the research studies of TIMSS and TIMSS-R (Howie, 2003; Reddy, 2006 and Mji and Makgato, 2006) in respect of high school students' lack of understanding of mathematics questions and thus, the inability to communicate answers especially because they had not understood the questions. Studies by Bohlmann and

Pretorius (2002) have isolated the challenges of problem solving (which is crucial to mathematics) and its demands on students' reasoning, interpretive and strategic skills; and how reading ability influences mathematical performance. Included in the foundation mathematics course manual are problem-solving strategies (See Appendix 23) followed by a range of word problems, such as the example cited in the extract in the preceding paragraph.

A very significant reflection from Siva is that mathematics discourse is not only confined to the foundation mathematics lecture venue:

> "*... word problems do not at stop at foundation level. In mainstream health sciences, in a topic like bacterial decay or growth you would use exponential equations. Maths language can continue in any field in science ...* [pause] *statistics, medicine ... basically, in any field of study. Mathematical knowledge together with language is used in everyday activities like shopping, baking, banking".*

Siva's response on the *"relevance of mathematical knowledge and language"* (i.e. the literacies) beyond the educational contexts and in social contexts, such as "*shopping and banking"* emphasize "the contextual nature of literacies and the fact that literacy is socially constructed" (Street, 2003: 77), the basic tenet of the ideological model of literacy. The opinion of mathematics portrayed by Siva fits into that of NLS (Street, 1984) which views literacy as a socio-cultural practice. The way in which Siva illustrates the use of mathematical discourse in social contexts conforms to Halliday's (1994) SFL model of language which sees language as a social phenomenon and language is explained as a result of countless social interactions. Furthermore, Siva's response highlights the use of traditional mathematics across curricula (in the educational context) as well as the use of quantitative literacy in social contexts *("in everyday activities like shopping, baking, banking").* Students need to be apprenticed into translating/applying their quantitative competencies to authentic settings outside the classroom to solve practical problems for which they would not only require quantitative literacy but also the ability to synthesize and comprehend information, reason logically and justify their conclusions.

6.7 The importance of Listening in science

The importance of purposeful listening in foundation biology was raised by Josh who explained that *"students need to listen carefully, absorb and comprehend and eventually be* *able to explain content matter either verbally or in written form".* With regard to this response, the first point of discussion is that listening in an academic setting is far more complex than that in a social setting. Even though surface skills of listening generally associated with BICS are typically acquired quickly by many students (Cummins, 1979), academic discourse is generally cognitively demanding and is reliant on context-reduced communication. It entails a deeper level of listening and is thus reliant on CALP. The second point of discussion from Josh's response is the *"need to listen carefully"* which is a reasonable expectation of students, i.e. to acquire and learn content knowledge which they would have to recall or show evidence of understanding in tests, examinations and other forms of evaluation and assessments such as assignments, oral presentations, laboratory practicals and field research in the FP. But, for effective learning to take place, apart from 'careful' listening, students would need selective listening skills to comprehend the content being taught, and to assimilate this with what they already know. In addition, while the lecture is in process, they would need to be able to distinguish between important and unimportant information.

The responses from the DSs in this study have shown the emphasis placed on the need for students to listen in class. On this issue, Annah's comment was that*"most of them* [FP students] *don't make notes on their own while I am explaining* [foundation physics content]*; they only take down what is written on the board. They are poor at making notes because I think their listening skills are not so good".* The critique of the students' listening skills needs to be understood in light of the profile of the FP students. English, the LoLT at UKZN is not their mother tongue. They speak EAL. This study has shown that the FP students were taught by tutors with different accents, and voice modulation; each with his or her own pace and style of delivery of the lecture. In fact, as was the case in this study, forty percent of the RPs were not first language English speakers themselves (and spoke English in varying accents) which could place demands on students' ability to comprehend accented English. These factors can pose challenges to students' listening abilities. The responses in this study indicated greater reference to the issues of reading and writing. Discourses are "the integration of ways of talking, listening, writing, reading, acting and interacting" (Gee, 2001: 719) but, in this study, listening seems to have been neglected. If *"students' listening skills are not so good"* (Annah), and if attentive listening is essential for academic success, then the use of discourse markers[78] in the 'spoken' academic lecture could help students in the listening process and so enhance their comprehension of the content knowledge.

In addition to this, the transition from school to the tertiary institution means an adaptation to the way in which students need to learn. This, for the FP students, means moving from the teacher-centred approach that had characterised their learning at school to independent learning expected at HE level. Thus, Annah's reference to FP students' poor or lack of note-taking in the foundation physics classroom needs comment. Making notes during lectures is a complex activity that takes place during the process of listening. It involves being able to isolate important information, to be able to write quickly yet concisely, sometimes with the reliance on shorthand and abbreviations. Once done, it needs to be understood and will have to be later recalled. However, considering the FP students' educational background, where their "written work in schools emphasizes copying from the blackboard rather than pupils writing their own texts" (Parkinson *et al.* 2008: 12), it is quite probable that making notes as a lecture is being delivered can be challenging, as opposed to copying notes written on the board. Students can be encouraged to learn to make their own notes from the spoken academic lectures if they are alerted to significant content as the lesson is being taught.

Like Josh, Nancy's view was that academic success could be achievable in the foundation chemistry class *"if students were able to listen very well, learn from the visual aids* [i.e. transparencies and power point presentations], *from the talking* [teaching], *from the bit of reading* [of notes in the course manual] *they would probably be fine".* An observation of Nancy's lesson on 'The Mole and Formulae' below shows the lesson being conducted using all these practices.

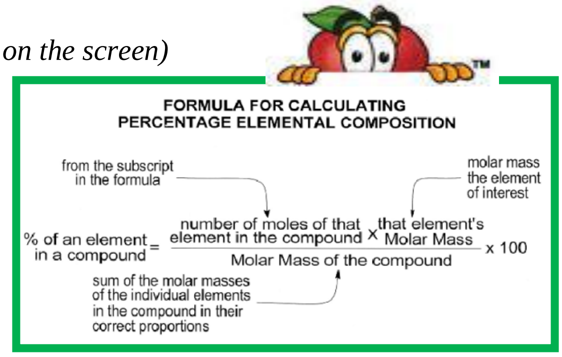
Observation of Foundation Chemistry Lesson (Student Group D) Date: 11 August 2011 Topic: The Mole and Formulae Nancy: Right, for today's lesson. 'Moles and Formula' *(writes this on the chalkboard).* Page 20 – okay, open up those manuals. Let's read that bit at the top of the page.(Nancy reads the following from the course notes) "A formula is a way of representing a

[78] Schiffrin (1987) defines discourse markers as "members of a functional class of verbal and nonverbal devices which provide contextual coordinates for ongoing talk" (41). They signal the information structure of discourse by emphasizing directions and relations within discourse, e.g. to indicate a topic shift by saying '*now, let's turn to…*' (Eslami and Eslami-Rasekh, 2007: 29).

chemical compound using atomic symbols for the types of atoms present and subscripts for the numbers of them. Different kinds of formula can be used to give different levels of information about the chemical composition and the structure (the bonding sequence of atoms) of the compound." (*Foundation Chemistry:* Lecture Notes, Semester 2, 2011: 20). (Students followed in their course manuals while Nancy read out aloud).

Nancy: So let's look at this example H_2SO_4 *(writes on chalkboard)*. This is a formula for sulphuric acid which is a compound. So what does this formula tell us*? (Students do not answer)*. It tells us that sulphuric acid has the elements hydrogen, sulphur and oxygen. It also tells us how many of each element the compound has. So it tells us it has two hydrogens, one sulphur and four oxygens. But does this formula tell us the mass of each element in the compound? No it doesn't. This has to be calculated.

(Nancy projects the following slide on the screen)



Nancy: So for example, if you had one mole of sulphuric acid and you wanted to know the amount of oxygen in the compound, you'd have to use the formula in the slide. The number of moles of oxygen is given by its subscript: 4. Then you'd times that by the molar mass of oxygen, which you'd get from your periodic table. That's 15.99 g/mol. So the answer is 63.96. Then you'd divide this answer by the molar mass of the whole compound, which you'd calculate using your periodic table. As I said before, You have two hydrogens, one sulphur and four oxygens. You'd add up all those masses using the periodic table and you'd get 98.042 g/mol. Then divide 63.96 by 98.042 g/mol and you'd get 0.65. Times that by 100 and you'd get 65.23%. So this tells you that sulphuric acid is made up of 65.23% of oxygen. Got it?

Nancy: Now let's look at the example in your manual.

Textbox 1: Lesson Observation A

Nancy's lesson was, to a very large extent, teacher-centred/teacher-dominated: with her reading from the manual, explaining the concepts on the chalkboard, explaining the slide and finally, discussing an example from the manual. The academic discourse in a science course is characterised by complex language structure, abstract concepts and specialized vocabulary which in itself requires close, careful attention. Besides, to expect students to listen attentively and to actively combine the spoken input with the input from the visuals as well as refer to their reading notes, all – at the same time – can be challenging, more particularly so for students for whom the LoLT is an EAL.

6.8 The need to talk science

From the interview sessions, I have gathered that some RPs strongly feel that besides the written text, students studying science need to be able to talk the language of science. Lisha, who claims to advocate *"the holistic development of the student"*, drew attention to the importance of communication in the science lecture room: *"As much as I know that students can get stressed over* [oral] *presentations I think it is absolutely crucial to get away from being this introverted kind of student to somebody that can speak out loud, articulate and justify a point* [in the science class] *or whatever the case"* (Lisha). Lisha's suggestion needs to be seen in light of the FP students' transition to university; and the way in which their learning occurred in their schooling system which involved teacher-dominated approaches against student passivity. Therefore, the adjustment for students who had come from a culture of schooling where facts and content knowledge were learnt unquestioningly; and to be suddenly expected to *"speak out loud, articulate and justify"* at university is a major shift for the students[79]. In any event, FP students are newcomers to academic culture; they enter the university environment with their own discursive experiences and they can only participate successfully in oral academic discourse if they are adequately socialized into using specific discourse practices.

In addition, the communication that Lisha encourages is not the type that is reliant on BICs or what Gibbons (1991) refers to as playground language, i.e. the language which enables children to make friends, join in games and take part in a variety of day-to-day activities that develop and maintain social contacts. On the contrary, the language that Lisha expects the FP students to manipulate can be cognitively demanding, used in a context-reduced situation, the science class, so students can *"get stressed".* Lisha's suggestion aims at promoting the need for communication and dialogue; it can only be effective as long as the FP students are able to navigate through content knowledge, presentation skills and proficiency in the LoLT. Linguistic competence is essential to handle the cognitive

[79] This point has parallels with the following study: Lankshear (1997) discusses a study conducted by Jones in New Zealand which illustrated how two groups of students from two very different social groups (migrant working-class families and white middle-class families) from the same school had different views of work to be done which corresponded to their different views of how to operate language within learning. Where the students from migrant working class-families saw the teacher as *the* authority on imparting school knowledge and had no idea that the knowledge could be verified; those from the white middle-class families saw the teacher as just one of the resources for getting knowledge and would question, probe and even challenge the information she conveyed (27-28).

demands of a task. This is also dependent on the students' confidence levels and how they interact with their peers and the DS. Having outlined all of these, a point that is relevant is that if students need to become members of the discourse community of science, they need to display this discourse acquisition by "learning to talk the language of science" (Lemke 1990: 1) but this, too, requires support and practice.

Conclusion

This Chapter began with a discussion oriented around the changing cohorts of students in the HE sector and in the FP. It then described the reasons given by the RPs for changes to the foundation modules of biology, chemistry, mathematics, physics as well as SCOM. The responses from the RPs have indicated that changes to the modules were a result of the FP students' inability to cope with dense and voluminous content in foundation biology which had accounted for the lack of time to focus on both content and literacies. This Chapter has also noted the perception of the FP students as being viewed as 'deficit' on account of their perceived challenges with reading and comprehension of the content of foundation biology. With regard to the change in foundation chemistry the response intimated that the level of the module had been dropped, however perusal of the course manuals over a period of time has not been able to conclusively locate evidences of this having taken place. The foundation mathematics module had been revisited and the changes that were incorporated were linked to senior secondary school level mathematics, with the emphasis on the inclusion of mathematical skills. Amendments in the foundation physics module involved removing content; adding on more examples; and facilitating and strengthening conceptual understanding. The change isolated in the SCOM module was based on the need to address the FP students' challenges with writing scientifically. This was in light of the students' writing experiences acquired at school which differ substantially from the demands of writing science at tertiary level.

According to the data, module amendments were implemented mainly to accommodate the 'changing' students who enter the FP, who the RPs have deemed 'underprepared' for tertiary level as a result of the articulation gap between high school and higher education. This was directed at disadvantaged schooling which included the lack of educational resources; poor and ineffective teaching and teaching practices; and, learning mechanisms such as memorizing that worked at school but were unsuitable at tertiary level.

On the question of the discipline-specific literacies for science discourse in the FP, the data has shown that in light of its philosophy (discussed earlier in this dissertation), the SCOM course has, as its primary focus, the attention to literacies required for science, particularly for scientific reading and writing and for science genres. Responses from the ALSs have shown, too, how SCOM satisfies the notion of reading, “talking, doing and writing science” as advocated by Lemke (1990: 1; Lea and Street, 2006) as a way of apprenticing students into science discourse.

This Chapter focused, too, on the way in which SCOM is perceived by the DSs teaching in the FP. Issues that came to the fore were SCOM being perceived as a study skills model, where students are taught an autonomous list of generic skills or decontextualised skills. A major response was that SCOM was perceived as an arena where students' language/grammar difficulties are fixed. There was also emphasis on the fact that the literacies acquired in SCOM should be transferrable to other contexts, viz. the foundation modules in science in the FP and the ‘real’ world beyond the university, the workplace.

The analysis of the data obtained from the DSs on the issue of discipline-specific literacies for science discourse showed that any reference to literacies was associated with the traditional thinking of being able to read and write, thus the tendency to perceive it as a ‘language’ issue. The responses of the DSs thus showed a preference to leave the literacies for science within the confines of the AL lecture venues and the domain of the AL ‘experts’ while the DSs get on with their job of teaching science content, a view corroborated by the perceptions of the ALSs. This Chapter has conveyed the DSs' reservations about stepping into academic literacy, a discipline in which they claimed to have had hardly any academic or professional training. The general consensus among the DSs was that the acquisition of discipline-specific literacies should remain the domain of the AL staff.

Despite the belief that discipline-specific literacies are ideally handled in SCOM, the responses from the DSs illustrated the literacies needed in the foundation modules in science. Through probing, I gathered from the data that apart from the primary literacies being reading and writing in science, the DSs interviewed were aware of the need for the students to comprehend, solve problems, listen and talk in science. The data has shown that foundation biology pays much attention to various discipline-specific literacies in light of the discipline being language-dependent. This Chapter has noted, too, that the nature of reading texts in the foundation modules of chemistry was scanty, and that writing was minimal, with a greater propensity for calculations and visual-graphical representation. With regard to foundation physics, according to the data the explanation of concepts in the form of short notes dominated the course manuals. In terms of foundation mathematics, this Chapter showed a reliance on the discipline-specific literacies of reading and reading comprehension as being crucial for solving word problems. There was reference to the need for purposeful listening as well as the importance of communicating in the science classroom (viz. articulating and justifying).

Having ascertained the RPs views on the discipline-specific literacies in the foundation modules in science for science discourse in this Chapter, Chapter 7 explores data gathered for critical research question 2: *What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation) programme?* This is followed by the data gathered in respect of critical research question 3: *How do disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

CHAPTER 7

DATA ANALYSIS: EVIDENCES OF THE PHENOMENON

Introduction

Chapter 6 discussed research participants' understandings and interpretations of the student profile that comprised the FP. It engaged with their perceptions of the students they taught. The probing in the interviews yielded data that assisted the study to understand participants' responses to the issue whether the foundation modules offered in the FP had undergone any changes, and, if so, to understand the reasons behind such changes. Chapter 6 explored the responses from the ALSs and the DSs in respect of the discipline-specific literacies in science that they believe are required by students in the FP. The data from the interviews was triangulated with documentary evidence and observation.

Chapter 7 begins with an analysis of the data gathered in response to critical research question 2*: What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation) programme?* The discussion of this data is presented here from 7.1.1 to 7.1.9. This is followed by an analysis of the data from the responses to critical research question 3: *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?* The discussion of this data is presented here from 7.2.1 to 7.2.8

To answer critical research question 2, data was gathered qualitatively. To gain a holistic understanding of the research focus, data was gathered from multiple sources. These included the semi-structured interviews; observation (of lectures, tutorials, laboratory practicals and field trips); as well as documentary evidence (i.e. the discipline-based course manuals used in the FP; the FP students' laboratory practical workbooks, scientific reports, and tests; and discipline-based module reports).

I used case study as a research design to collect data. This data was needed in order to offer insight into the existence of perceived challenges that the language of science and the use of discipline-specific literacies in science might have posed to students in the FP. Data was obtained from documentary evidence; and observation of lectures, tutorials, laboratory practicals and field trips. Where necessary, this data was validated with the RPs' verbal responses that had emerged from the semi-structured interviews. Critical research question 3 then explored how the DSs assisted the FP students with the acquisition of discipline-specific literacies required for science discourse. This data was mainly obtained from the documentary evidence and observation in the natural setting of the FP in science within the research site.

7.1.1 Perceived challenges of reading science

In response to critical research question 2, reading was highlighted as one of the literacies considered to be a major challenge facing students in the FP. In this study, the following response from Lara in the interview session drew attention to the lack of effort by students to read their course readings: *"The expectation is that they must do some reading* [in foundation biology] *before coming to a lecture, unfortunately they just never do"*. Lara's view was supported by Josh's reference to the FP students' *"lack of reading"*. On attempting to provide reason/s why students do not read the texts such as the marine theme readings[80] in foundation biology (an extract of which is in Appendix 22), Josh surmised that: "*it could just be exasperating to read some text that's technically difficult. It may be just so frustrating to try and get to grips with the technical aspects of science ... with the language, the scientific language ... that they* [the FP students] *want to avoid it, really".* Appendix 22 has the type of reading material to which Josh refers (extracts from which are further discussed later in this Chapter). A perusal of marine theme readings shows that they are lexically dense (or as stated by Josh, *'technically difficult'*); and that they have been lifted directly from the original source without any form of scaffolding that could help the FP students' reading and comprehension of them.

Students in HE are exposed to a number of texts and textbooks that require independent reading. The importance of reading at tertiary level is crucial as effective reading competencies are required across disciplines and are fundamental for comprehension and writing within disciplines. Thus, the expectation that students read in preparation for a lesson is a reasonable demand of university students. However, the FP students' involvement in reading independently needs to be understood in terms of their educational

[80] *Diversity of Marine Life* was a theme in foundation biology (Semester 2, 2011). Students were given a set of marine readings based on different marine organisms.

experiences. As explained earlier in this dissertation (Chapter 4), the FP students come from disadvantaged schooling backgrounds (ex-DET schools) where there was “lack of explicit attention paid to reading” (Mgqwashu, 2009: 216). As stated in the Chapter 6, students accepted into the CSA (including the FP) come from the poorer, under-resourced quintile 1-3 schools. The quality of teaching and learning at the ex-DET schools has already been discussed in Chapter 4. Furthermore, research has isolated the challenges associated with unpacking the meaning of reading texts which have difficult language (Kirkwood, 2007); and, the link between context-reduced science textbooks and reading strategies that have not been developed (Clark, 1993). Barring the issue of the FP students’ literacy experiences which they bring into university, and with reading being a fundamental literacy required for tertiary/academic studies, reference to any reading challenges that surface need to be addressed (The extent to whether this does take place in the FP is explored later in this Chapter, under critical research question 3) .

Challenges with reading, however, are not necessarily confined to students at foundation level. Research on reading undertaken within the HE sector in South Africa has pointed to [mainstream] university students’ low reading levels and slow reading speeds (Pretorius, 2000a); and problems with vocabulary, fluency, reading comprehension and reading strategies (Nel *et al.* 2004). In addition, a study undertaken by Pretorius (2000a) at Unisa revealed that many first year students studying psychology and sociology were reading at ‘frustration’ level[81], with an average comprehension level of 53%.

Josh’s reference to the texts [in science] being *“technically difficult”* ties up with the research on academic reading by Rose *et al.* (2003) and van Wyk and Greyling (2008) that the patterns of language in academic texts are different from the patterns of language in everyday spoken discourse. In SFL research, Halliday (2008) has distinguished between spoken and written language. Where spoken language has intricate clause combinations and lesser lexicalization, written language is syntactically simpler with denser lexicalization. Earlier references in this study (in Chapters 2, 3 and 4) have described the nature of academic language as being highly specialised, often involving dense abstract concepts and technical terminology which can compound reading and reading

[81] “Frustration level of reading is when students read well below their assumed reading level; or the reader reads with less than 90% or less word recognition accuracy and 50% or less comprehension accuracy” (Lesiak and Bradley-Johnson, 1983: 8).

comprehension. The reading of academic texts involves engagement with "secondary discourse" (Gee, 1999); or what Bernstein (1972) refers to as the "elaborated code". Having outlined the views of these DSs on reading as one of the challenges in the FP, the next issue that is discussed is lexical density in science texts.

7.1.2 The Challenges of Lexical Density

An example of *"technically difficult texts"* referred to by Josh were the marine reading texts, some of which students were expected to read in preparation for a marine theme laboratory practical called 'Mode of Life'[82]. It is from these compulsory pre-preparation reading tasks and the observation of specific marine specimens in the laboratory practical session that students had to derive knowledge to answer a variety of questions relating to marine organisms. Knowledge on the specific marine organisms in the reading texts was also vital for a field trip to the rocky shores (See footnote[47] in Chapter 5). The extracts below taken from the 'Mode of Life' readings illustrate the extent of lexical density, i.e. the density of the information in the text; in other words, "how tightly the lexical items (content words) have been packed into the grammatical structure" (Halliday and Martin, 1993: 76). The lexical items have been underlined in the text boxes below:

<u>Extract 1:</u>

Octopus <u>Octopuses</u> or <u>octopi</u>? Whatever we <u>choose</u> to <u>call</u> these <u>cryptic</u> <u>cephalopods</u>, The <u>eight-armed</u> <u>octopus</u> is <u>among</u> the most <u>sophisticate</u>d of all <u>invertebrates</u> and a <u>key player</u> in the <u>food</u> <u>webs</u> of most <u>marine</u> <u>ecosystems</u>. These <u>cephalopods</u> <u>represent</u> the <u>peak</u> of <u>molluscan evolution</u> and, with <u>finely-tuned</u> <u>sensory</u> <u>organs</u> and <u>complex</u> <u>nervous</u> <u>systems</u>, they are <u>thought</u> to be the <u>most</u> <u>highly</u> <u>developed</u> of all <u>invertebrates.</u> *(Foundation Biology* Readings, 2011: 39*)*[83]

[82] In the *Mode of Life* practical, students had to answer questions by relying on the information in the marine readings and observations of specific marine specimens in the laboratory. See Appendix 22 for *Mode of Life* practical worksheet.

[83] These readings were extracted from Branch, G. M. L. 1981. *The Living Shores of Southern Africa*. Cape Town: Struik; Branch, G. M., Griffiths, C. L., Branch, M. L. and Beckley, L. E. 1994. *Two Oceans: A guide to the marine life of Southern Africa*. Cape Town: David Philip, Claremont and, Payne, A. I. L. and Crawford, R. J. (eds) *Oceans of Life off Southern Africa.* Cape Town: Vlaeberg Publishers. They were compiled into a booklet under the marine theme for foundation biology and were referred to as *Foundation Biology Readings*.

Extract 2:

Chitons
Chitons or armadillos are primitive, oval, flattened molluscs with eight shell plates surrounded by a fleshy girdle, which is usually strengthened and protected by scales, bristles or spines. Chitons are grazers that rasp algae from the rocks. Common with almost all molluscs, chitons possess a radular – a long tongue with rows of tiny teeth – that is projected from the mouth to scrape up food. The most common species is the black chiton which is dark and velvety with minute imbedded bristles. *(Foundation Biology* Readings, 2011: 45*)*

Extract 3

Anemones
Anemones belong to the phylum Cnidaria, which also includes jellyfish, corals and hydroids. All have a simple sac-like structure with two cell layers, radial symmetry, a single opening and specialised stinging cells.
(Foundation Biology Readings, 2011: 29*)*

Each of these extracts conveys factual knowledge, and is written along the lines of information found in textbooks. These extracts illustrate that the language of science is unambiguous, precise, information oriented and conceptually dense. Understanding these texts is reliant on science discipline-specific CALP which involves context-reduced language. Information in these extracts is tightly packed, illustrating the reliance on lexical density, a feature of scientific discourse (Halliday and Martin, 1993). Students would have had to be able to fathom the meanings of several of these lexical items in order to understand the texts. The difficulties experienced by the FP students in understanding these and other extracts in the readings were as a result of the use of a series of lexically items used consecutively such as *primitive, oval, flattened molluscs* and *minute imbedded bristles*; and/or the use of tightly packed lexical clauses. For example, "*These cephalopods represent the peak of molluscan evolution"* that has a lexical density of 5 ($\frac{\text{number of lexical items}}{\text{number of clauses}}$) and the statement "*All have a simple sac-like structure with two cell layers, radial symmetry, a single opening and specialised stinging cells*" has a lexical density of 12 ($\frac{\text{number of lexical items}}{\text{number of clauses}}$). Scientific texts with high lexical density become more difficult to read. Students would have to process more ideas per clause, unpack more concepts and unravel tightly packed information, all of which can impact on comprehension.

For students to be able to fathom the meanings of the numerous, difficult uses of the nouns, verbs and adjectives and adverbs (i.e. the four word classes belonging to lexical items) in the texts, they would have had to have access to a dictionary, more especially, a scientific dictionary. Having observed[84] the 'Mode of Life' practical session, I had noticed that of the 35 students in the class group, only 4 students had access to their own personal dictionaries, one of which was an *Oxford South African School Dictionary*. An observation of the laboratory practical conducted by Lara (extracts of which have been transcribed in Textbox 2 below) showed that students understood the technical words in the reading texts such as *phylum, cephalopods, hydroids and molluscs* as they had access to the meanings and/or definitions, either in the course manual or the marine theme readings. They were also very much aware of the meanings of words commonly used in the discipline of biology, such as *species, invertebrates, symmetry and structure.* They were aptly able to define these words in the context of science and, specifically, in the context of the marine theme and in relation to the marine organisms under study. Their quick responses to the meanings of such words were suggestive of prior knowledge. These words were thoroughly reinforced by Lara.

However, some of the more common or everyday words, as well as unfamiliar English words interspersed with technical words, were either given minimal or no attention by the tutor in the practical. Where words were mispronounced (which meant that their meanings were changed), the tutor merely corrected the students' pronunciation of them. An outline of these challenges as they featured in the laboratory practical is given in Textbox 2 below:

(After the briefing session in the practical)
Lara: So, what is this organism? Yes, Mr Duma[85]?
Mr Duma: Octopus
Lara: Yes, good. You know it's one octopus and two … what?
(*Several students respond that the answer was '*octopi'*).* Octo**pi** (Lara *emphasizes syllable* 'pi') Now, you know that the octopus is a **Cephalopod** *(emphasizes pronunciation twice*) To what phylum does the octopus belong?
Justice: Mollusca

[84] The observation of lectures, laboratory practicals, tutorials and field trips which I had personally undertaken forms part of the data collection in this study. It is through such observation that student participation has been reflected.

[85] Students' surnames and/or first names in this text box and in all other data in this study have been changed to protect their identities and to conform to ethical considerations.

Lara: *(nods)* That is correct. It is classified as a mollusc. (*Repeats and emphasizes* **'mollusc'** and *writes the word on the board)* In fact, in the notes it says it 'represents the peak of molluscan evolution', hey.
Lara: Okay, Justice, tell me a bit about the octopus … movement, feeding, and So forth. *(Justice does not answer).* Anybody? *(Urges students)* You can look at your manuals for some answers. It'sfine.
Zanele: Got tentacles to grab the prey.
Lara: What types of prey?
Students: *(shout out answers randomly)* crabs … mussels …. Small fish … lobsters.
(Later in the practical)
Lara: Now, the chiton, it belongs to the same phylum and that is …
(*A number of students shout out* 'Mollusc")
Lara: Let's describe it.
Sthembiso: It is flat
Primrose: oval
Sibu: Has eight plates
Zama: protected by spines … bristles (*student pronounces* 'bristles' *incorrectly, emphasizing the silent letter **'t'**)*
Lara: (*corrects student's mispronunciation*) Bristles
Lara; There are many chitons but … which is most common? You can look at your notes, you know.
Nkanyiso: black
Lara: You mean the black chiton? Yes. And how would you be able to recognise this?
Nkanyiso: (*reads)* The girdle is dark and velvety with minute (*pronounces* 'minute' *as* mĭn'ĭt) imbedded bris ... er … *(stumbles over pronunciation)* bristles.
Lara: Eh … (*Writes* 'minute' *on the board*) Who can pronounce this? (*Shouts of* mĭn'ĭt *from students*). mīnyoot. Minute bristles. What does minute (mīnyoot) mean*? (No response from students)* Do you know? How many of you know? *(No response)* It means very small, tiny.
Lara: Now, tell me a bit about its feeding"
Philisiwe: *(reads out)* Chitons are grazers that rasp algae from the rocks.
Lara: Right … **algae** *(emphasizes pronunciation)*. It's al**ga** and al**gae** *(Lara emphasizes the syllables).* And how is this done?
Philisiwe: With the tongue and teeth to 'scrap' (*incorrect pronunciation of* 'scrape') the food.
Lara: to 'scrape' … *(repeats)* 'scrape' food
(Much later in the practical)
Lara: Now, for the anemone. (*Writes the word on the board and emphasizes the spelling and pronunciation).* It belongs to … the phylum?
Fortunate: Cnidaria (*Lara writes word in print form on the board, syllabifies, pronounces and emphasizes it)*

Textbox 2: Lesson Observation B

In the observation of the practical, it was not possible to gauge whether the students struggled with the pronunciation or meanings of the technical words related to the marine theme. This was mainly because Lara paid specific attention to words such as *octopi, cephalopod, algae, anemone* and *Cnidarian.* There was evidence of the challenges of the pronunciation of everyday words such as *minute, bristles* and *scrape* as students stumbled over them. Lara merely pronounced the words *bristles* and *scrape* correctly without offering any clarification of their contextual meanings. There was evidence of students' mispronunciation of the non-technical word, *minute,* used in the context of description of size i.e. *minute* bristles. There was distinct confusion over both the pronunciation and meanings of *minute* in the context of the sentence. It was pronounced as mĭn'ĭt (the noun, illustrating time) rather than as mīnyo͞ot (the adjective, to show size). Almost all the students (judging from the number of raised hands) had not known the latter contextual meaning of *minute.* The contextual meanings of unfamiliar or infrequently-used words (*rasp; imbedded*) or phrases that were contextually more difficult *(peak of molluscan evolution*) used in English were overlooked in the laboratory practical.

The purpose of highlighting the issue of vocabulary in this study is to show how DSs can neglect non-technical and everyday words that find their way into science texts despite the fact that understanding their contextual meanings is crucial for reading comprehension. This study illustrated, furthermore, the FP students' difficulties with pronunciation. But, the aim of drawing attention to vocabulary issues was to show that the language in science can present difficulties for EAL students, especially when used in lexically dense, non-scaffolded science texts, as was the case in this lesson.

According to the DSs involved in teaching foundation biology, FP students *"lacked the initiative to read"*. Lara explained that lack of pre-reading *"impacts on* [students'] *time management* [in respect of completion of the practical] *and the quality of their answers because they rush through or scan through those* [readings]*".* In a review of the answers to a foundation biology practical, Lara alerted the FP students to the way in which poor reading can impact on the type of answers that had been provided. Using the following question included in the practical task: 'Cephalopods both kill and eat other organisms, and are eaten themselves by larger organisms. Find a sentence on page 37 that describes this ecological role', Lara showed students how lack of attention to the reading of a text can result in a question being answered incorrectly. For this study, Lara's explanation in the practical has been diagrammatically illustrated in Textbox 3 on the following page:

Question

Cephalopods both kill and eat other organisms, and are eaten themselves by larger organism

1ST Clue
What is the word for an animal that kills and eats another animal?

2nd Clue
What is the word for an animal that is hunted and killed for food?

Find a sentence on page 37 that describes this ecological role.

Where to find the answer – which page?
*And it is **1 sentence.***

Expected answer:

"As a class, cephalopods play a key role in food webs of most marine ecosystems since they fill niches as both *predator* and *prey*."

Answer to 1st clue

Answer to 2nd clue

ecological role

Most commonly quoted answer provided by students

"As a class, cephalopods play a key role in food webs"

This answer is incomplete. It is missing the most important part of the answer – in the marine ecosystem, the cephalopods are predator and prey.

Textbox 3: Lesson Observation C

A feature of Lara's lesson particularly pertinent to this study was probing the students for reasons why they had not read. Some of the common reasons that had surfaced from the group of students were *"hard words"; "no time"; "*[we were] *learning for our* [foundation] *tests"; "too much to read"; and, "I like to do calculations".* (Since Lara had not directed the question to specific students in the group, these reasons were randomly blurted out from across the group).

Reading lexically-dense texts without any support in the form of scaffolding process in the disciplines of science could very likely be a reason why the majority of the FP students are reluctant to read in advance. This stands in contrast to the situation in SCOM where Cindy explained that "*in SCOM students don't give us a problem when it comes to reading in advance – they're okay because the texts are rewritten and nicely scaffolded*[86]*"*. The SCOM class is characterised by teaching students to read science texts as expressed by Sudeer: "[the AL tutor] *gets the students to read a text and to read parts of a text in class.* [T]*he idea is that they* [the students] *read information, they process it, we* [the ALSs] *teach them how to read, how to deconstruct a text".* These comments by the ALSs illuminate the

[86] Appendix 1 has a sample text is rewritten for SCOM. Appendix 2 has texts that are scaffolded.

fact that with appropriate assistance, FP students are able to engage with science texts. (Teaching students to read in SCOM has been discussed in Chapter 6. Appendix 2 is a sample of the scaffolded reading text. Appendix 21 shows how Sudeer taught reading). Similarly, Lara is also in praise of "*one or two diligent students who will go through the* [scientific] *readings* ... [y]*ou can tell by their answers who has done proper reading*". Students learn to read in SCOM; if the FP students are expected to read to learn, it is imperative that they are appropriately apprenticed to do so. Responses from DSs in this study have indicated an awareness of the FP students' challenges with reading in science and the ways in which the students attempted to cope with the challenges as expressed by Lara in the excerpt below:

> "*We've had students who actually complained about the readings and the reading exercises. They found the reading tasks difficult. We've had some students who admitted last year that they copied some of the exercises from their friends because they just could not go through the readings. It was just a pain for them to go through so they copied from their friends*" (Lara).

In addition to this, the feedback from module evaluations was an indication of the challenges confronting the FP students: *"In our* [foundation biology] *evaluations, 50% will admit they haven't read the notes"* (Teresa); *"in evaluations of the* [foundation chemistry] *course at least 40% will state that they did not read the entire manual* (Dennis); *"we had a specific question asking them if they thought language was a barrier to their performance in* [foundation] *biology and we had 58% that actually agreed with the question"* (Lara). If the DSs are armed with this knowledge, then what should follow is that the reading texts which the FP students are expected to read both independently and as part of class work, be revisited and amended so that they are made accessible to the students. Doing so would serve the added advantage of enabling participation in science discourse. In addition, students need support (such as scaffolding) to execute tasks that they were unable to do unaided. This could thus reduce students' tendency to avoid reading the texts; and their reliance on copying answers from perhaps more capable friends as a coping mechanism (as communicated by Lara in a quoted response above) when they have trouble engaging with the texts and are under pressure to submit tasks for assessment.

Exposure to lexically dense academic texts in science is unavoidable at tertiary level. The data has shown the challenges presented by non-scaffolded science texts to which students have had little exposure. Complex texts require "supported practice to allow learners to develop reading and writing skills that they can then use independently" (Rose *et al.* 2003:

41). It is thus imperative that students in the FP are taken through the stages of ZPD through modelling and support. Successful engagements with exceptionally dense academic texts in science require scaffolding to help students navigate their ZPD and extend current knowledge and skills. The students need to ease their way through each stage of the ZPD until the task is "internalized, automatized and accomplished without assistance" (Gallimore and Tharp, 1990: 183) and with competence.

7.1.3 Nominalisation in science texts

Nominalisation features prominently in written language, i.e. the registers of technical and academic discourse such as science texts to convey science discourse. This is primarily because science texts are precise, specialized and objective. Lexical density, and thus nominalisation, is the consequence of GM which is a "variation in the expression of a given meaning" (Halliday, 1994: 342). Nominalisation represents events and qualities, not as verbs, adjectives and adverbs, but as nouns. Nominalisation is frequently used in scientific texts as cited in each of the examples below which was lifted from each of the science disciplines offered in the FP. The reason for drawing attention to them in this study is to show that nominalisation is characteristic of science texts and therefore unavoidable. In the extract below, for example, which has been taken from the foundation physics notes, a nominalised verb changes from an action (e.g. accelerate or metabolize) into a concept (e.g. acceleration or metabolism), also functioning as nouns, which results in information packaging:

> Now that we understand the meaning of speed and velocity, we need to be able to describe how quickly objects accelerate (speed up) or slow down. **Another term that is needed for describing different kinds of movement is acceleration** [emphasized in bold in the text]
> (*Foundation Physics*: Kinematic Notes, 2011: 29).

Similarly, in foundation biology, the students had to decode the following text which contains the example of nominalisation of 'metabolize':

> In this experiment, you dissolve sugar in water and add the yeast. Then you leave the mixture at a specific temperature and allow the yeast to **metabolize**. After a certain amount of time, you measure the volume of the CO_2 foam bubbles that has been produced. The greater the volume of foam, the more active the yeast **metabolism** (*Foundation Biology:* Scientific Method, 2011: 39).

Common in mathematics is the use of the nominalisation of verbs to nouns, e.g. where **estimate** becomes **estimation** or **divide** changes to **division**. However, there is also the change of adjectives to nouns like the use of **"wide"** and **"width"** as shown in the example below:

> A corporation plans to locate its headquarters in a new rectangular one-storey building to be constructed. They need 30 000m^2 of floor space. In addition, they would like to have a walkway 15m wide at the front and back of the building and a grass area 20m **wide** on the other two sides. Determine the length and **width** of the plot of smallest area that can be used (*Foundation Mathematics*, 2011: 153).

An example of nominalisation in foundation chemistry:

> Copper **precipitates** out of copper sulphate solution. **Precipitation** is the formation of an insoluble product by mixing two aqueous solutions of compounds (*Foundation Chemistry*: Lecture Notes, 2011: 68).

Nominalisation creates some measure of difficulty because of its reliance on abstract nouns such as 'metabolism' and 'precipitation' used in the examples above rather than the use of active verbs, e.g. 'accelerate'. Bulman (1986: 23) states that active verbs are easier to read, recall and comprehend than abstract nouns formed from the verb. The verb, **metabolize** (see example above) can be turned into the noun, **metabolism**, enabling it to be modified and expanded (e.g. **yeast metabolism**). According to Fang (2004), "when an action or an event is reworded as a nominal group, much of the semantic information becomes [lost, or rather,] hidden and ambiguity often sets in" (340). Simply explained, nominalisation conceals the action of a sentence in a noun.

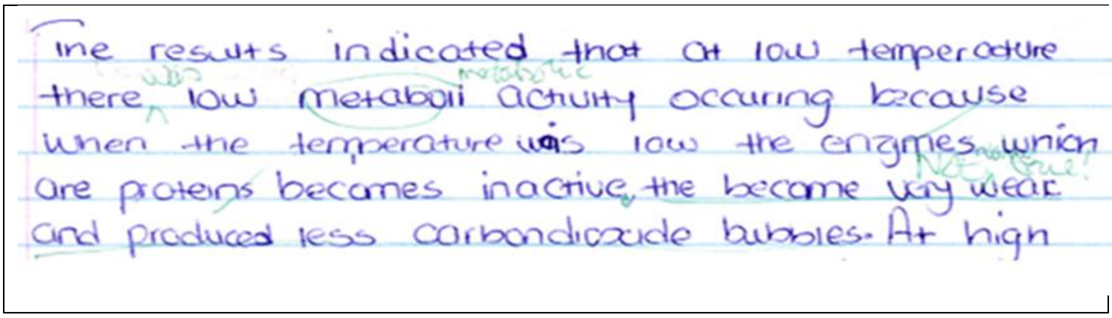
Nominalisation allows for information density and referential linking that builds in the construction of a text. When students are not familiar with this type of texts, they have difficulty identifying the precise referents of nominalised phrases. Texts that are heavily nominalised need careful reading, especially if meanings are obscure. They would have to deal with locating meanings and unravelling the ambiguity. Such texts present major difficulties for students who do not have a thorough understanding of the way nominalisation operates in scientific texts. The students would have to focus on the meanings of these nominalisations to understand what they refer back to (e.g. width → wide) for a better understanding of the text. In addition, science texts contain more relational processes that require greater reading and comprehension skills. This can present problems for EAL students, especially if they have pervasive difficulties with reading and comprehending science texts.

With regard to the use of 'metabolism' in foundation biology, this study has shown that the majority of the students displayed a clear understanding of this concept in their scientific reports, even to the point of some of the students defining it unproblematically in the introductions of the scientific reports. This definition (as well as other technical words relevant to the topic) was thoroughly and deliberately explained during the laboratory practical on 'Yeast Metabolism' as shown in the extract below (Textbox 4) from the observation of the practical:

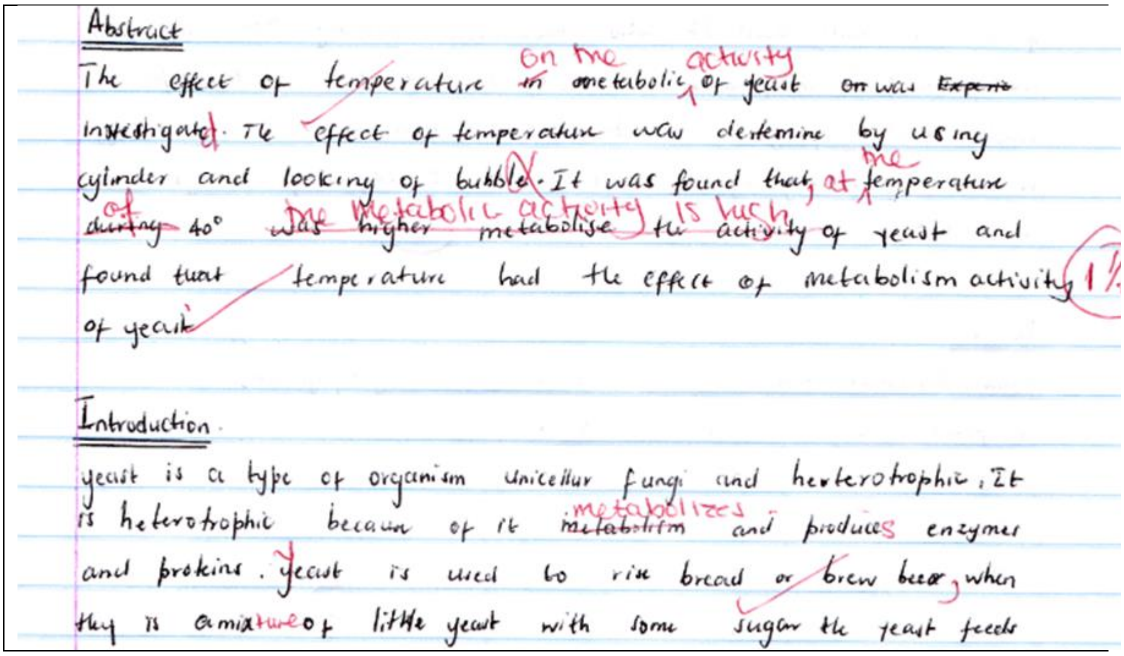
Lisha: You're going to do the experiment where we measure the metabolism of yeast at a range of different temperatures. What do we use yeast for?
Philani: Making beer *(Students laugh)*
Lisha: Yes, that's right, good … we use it to brew beer. Please don't try and make any beer here today *(class erupts into laughter)* Okay, what else do we use it for?
Zinhle: To make bread.
Lisha: Absolutely, to make bread rise and then we bake it. Now, yeast is a living organism, okay. And it is a unicellular fungi ... meaning what?
Several Students *(in unison)*: Has one cell.
Lisha: Good. Besides that, the yeast is also heterotrophic. What's heterotrophic? Yes, Sibo?
Sibo: an organism that can't make its own food.
Lisha: Good. An organism that cannot make its own food and requires preformed organic molecules as food *(Writes this on the board and underlines it)*. Remember that … for your report. Right, now in this experiment, you can see on page 39 you will have to dissolve sugar in water and add the yeast. Now, what takes place is metabolism (*Writes this on the board in capital letters and circles it)*. That is a very important concept for this experiment. So, what is metabolism? Who knows?
(Some of the students respond). Metabolism is the sum of all chemical activities of an organism.
(Writes this in bold and reads it) You can copy that *[points to the definition]*. Now, what you do is, you leave the mixture at a certain temperature to metabolize. Now as metabolism takes place, CO_2 and ethanol are released … given off. Then, after a period of time, you measure the volume of CO_2 in the foam bubbles produced. Now yeast metabolism is controlled and helped by enzymes. So, what are enzymes? *(Writes the word on the board)*
Thobeka: chemical catalyst
Lisha: Ja, enzymes are chemical catalysts that speed up chemical reactions. These enzymes are proteins which become inactive at low temperatures and they are **denatured** (*Lisha's emphasis*) at high temperatures. Denatured *(spells as she writes it on the board)* means … destroyed.

Textbox 4: Lesson Observation D (Student Group B)

The challenge of nominalisation experienced by 60% of the students was apparent in their scientific laboratory reports, especially with the use of the verb or the process word 'metabolize' and/or the adjective 'metabolic' (as reflected in the extracts 1 and 2 from students' scientific reports below). The use of neither of these forms of words was made explicit in the laboratory practical despite students needing to use them in their explanation of yeast metabolism. Furthermore, the process word ('metabolize') was used in the laboratory practical. The DSs cannot assume that students will acquire understanding of words without paying explicit attention to the ways in which they are used in the context of the topic. Since nominalisation is a key feature of scientific writing and needs to be understood by the FP students so that they are able to read and understand science texts, it is imperative that students are familiarised with it as they would also need to be able to use it in their own scientific writing.


The results indicated that at low temperature there was low metaboli metabolic activity occuring because when the temperature was low the enzymes which are proteins becomes inactive, the become very weak and produced less carbondioxide bubbles. At high
Not true!

Extract 1: Scientific laboratory report of Hlaulani, a FP student


Abstract

The effect of temperature in metabolic on the activity of yeast on was ~~Experi~~ investigated. The effect of temperature was determine by using cylinder and looking of bubble. It was found that at the temperature during of 40° was higher metabolise the metabolic activity is high the activity of yeast and found that temperature had the effect of metabolism activity of yeast 1½

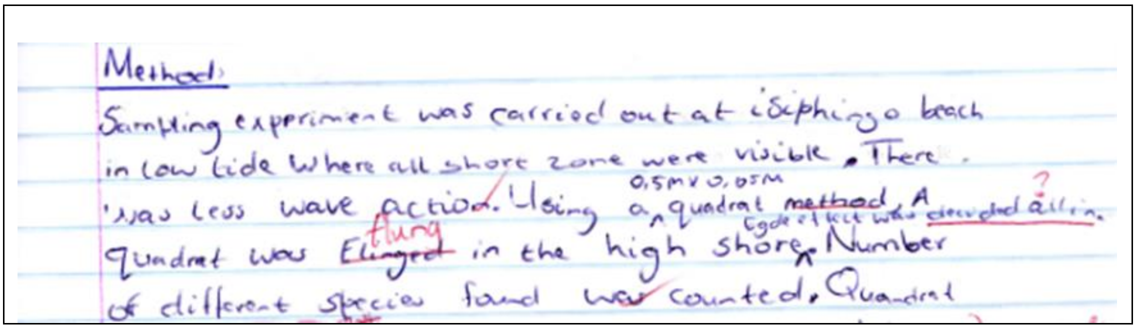
Introduction

yeast is a type of organism unicellur fungi and herterotrophic, It is heterotrophic becaus of it metabolism metabolizes and produces enzymes and protiens. yeast is used to rise bread or brew beer, when they is a mixture of little yeast with some sugar the yeast feeds

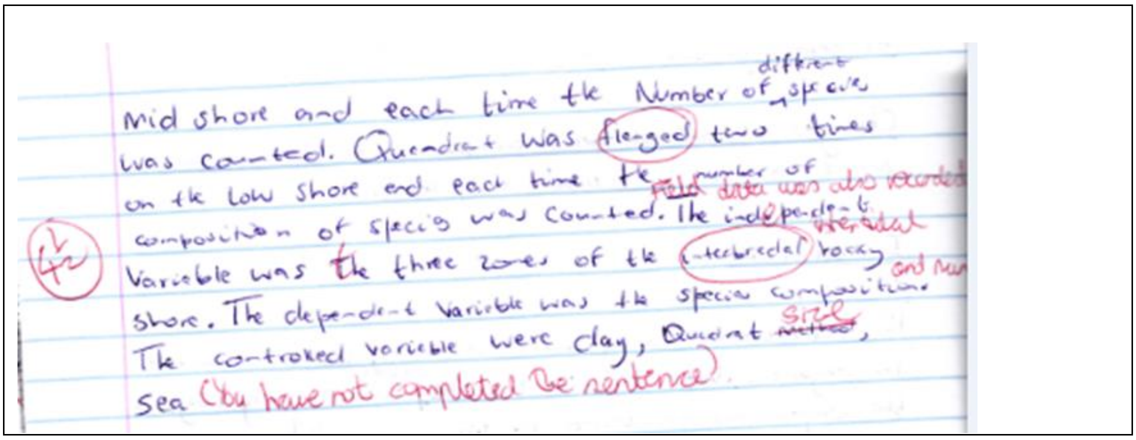
Extract 2: Scientific laboratory report of Mondli, a FP student

In the extracts of students' work above, there was evidence of confusion with the use of 'metabolic' and 'metabolize'. The marker had authoritatively corrected each of the misused words. A similar situation arose with the use of 'flung' in the scientific report based on "Composition of animal species in the inter-tidal regions" in foundation biology. In extract

3 below the incorrectly used word, ‘flinged’ was merely struck off and the correct use of the passive voice verb (‘flung’) was written above while in extract 4, the incorrect word (‘flenged’) was merely circled. What was needed in each of the errors isolated in the scientific reports was to move away from merely correcting students’ grammatical errors to actually assisting them in expanding their repertoire of grammatical forms. According to Lara, the misuse nor the grammatical function of these words was *“unfortunately”* not clarified upon the return of the students’ marked scientific reports, showing that an opportunity to dispel grammatical inaccuracies was completely missed.


Method:
Sampling experiment was carried out at iSiphingo beach in low tide where all shore zone were visible. There was less wave action. Using a quadrat method, A 0,5M x 0,05M quadrat was ~~flinged~~ flung in the high shore. Number of different species found was counted. Quadrat

Extract 3: Scientific laboratory report of Siboniso, a FP student


Mid shore and each time the Number of different species was counted. Quadrat was flenged two times on the low shore and each time the number of field data was also recorded composition of species was counted. The independent variable was the three zones of the intertidal rocky and ... shore. The dependent variable was the species composition. The controlled variable were clay, Quadrat size, sea (You have not completed the sentence)

Extract 4: Scientific laboratory report of Nonhlanhla, a FP student

In an observation of Jessie’s foundation chemistry lesson on the topic ‘Precipitation Reactions’, all of these words were used: ‘precipitation’, ‘precipitate’, ‘precipitates’. However, there was specific focus on the key concept of ‘precipitation’. At the start of the lesson, Jessie asked the students if they knew what was ‘precipitation’. The response from the class was a thunderous echo of a memorised textbook-definition of the concept. Even though there were several references to the word ‘precipitates’ in the context of the topic, there was no attempt made by Jessie to explain its meaning nor to distinguish between ‘precipitates’ and ‘precipitation’.

7.1.4 Comprehension

With the language of science being conceptually dense and heavily nominalised as shown thus far, and the fact that academic texts (used by DSs in this study) are written in English and the LoLT at UKZN is English, the presence of barriers to the comprehension of textual material in science by students for whom English is an additional language, is highly likely. This is what Bernhardt *et al.* (1995 cited in Snow and Brinton, 1997: 315) refer to as ‘double jeopardy’. Research around this issue has been amply undertaken (Ramorogo and Wood-Robinson, 1995; Rollnick, 2000; Johnstone and Selepeng, 2001; Block, n.d.; Prophet and Badede, 2006). In this study, the FP students’ ability to comprehend science was explored via their written responses to questions in their laboratory practicals and their tests; and the way in which they engaged with questions in the lectures, tutorials, the laboratory and/or the field (i.e. the research site). Therefore, this study necessitated a reference to the students’ interpretation of question types in science and the presence of any perceived challenges in engaging with them.

7.1.4.1 Interpreting Question Types

The FP students’ challenges with reading comprehension were noticeable by the way in which they answered questions on various marine organisms in the foundation biology practical called ‘Mode of Life’. With reference to this practical, this study had shown that 95% of the students were able to answer with ease and accuracy, the simple, straightforward literal, surface-level type of questions (viz. *What?*) where they had to retrieve answers from the readings. In terms of Bloom’s Taxonomy (Bloom *et al.* 1956), questions such as these, at the lowest level of hierarchical categories in the cognitive domain, are at the test Level 1 category of ‘knowledge’. Below are examples of such questions in the task based on the readings on ‘Molluscs: Octopus’:

- What does an octopus feed on?
- Cephalopods have special cells called chromatophores in their skin. According to the text, what are these cells for?
- What are the ink glands of a cephalopod used for?

The observation of the tutorial on this practical had shown that students were able to find the answers easily to these types of questions by merely locating the key words (i.e. *feed*; *chromatophores* and *ink glands*) used in the questions within the reading text. This was also applicable to questions on other organisms in the same practical exercise. For example, in the questions below, locating the answers in the texts on *Crustaceans* and *Chitons* was guided by looking for contextual clues such as the key words, *sessile* and *feed,* especially in texts where these were explicit. Providing the meaning of 'sessile', as a cue in the question below helped with locating the answer and minimizing the possibility of misinterpretation of the question.

- Which of the crustaceans cannot move (is sessile)?
- When do chitons feed?

Data has indicated that 'skimming and scanning' science-based reading texts have been the type of reading strategies developed and reinforced in SCOM. Reference to this was communicated in a point made in an SCOM academic report (Board of Studies: 2010) that "readings texts were used to teach skimming, scanning, extracting information, summarizing and paraphrasing, note-taking and mindmapping" (SCOM Report, Board of Studies: 2010). This point was by further highlighted by Sudeer who explained that *"we* [ALSs] *teach them some skills like scanning and skimming for answers and for information in the science reading texts"*. However, it was not possible in this study to ascertain whether such transfer of understanding of the reading strategies learnt in SCOM and applied to the science FP disciplines was attributed to SCOM. This was mainly because these reading strategies, according to Cindy *"were not taught as a formal lesson but more as a* [informal] *strategy to test oral reading comprehension during class discussions".* However, Appendix 21 (an observation of a lesson in which Sudeer teaches reading) does show some reference being made to skimming/scanning.

However, the challenges with answering questions in science arose when they were denser, more conceptualized and the answers had to be inferred from the text. Academic reading involves "critical thinking and creative thinking" (Fisher, 2001:193) and in-depth comprehension. This study has shown the challenges of close reading of texts in science. One of the obstacles was strategy awareness – how to retrieve information required by the criterion task (Anderson and Armbruster, 1984). Another was locating information that was not implicit in the texts and which required close attention to information in the texts.

These challenges were apparent in the way students handled questions in their foundation modules outlined in the examples below.

A recurring problem involving questions with two parts was that students did not answer both parts of the question. They answered either part 1 or part 2 of the question. This was applicable to 65% of the students. According to the analysis of the data, there was a general tendency to answer the part of the question that was easy to lift off the text by following contextual clues. An example of this was the following type of question based on the reading of the *Anemones*: '*What are the specialized stinging cells called* *and* ***what are they used for****?'* [my emphasis]. This was how the information to this question was presented in the reading text:

> The tentacles are packed with microscopic stinging cells, called nematocysts. When anemones touch and taste food, the stinging cells paralyse and entangle their prey (*Foundation Biology* Readings, 2011: 29).

The answer to the first part of the question above '*What are the specialized stinging cells called'* (which has been underlined in this study for emphasis) was clearly expressed in the text and easy to locate. This was mainly because of the contextual clue 'stinging cells, called nematocysts' which directed students to the correct answer. However, because the second part of the question '***what are they used for'*** (typed in bold script for emphasis in this study) was based on a sentence that began with a relative clause (using the relative adverb 'when') which involved some measure of inference and was not as direct and straightforward as the first part of the question, students had trouble in locating the answer. In fact, 55% of the students had not provided an answer to the second part of the question.

This study has also shown instances where questions are relatively easy to understand but locating their answers in the text was particularly problematic. One such example is the following question based on the readings on the *Octopus*:

> Question: How does an octopus find and catch its food?
> Expected answer: An octopus has excellent eye sight, which helps it find its prey. It attacks its prey by grasping it with its sucker covered tentacles. The eight arms hold the prey while they eat it. Some species inject a poison into their prey (Mode of Life Memo, 2011).

The information in the reading text appeared, under headings (which were in bold print in the reading text) as follows:

Feeding An octopus attacks its prey from close proximity, grasping it with its arms and injecting a poisonous substance into it. Octopuses feeding on mussels will make a small hole in the shell before injecting the toxin into the animal's tissues. In some species of octopus, like the blue-ringed octopus of Australia, the toxin that is contained in the animal's poison glands is so deadly that it is capable of killing a person within minutes! **Highly developed senses** One of the most remarkable features of octopuses is that their eyes are very advanced. With a cornea, lens, iris, pupil and retina, their eyes resemble the human eye, although it is quite likely that octopuses' sight is superior to humans'. This is because the nerve cells run behind the retina and so octopuses do not have a 'blind spot' as we do where our optic nerve leaves the eye *(Foundation Biology* Readings, 2011: 40).

Fifty three percent of the students were able to answer the question on how the octopus catches its food by following two contextual leads in the text: 1.) the heading '**Feeding**' and; 2.) the specific statement about capturing of prey, viz. "grasping it with its arms and injecting a poisonous substance into it" (*Foundation Biology* Readings, 2011: 40). But, 9% stated that the octopus catches its food by "close proximity", which indicates that they did not understand the meaning of this phrase. Another 7% claimed that it catches its food by hiding in holes. This was on account of this statement from the reading text: "When escaping from predators, octopuses will shoot ink out of their funnel, rapidly change their colour and escape to a hole where they can hide" (39). On the question on *how* the food is found, students were supposed to have located the answer under the heading **'Highly developed senses'** where they were meant to infer from the statement "one of the most remarkable features of octopuses is that their eyes are very advanced"; the fact that the octopus uses its good eyesight to find its prey. However, students had much difficulty linking this scientific fact about the octopus's excellent sight with its ability to find food. They had difficulty making connections with and deductions from information in the texts especially because it was not explicit. Answers to these questions were clarified/discussed after the laboratory practical had been conducted. According to Lara, the review of the answers usually involves the questions that were really *"poorly answered"*. In this review of the Mode of Life practical, words and phrases that warranted discussion were 'paralyse and entangle'; 'grasping'; 'injecting'; and 'close proximity'.

To be able to answer questions based on reading texts easily and successfully, students should be able to read, infer, interpret and synthesize what they have read. As stated in the beginning of this discussion to critical question 2, a combination of decoding and comprehension competencies are essential in reading. “Skill in decoding establishes the atomisation of lower-level perceptual and linguistic skills which facilitate the operation of higher-order comprehension processing” (Pretorius and Machet, 2004: 133). In the FP, students had trouble decoding and comprehending non-scaffolded texts which they were expected to read independently, from where they had to search for conceptual knowledge in order to answer questions based on the texts which they had to interpret clearly and correctly.

Students who are learning science in a non-native language need to be proficient in the language of learning as well as the language of science. To counter the challenges that questions can present to EAL students, DSs should re-consider the way in which questions such as those that are double-barrelled are framed so that the objective of the specific task is achieved. In the examples of the questioning technique cited above, each part of the question could have been posed separately. It is also crucial that students are gradually apprenticed into varying question types, from the simple to the more complex. The DSs teaching FP students need to take cognisance of the FP students’ educational backgrounds which were characterised by inadequate exposure to reading material and reading strategies (Heath, 1994; Pile and Smythe, 1999; Rose, 2005a; Mgqwashu, 2009). In a study which investigated the relationship between readability of questions and South African learners’ poor performance in TIMMS (2003), Dempster and Reddy (2007) have identified “[t]he inability to comprehend the language of the questions” (910) as being one of many factors.

This study has shown that interpreting questions was not only confined to the science disciplines in the FP. Evident in the SCOM course manuals is the exposure of students to a variety of question types based on reading texts. These questions are used to consolidate students’ understanding of the content of the reading texts (See Appendix 26). The data below shows students’ responses to the following question in a SCOM test based on a text on *Biofuel:*

> Question**:** List five advantages of biofuel, with a brief explanation of why each is an advantage.
> Expected Answer:

Advantage	Explain why each is an advantage
1.reduces greenhouse gases	so we don't increase carbon in the atmosphere because plants use atmospheric CO_2 to grow and this is released when biofuel is used; fossil fuel releases CO_2 that was buried under the ground
2.reduces dependence on petrol	which is rising in price
3. biodegradable	so not a problem if it spills, unlike oil
4. increases rural development	greater demand for agricultural product
5. sustainable	unlike oil and coal which will eventually be used up

(*SCOM* Test Memo: Biofuel, 2011)

According to the data, only 30% of the students attempted to answer both parts of the question: 52% of the students attempted to provide an answer relating to the advantages of biofuel (which were all not necessarily correct) without furnishing reasons and 18% left the question unanswered. A few of the advantages of biofuel were easy to locate in the text while others had to be fathomed. In this regard, Pretorius (2000a) explains that reading is a meaning construction process and [m]uch of the information we derive from texts is not always stated explicitly but is deduced – via the making of inferences. In this type of question students were expected to 'explain why'. They needed to understand and justify each advantage that they had identified from the text. This type of question is complex and falls in the evaluation level (V) of Bloom's taxonomy (Bloom *et al.* 1956). It tested comprehension, i.e. students had to illustrate understanding. According to Snow (2005), one of the components of academic discourse that contributes to academic success is the ability to think critically. A reflection of the way this question in this study was handled indicates that students were challenged by the ability to think critically. This conclusion was drawn from the fact that a number of students who answered the part of the question dealing with the advantages simply extracted an entire paragraph from the reading text where they found the word 'advantage' as shown in the following example:

> A. One advantage claimed for biofuels is that they produce energy without increasing carbon in the atmosphere. This is because while they were growing, the plants removed CO2 from the atmosphere. In contrast, fossil fuels return carbon that was stored underground for millions of years back into the atmosphere. Therefore, biofuel is, in theory, less likely to increase greenhouse gases in the atmosphere. However, some people doubt that this benefit can be achieved in practice (*SCOM* Test: Biofuel, 2011: 7).

Analysis of the data indicated that half the number of students was able to understand the scientific reasons behind the use of biofuel as an energy source especially since they were able to identify the following advantages from the text:

- 'One advantage claimed for biofuels is that they produce energy without increasing carbon in the atmosphere';
- 'This is because while they were growing, the plants removed CO_2 from the atmosphere';
- 'Use of biofuels reduces dependence on petrol which benefits a country by making it more secure in its energy requirements' and
- Another advantage of biofuels over other fuels is that they are biodegradable, and less harmful to the environment if spilled' (*SCOM* Test: Biofuel, 2011: 7).

According to the data, students lost marks for copying sentences verbatim from the text rather than 'listing'; and for including irrelevant information that had little to do with the advantages of biofuel such as the following statement: *"However, some people doubt that this benefit can be achieved in practice*". The data had illustrated the challenges associated with interpreting task words, responding critically and answering succinctly. These challenges need to be understood in light of the rote learning and the uncontested and uncritical approaches that had characterised the students' educational background. Guiding students to infer from and respond critically to science texts is crucial at HE level and needs to be developed.

7.1.4.2 The Challenges of fulfilling the Requirements of Task Words

Data from the interviews had shown that besides the problems with comprehension, the DSs were very much aware of the challenges facing FP students with interpreting the demands of tasks and questions. Lara outlines this in the following response: *"Sometimes they don't even understand the question. And they will say 'I didn't understand the question'. It's not that the question was vague ... they just could not understand what the question was asking for".*

Lara's reference to students' responses that "*they just could not understand what the question was asking for"* is primarily because of the difficulty at interpreting the meanings and requirements of task words (or action verbs); also referred to as "key terms" (Bearne, 1999: 62); or "operative words" (Bulman, 1986: 188) used in questions given in laboratory practicals, tutorials, assignments, tests and examinations to communicate science discourse and to show evidence of understanding of content knowledge. Wilson (1999) offers a thorough expansion of these words, distinguishing between metalinguistic verbs (e.g. *define, describe* and *explain*) and metacognitive (e.g. *predict, calculate* and *deduce*) verbs. Students need to show an understanding of the meanings of these verbs in both written and oral contexts in science. The inability to distinguish between any of these task words can compromise student performance in any assessment task as conveyed by Susan: *"Well sometimes they can lose marks because they misinterpret the question. They don't understand what you've asked them and they answer something else".* In support of this claim, she referred to the following question: 'Compare and contrast work and energy'. She then explained that*"*[the students] *don't realize that 'compare' means similarities* ***and*** [participant's emphasis] *differences. Because they don't know that, they only answer half the question which is generally the similarities*". This comment draws attention to the point that students have perceived understandings of words. Gilbert and Osborne (1980) mention that a subtle but problematic issue in the teaching and learning of science is where "a student believes that understanding of what has been said or read has been achieved, but where this understanding or interpretation is quite different to that which was intended" (664). DSs cannot assume that students understand the meanings of these task words. A task word used in a rubric that is likely to be an obstacle to students' understanding needs to be clarified. Students need to be inducted into the appropriate literacy practices. If the DSs are challenging students by expecting them to 'compare and contrast' which fits into Level IV (analysis) of Bloom's Taxonomy (Bloom *et al.* 1956), then they would have to induct them into it; the way they test is the way in which they need to teach.

The sciences rely heavily on processes, scenarios and situations that need to be explained, described, predicted or even justified. How these need to be answered are determined by the task words used in the question. To prevent students from being penalized for not understanding task words used in a question (as explained by Lara and Susan above), it was important for them to have been guided as to the interpretive demands of the task words. Academic discourse is context-specific and is best taught within specific disciplines, but with task words being generalized across disciplines, it should be the responsibility of all the DSs to clarify their meanings and the expectations that they command in any assessment. DSs should not totally exonerate themselves from blame for students' misunderstandings as "in many cases, academics are themselves so immersed in their disciplines, as to be unaware of the specificity of the cognitive and linguistic demands they are making" (Kapp, 1994: 114). The role of the DSs is aptly summed up by Susan's response: "*If you* [the tutor] *explain what you wanted, they'd* [the FP students] *probably have understood. Basically they needed such intervention from the tutor"*. Susan's response needs to be put into practice. The 2011 course manuals in the science modules in the FP has shown no inclusion of a list of task words. Ideally, SCOM could serve as a suitable domain where the task words can be clarified especially since the course is designed to include reading comprehension questions and exercises (of varying types and levels) at the end of each scientific reading text. Examples of these have been extracted as they appeared in the SCOM course manuals and have been illustrated in the table below. However, a list of task words had not featured in the SCOM course manual either.

3. Describe two consequences of global climate change for the coastal regions of Egypt. 8. List three consequences of this population growth in the Nile Delta. Task: Demonstrate your understanding of what you have learned from this article in a mindmap. (*SCOM,* Semester 1, 2010: 37, 39)
2. Briefly describe your understanding of sustainability as it is used in this article. 9. In your own words, compare resource conservation and resource recycling. (*SCOM*, Semester 2, 2010: 42, 54)
Task: Using the reading paraphrase what are natural disasters. 4. Outline the 5 major areas that are crucial to communicable diseases transmission. 9. Suggest 3 ways that disaster related interruption of services could result in disease. (*SCOM,* Semester 1, 2011: 35, 36)
4. Comment on the link between yeast growth and oxygen. 8. Do you agree with the following statement: 'Monitoring wine fermentation process in absolutely important?' Motivate your answer by substantiating from the text. 4. Highlight the importance of temperature control. (*SCOM,* Semester 2, 2011: 36, 37, 40)

Types of Comprehension questions/tasks featured in SCOM

Expecting students to 'predict' is a common practice in science experiments and in terms of Bloom's Taxonomy (Bloom *et al.* 1956) falls within the Comprehension Level II. To be able to 'compare and contrast' is more demanding and falls within the Analysis Level IV while the ability to 'justify' is at the peak of Bloom's Taxonomy (Bloom *et al.* 1956), i.e. Level VI - the most difficult level - which is the Evaluation Level. Expecting students to 'justify' means exploring reasons for specific answers which requires stronger comprehension and critical thinking and reasoning abilities which need to be well articulated. According to this study, the most common level of testing and the verbs used in testing were confined to Levels I; II and III of Bloom's Taxonomy (Bloom *et al.* 1956). For effective learning, students need to be taken through each level, but it is also necessary for them to get exposure to; as well as support and practice in the way questions are framed at each level if they are eventually expected to work at these independently – when doing class exercises as a form of consolidation of learning and/or answering questions in laboratory practicals, quizzes; tests and examinations. The foundation biology course manual abounds with various question types and exercises (that appear within and at the end of readings) that students are expected to answer, examples of which are shown in the textboxes below. These questions, according to Josh, "*are what the students should be able to answer, as they work through these readings, it's hard for us* [DSs] *to take them through these questions – there's the time issue".*

- List the human sense organs and the stimuli to which they respond.
- Describe why you think the cell is the smallest unit of life.
- Explain why a cell, and not an organelle, is at the bottom of the hierarchy of life. (*Foundation Biology,* Semester 1, 2011: 12-13)

Questions based within readings

<u>What are living organisms?</u>

1. How can we define life?
2. In your own words, explain what the cell theory is.
3. Why is metabolism so important for the survival of living organisms?
4. Suggest a reason why adaptation is important for species survival.

(*Foundation Biology,* Semester 1, 2011: 13)

A sample of questions in an exercise at the end of readings on a topic

At this point, the assertion that the university teachers "tend to use vocabulary as common currency – without explanation or definition, yet with an intended precision of meaning" (Jacobs, 1989: 395) supports the danger of academic staff assuming students know what they are expected to do or how they are expected to answer. The following question: "Give two observations that prompted this investigation" based on a reading text on 'Maize' appeared in a foundation biology test (see Appendix 27A). The data in this study showed that of the 35 students who had written the test in one of Josh's groups, 25 of them had misinterpreted the question. Instead of stating the observations that **initiated [**my emphasis] the research investigation as explained in the reading text, the students stated the observations arising from the experiment conducted **after** [my emphasis] the research investigation (which they extracted from the reading text). Josh's review of the test had pointed out that students had not understood the meaning of ‘prompted’; and had interpreted the words ‘investigation’ and ‘experiment’ as synonyms.

“In the classroom, the implicit [must be] made explicit, so the students are not forced to guess what is in the teacher’s head, and learning is not reduced to a game of hide-and-seek” (Polias, 2004: 4). This study had also shown instances where DSs were so accustomed to using specific concepts in science that they assume that students assimilate these as easily too. Two such concepts were *observation* and *interpretation*. In the foundation chemistry experiment on ‘Titration’ that I had observed, Jessie clarified the expectations of each of these processes in the laboratory as shown in Textbox 5 below:

Jessie: There seems to be a problem with some of the observations you guys are writing. Let’s look at this one *(Reads from a student’s work)* “Colour changes to pink. There is enough base to neutralize the acid”. Now, what do you think about that answer? Sanele?
Sanele: It’s right.
Jessie: Mmmm … *[pause]* What do the others think?
Godfrey: It’s not right.
Jessie: Well, The observation is correct – the colour does change to pink. That is an **observation** (*emphasizes* ‘observation’). But, the second part of the answer – the neutralization part … is an interpretation that you make based on your observation. So, an observation is what you see. And, what’s an interpretation?
Fakazi: like a conclusion
Jessie: yes, a conclusion and understanding of the observation - what the observation tells you and what it means.

Textbox 5: Lesson Observation E

Understanding the demands of task words is essential throughout the FP students’ academic study and should have been cued and supported through scaffolding. This is type of *“intervention from the tutor*” (Susan) that could benefit the FP students. What was needed in the disciplines was a form of “micro scaffolding” (Wells, 1995) assistance which provides the opportunity within a lesson for the DS to test and facilitate understanding of the task word through discourse strategies of questioning, repeating, rephrasing, explaining and providing similar or other examples. These would have been helpful in mediating understanding, helping students to internalize what they have learnt. This would have eventually enabled students to interpret these task words independently. Thereafter, using the task word in a discipline-specific question would serve to test students’ linguistic and conceptual understanding.

Lara cited the example below to show the misinterpretation of task words in a foundation biology practical task:

> Question: Describe the Cape urchin.
> Expected answer: It is round and densely covered in short sharp spines and its colour is variable – either purple, red, green or pink.
> An example of a students' answer: It comes in different colours and is round with spines. The spines and the tube feet help to propel the urchin[87].

In the example above, an analysis of the students' answers indicated that of the 25 students in the group, 55% described the organism **and** [my emphasis] explained the function of its features, which as outlined by Lara, shows a lack of understanding of the key task word 'describe' which had not called for an explanation of its function. Similarly, the following question with a combination of two task words was included in a foundation biology test: **"<u>Describe</u>** and **<u>explain</u>** how the first cells were formed"[88] (October, 2011: 4). Even though the task words in the test were underlined and in bold print, students had trouble with both 'describing' *and* 'explaining'. Thirty percent scored the total mark of three; 18% left the question blank; 45% either described or explained; 7% gave incorrect answers to the question. Lara used the test review time to extend students' understanding of these words because *"they are used so often in questions; if the students don't understand these words, they get the answer wrong"* (Lara). The students were asked to explain their understanding of 'describe and explain'. The only explanation that was volunteered was from one student: which is shown in Textbox 6 below:

Sanjay[*]: <u>Describe</u> tells you about something, like what an organism looks like, if it is big or small or flat. Like the features. And <u>explain</u> tells you how something works or to show how something happened. * Sanjay's home language is English.

Textbox 6: Lesson Observation F

[87] This is one example of the instance where the student described the urchin *and* explained the function of its spines. The range of answers given was similar.

[88] <u>Expected Answer:</u> The oceans were filled with organic molecules, like lipids, carbohydrates, amino acids, proteins, and nucleotides. ✓These organic molecules, the building blocks of cells, ✓ have an affinity for one another and so they clumped together. ✓Chemical reactions occurred between them✓ and nucleic acids were formed with the ability to produce proteins and to replicate. ✓Lipid and protein membranes formed around these organic molecules. ✓Metabolic reactions were now enclosed by membranes and separated from the environment: the first primitive cells had evolved (*Foundation Biology* Test, October, 2011: 4).

The data in this study indicated that specific question words in the English language such as 'describe' and 'explain' do not have matching translations into isiZulu. The following comment from Annah, *"in my language – isiZulu - 'describe' and 'explain' mean the same thing*" (anecdotal evidence from a conversation with Annah) could account for students' difficulty with understanding the meanings of these task words which would determine how the questions were answered. This is a particularly valid point in this study even though it has neither code-switching nor translation as its prime focus. In the preceding paragraph, reference was made to the use of the task words 'describe' and 'explain'. Each of these words has specific meanings in English but is synonymous in their usage in isiZulu. The translation of both these words into isiZulu are exactly the same which are '*Caza'; 'cacisa'; 'chaza'; and/or 'chasisa'* and their English translations are to 'explain/clarify/describe/make clear' (isiZulu.net, 2012). An important point arising from the data is that DSs need to take into account the fact that they teach EAL students and there is the likelihood of there not being equivalent translations of English vocabulary into isiZulu or that the word does not exist in the students' first language. This could be complicating for students especially because they would have to acquire both the word and its meaning in the second language. Therefore, an explanation of the demands/requirements of task words is especially necessary. In science, students are often asked to 'explain' (for example, processes and phenomena)[89].

Due to the challenges of understanding of the meanings of these task words, the students were unable to satisfy the demands of the question in which the task words ('describe and explain') were used, thus accounting for the incorrect responses even though the task words were signposted (underlined and typed in bold print). This shows that merely drawing attention to the task words in the questions by word processing/formatting strategies (such as the use of underlining and boldscript) are not adequate. Such strategies serve little use if students do not understand what the words mean or how they are expected to answer. Researchers have noted that it is the non-technical words such as these task words used in the context of science that proved most problematic to second-language learners of science (Cassels and Johnstone, 1985; Clark, 1997; Howie, 2003). Research by Howie (2001b) has

[89] "Explain how you would test for CO_2 gas (*Foundation Chemistry* Tutorial Manual, Semester 1, 2011: 20). "In your own words, write out/explain the steps needed to use the equal arm balance to find an unknown mass" (*Foundation Physics* Notes, Semester 1, 2010: 19). "Explain how the process of evolution has affected oxygen levels over the history of the earth" (*Foundation Biology* Tutorials, Semester 1, 2010: 36).

shown that majority of the pupils tested in South Africa were not fluent in the language of testing.

Task words commonly used to test mathematical knowledge are: *'define', 'prove', 'show'* and *'verify'* (none of which have been included in the list of words frequently used in mathematics included in the course manual; an extract of which has been included in Chapter 6). The RPs teaching foundation mathematics indicated that these task words have specific connotations in mathematics. Wilson (1999) refers to these words as metacognitive verbs which take the place of the verb to 'think'" (1069). The RPs also commented that students often lose marks because they either did not understand the meanings of these words or had not read the question carefully. This is thus an issue that deals more with the challenge of using non-technical words in a discipline rather than mathematical inadequacy. Both Kenneth and Vusi commented on this dilemma in foundation mathematics:

> "*For example, the question is:* (**a) Define a rational number. Then, (b) Prove that ___ is a rational number (3 marks).** [my emphasis in bold print] *But, what students did is they did not define the rational number - they just proved. They lost marks for this. This is because they do not read carefully and closely. Students also argue that they did not see the need to define because they proved it was a rational number*" (Kenneth).

The above example cited by Kenneth in the interview is an example of the micro scaffolding mentioned earlier in this Chapter that students need to be exposed to in all disciplines of science. Even though there exists the belief that "[foundation] *mathematics has less dependency on language*" (Raj) than other descriptive courses such as foundation biology, discipline-specific literacy issues need to be interrogated in class especially since the task words common to mathematics discourse (e.g. *define* and *prove*) have specific meanings. Alerting students to the need to **read** [my emphasis] texts carefully is particularly important so that students do not miss cues as shown in the mathematical example (above) conveyed by Kenneth - where students missed the significant, actional cue, "Then". A similar situation of difficulty with interpretation of task words was illustrated by Vusi in the following mathematical example:

> "*This week, for instance, students were given a tutorial and it was a simple question:* **'Show that a certain function is a solution'. The other was 'Verify that this is the solution'** [my emphasis in bold print] *but because the English seemed to confuse them, they could not access what was actually required of them. All they had to do was just 'verify'- that word just confused them*" (Vusi).

Vusi's contention that *"it was a **simple*** [my emphasis] *question"* and *"[*a]*ll they had to do was **just*** [my emphasis]*'verify'"* is reflective of assumptions of the DSs that students know the expectations of the task words, as if they can acquire the academic discourses through "intellectual osmosis" (O'Toole, 1994 cited in Barker, 2000: 2). Vusi's response fails to consider the point that the way in which questions are often asked in academic settings can pose a barrier for students who have just entered the tertiary education environment and are becoming familiar with academic discourse. Vusi regards these words as "*the English* [words which] *confuse them"*, however words such as 'show' and 'verify' have precise meanings (and actions) in the context of mathematics therefore the students were unable to do what was required of them in foundation mathematics. DSs need to understand that academic register, "abstract concepts and technical terms are part of academic fields" (Rose *et al.* 2003: 41). Vusi's outline of this example and the reference to the task words being 'simple' (and not warranting clarification) is a contradiction of his comment quoted earlier in Chapter 6 when he stated that *"[T]he only language they [the DSs who teach foundation mathematics] would emphasize is the language that affects their course*". Since these instructional task words are always going to be used in the context of mathematics, it is imperative that they are understood thoroughly and, together with any other 'language', discipline-specific literacies or vocabulary used in mathematics; it should ideally be the task of the DSs teaching foundation mathematics to do so. Likewise, if the earlier assertion by Raj (in Chapter 6 of this study) that students require "*maths knowledge **and*** [participant's emphasis] *proficiency in literacy"* holds true then it is in cases such as these that the emphasis on literacies used in mathematics can be reinforced. Students can thus be guided along to work at the Application Level III of Bloom's Taxonomy (Bloom *et al.* 1956) where they should be able to apply the knowledge they have learned.

This discussion of the difficulties of interpreting task words in the disciplines of science shows that engagement with the discourse of a discipline is not only about the acquisition of knowledge but also its standards and practices. Each discipline in HE has its own register, conventions, genres and a set of ground rules that require mastery which define the way in which knowledge is construed. At university level, students need to be apprenticed into the way in which the linguistic codes function in a discipline.

Apart from the challenges associated with task words, yet another stumbling block for students in the FP – especially in test situations – is being bombarded with far too many directives in a question. Processing all of these directives created some measure of confusion more especially for EAL students. One such example is the question below:

> Consider the widgeon grass, the clam and the blue crab. Briefly explain **how** and **why** the amount of **biomass and energy** available for these organisms differs [emphasis in bold in the test] (*Foundation Biology* October Test, 2011: 6).

In attempting to answer the question above, the expectation was for students to focus on each of the following demands of the question:

1. Pay attention to the two organisms (clam and blue crab) and a plant (the widgeon grass).
2. Have knowledge of the amount of biomass and energy available for these organisms.
3. Explain how the amount of biomass and energy available for these organisms differs.
4. Explain why the amount of biomass and energy available for these organisms differs.

In addition to all of these directives, the expectation was that the answer be brief. Consequently, at least 50% of the students were penalized for omitting one or more of the above requirements of the question despite the use of signposting of key words in the test by underlining and using bold script. Since the DSs are familiar with the academic science discourse, they are able to use the "elaborated code" (Bernstein, 1971) with ease, and are comfortable with "longer, more complex grammatical structures" (Schallert *et al*. 1977: 18). The same cannot be said for EAL speakers who need to make sense of such explicit discourse and appropriate the elaborated code; understand and use academic discourse, what Bourdieu (1977) calls the 'educated' language". They need to be able to make sense of the questions, especially those that are complex and multi-layered. In an observation of the review of this test, Josh thoroughly explained the expected answer (as shown in Appendix 27B). Although Josh told the students that they had lost marks for not answering the question thoroughly, what was notably absent in the review was unpacking of the question, i.e. the emphasis on its demands or any explanation of the use of 'consider' in the stem of the question above.

If the purpose of asking questions is to test the students' understanding and acquisition of disciplinary knowledge, then effective questioning strategies are vital, especially for students for whom the LoLT is different from their mother tongue. Students require CALP to find meaning in context-reduced materials in academic settings. Students whose CALP may not be proficient enough for academic learning; and for whom the LoLT is in a non-native language (like in this study) can easily misinterpret questions so "language used must therefore be elaborated precisely and explicitly to minimise the risk of misinterpretation" (Starfield, 1990: 84).

7.1.4.3 Challenges with interpretation

In a test on 'The Impact of Climate Change' in SCOM, the following question based on an authentic journal article was included:

> <u>Question 1.5</u>
> List four evidences which prove that climate change is happening in Africa.
> <u>Expected Answer:</u>
> a. warming of approximately 0.7ºC over most of Africa during the twentieth century
> b. decrease of rainfall over large portions of the Sahara
> c. increase in rainfall in east central Africa
> d. global mean surface temperature expected to increase between 1.5ºC and 6ºC
> e. sea levels expected to rise by 15 to 95cm by 2100
> f. increased frequency of droughts and floods
> (*SCOM:* Test 2 Memo, 2011)

In answering question 1.5 above, students were expected to give factual information or scientific evidence from the reading text. Two of the RPs explained that the purpose of including such questions in SCOM enabled students to learn to relate to science content and science discourse –*"to get used to the language of science"* (Cindy) especially if they wanted to become members of the scientific discourse community and "*to create an academic identity* [for the students]*; to be able to write, read and speak and perform within the disciplines of science"* (Sudeer). Both RPs stated, too, that since the FP students had just completed secondary schooling, they needed to become familiar with the demands of science. At school, students often gave their own opinions and they needed to understand that tertiary level science relies on facts and verification. Both these RPs have cited the need to socialize students in the FP into the culture of science. Gee (1996) argues that in higher education contexts the role of the academic (the "insider" to the discipline) is to induct students (the "outsider") into the "Discourse" of a discipline through a process of participation in that particular Discourse community. With the sciences leaning heavily towards justifying and providing proof/evidence, engaging them in the literacy practices of science helps groom them into becoming 'insiders' of the discourse community of science.

In respect of question 1.5 noted above, one of the major shortfalls of the students was to write rather generalized, common-sense answers relating to climate change that they had extracted from the text such as "loss of biodiversity; increase in malaria and changes in rainfall patterns". This meant that 50% had not scored any marks in this question. Cindy explained how she addressed this problem: *"I made one student read the question out and then made a point of explaining the two significant words in the question – 'evidences' and 'prove'; I told the students they must always read the question slowly and carefully and underline the main words".* Cindy's review of the question seemed reasonable as it demonstrated to students that they were expected to deconstruct questions and look for cues as to how the question should be answered. However, specific ways of conveying science need to be thoroughly communicated in class discussions through the use of the reading texts and writing tasks, then only would assessing their understanding of these in test situations be meaningful. Since the texts used in SCOM are extracted from journals and textbooks in the disciplines of science, references to scientific evidence, statistics, data, proof and the link between cause and effect are likely to be evident in such texts[90] and would have to be discussed in class. Then, assessing understanding of scientific truths in test situations would be more meaningful. This would also be one way of alerting the FP students to the nature of scientific texts and apprentice them into how they should be able to present factual information in science.

7.1.4.4 Comprehending Word Problems

This study has shown that reading and reading comprehension in mathematics were particularly important in solving word problems, as expressed by Raj: "*Our students need to be able to read a word problem, understand the language used, reason, extract what is required and solve accurately by working out or writing down the answer. For this they need maths knowledge and proficiency in literacy".* According to this study, one of the areas that challenged students in the FP was the issue of word problems in foundation

[90] "Diarrheal disease outbreaks can occur after drinking water has been contaminated and have been reported after flooding and related displacement. An outbreak of diarrheal disease after flooding in Bangladesh in 2004 involved > 17000 cases; *Vibrio cholera* was isolated. In Aceh Province, Indonesia, a health assessment in the town of Calang 2 weeks after the December 2004 tsunami found that 100% of the survivors drank from unprotected wells and 85% of residents reported diarrhea in the previous two weeks. In the US, diarrheal illness was noted after Hurricanes Allison and Katrina and norovirus, *Salmonella* were confirmed among Katrina evacuees" (*SCOM*, Semester 1, 2011: 28).

mathematics despite the inclusion of strategies to solve word problems in the course manual (These can be accessed in Appendix 23). The following word problem question was extracted from one of the foundation mathematics tests:

> Question 3.4
> A chemist has two concentrations of hydrochloric acid, a 40% solution and a 70% solution. How much of each should she mix to obtain 100 millilitres of a 49% solution? (*Foundation Mathematics*, March Monthly Test, 2011: 5).[91]

In calculating the answer to this word problem, Kenneth, in reviewing the test, informed the students that they needed to deal with two concepts which were (1) 'concentration', denoted by percentages; and (2) 'volume', denoted by millilitres. Kenneth provided the answer to the way in which this word problem had to be translated into symbolic or numerical form which can be cited in Appendix 28.

The analysis of the data revealed that students experienced problems with understanding the phrase: "How much of each" that was used in the word problem. In this regard, many students failed to realise that "How much" was a reference to volume rather than the concentration of the solution and that the word "each" was a reference to the individual volumes of two concentrations of hydrochloric acid: i) the 40% solution; and ii) the 70% solution. According to the data, 61% of students calculated *concentration* instead of *volume* and 56% of students calculated the volume of one solution only. Only 32% of students scored above 1.5 out of 3 marks in this word question.

Students' responses to the word problem isolated above indicated difficulty with reading comprehension. Of the five strands of mathematical proficiency outlined by Kilpatrick *et al*. (2001), the way the problem was answered showed trouble with "strategic competence, i.e. involving the ability to solve a mathematical problem" (116). Solving word problems relies heavily on reading as "precise reading will lead to precise mathematical thinking" (Siegel and Fonzi, 1995: 638). Reading of word texts in mathematics goes hand in hand with reading comprehension. For constructive comprehension to take place, careful reading is essential. Siegel *et al.* (1989) state that the comprehension of word problems requires attention to the syntactic and semantic organization of word problems as this affects students' ability to solve them. "Problem solving generally involves multiple steps and often requires a combination of various basic intellectual skill and strategies" (Selvaratnam

[91] Appendix 29 shows a sample answer to this question by Nomfundo, a FP student.

and Mavuso, 2010: 70). Students needed to be able to interpret the language in the problem, extract information, convert them to symbols and solve accurately. The way the mathematical word problem illustrated in the preceding paragraph was answered indicates the challenges with reading, analysing, interpreting and comprehending word problems.

According to Raj, *"the language of maths involves symbols and solving equations which they* [the students] *are quite happy to work with rather than working out word problems"*. Evidence of this was in the foundation mathematics March Monthly Test (2011) where in two questions ahead of the word problem discussed above (Question 3.4), students were required to answer the following pure mathematical application:

Question 3.2
Solve for x and y

$$3x - 2y = -9$$
$$2x + 6y = 5$$

(*Foundation Mathematics*, March Monthly Test, 2011: 4)[92].

In Question 3.2 cited above, students managed to solve for *x* and *y* with suitable mathematical proficiency. Seventy percent of students scored above 1½ out of 3 marks in this question. In consideration of the five strands of mathematical proficiency outlined by Kilpatrick *et al.* (2001), there was evidence of procedural fluency as students were able to show "skill in carrying out procedures flexibly, accurately, efficiently and appropriately" (116). As with Question 3.2 in the test, Question 3.4 – the word problem – involved the same principle/calculation, i.e. purely solving for x and y: In Question 3.4, one volume was represented by *x* and the other volume was represented by *y*. Students scored better in Question 3.2, than they did in Question 3.4. This can indicate the challenges presented by word problems, mainly with regard to reading comprehension. An important point that surfaced here is that performance was better in the question where students had to manipulate numbers and symbols in mathematics than in the question where they had to read mathematics. Although the majority of the students was able to correctly answer Question 3.2 in mathematical form, success in calculating correct numerical answers does not necessarily imply a corresponding level of conceptual understanding (McDermott, 1991). Solving word problems requires mathematical and conceptual knowledge as well as linguistic understanding. According to Kintsch (1987), it has been found that "students do anywhere from 10-30% worse on word problems than when the same problem is presented in mathematical form" (197).

[92] Appendix 30 shows a sample answer to this question by Nomfundo.

According to the data, students performed well in Question 3.2 which involved a step-by-step procedure which, with repeated practice, can be perfected. However, situations similar to those presented in Question 3.4 can be embedded in a social context where students will have to draw on their mathematical competencies and understanding to solve real life problems. The mathematical literacies thus become a social practice just the way NLS advocates a sociocultural view of literacy which views literacy as a social practice. Mathematical problem solving is at the Application Level III of Bloom's Taxonomy (Bloom *et al.* 1956) where a concept is used in a new situation, i.e. what was learned in the classroom is applied in a novel situation.

This study has shown that limited understanding of the grammatical structures of sentences can be a barrier to the understanding of science. There are specific adverbs which need to be understood within the framework of mathematics. In one of the examples isolated in Kenneth's foundation mathematics tutorial that I had observed, 70% of the students had trouble interpreting the following word problem: "**Two years ago** a mother was **twice** as old as her daughter. How old is the daughter?" This percentage was arrived at from the number of students who were not able to answer the question correctly.

Being able to do this problem meant that the students were expected to interpret the words and put them into symbols. In this example, understanding the meaning of the adverb, *twice* (a common everyday word) and the relational statement (*twice as old*) was crucial if the students were to unravel the calculation of age. The common words highlighted in the word problem above (which had to be understood in a mathematical context) needed a translation into mathematical operations, i.e. **"two years ago"** (in the past) which implies that the students were expected to subtract 2 years; and **"twice"** ('two times as old as') implies the need to have multiplied the years by 2. It was the translation from words to mathematics (numbers/symbols) that posed a problem to students. This challenge had surfaced in the foundation mathematics tutorial even though the 2011 course manual has a detailed explanation of addressing questions of this nature as well as various examples that students were expected to work out (See Appendix 31). According to Kenneth, one of the reasons why students perform poorly in word problems in mathematics is that *"they do not read carefully, because for them 'maths is about solving, not reading'. In word problems, missing the meanings of certain key words means your entire answer can be wrong"*.

In the interview, Raj explained that DSs for whom English is a first/native language do have a tendency to assume that students would be able to interpret these words (e.g. twice, three times) and others (e.g. 'one in four seconds' and 'fourth second') when used in the context of mathematics and *"are* [therefore] *terribly surprised when they* [the students] *don't know what these words mean, which makes me realize that they are not reading as much now for them to pick up these commonly used words"* (Raj). This comment needs to be examined in the light of the students' past educational experiences where their mathematics classrooms were not about reading. Their classrooms were characterised by working with numbers and symbols, "listening to the teacher and then copying down examples" (Pretorius and Bohlmann, 2003: 235).

This study has shown that students had trouble interpreting the discipline-specific literacies in science, thus accounting for the overlaps of such challenges within the different science modules in the FP. However, if these words appear frequently in the science, then DSs should attempt to link language, literacies and content and reinforce these periodically. The development of mathematical language (e.g. *twice*) should go together with the development of mathematical practices (e.g. multiplying) to convey, reinforce or test mathematical knowledge and understanding.

7.1.5 Challenges with Quantitative Literacy in SCOM

"In Higher Education, students have to practice [quantitative] literacy in different curricular contexts and within different disciplinary practices" (Frith and Prince, 2009: 86). One such scenario is the inclusion of mathematical problems in the SCOM syllabus. In this study, the foundation students' difficulty with comprehending quantitative information in reading texts in order to solve a mathematical problem was not only limited to the foundation mathematics class. As shown by the ALSs' verbal responses (in Chapter 6 in this study), in the SCOM module, students are apprenticed into the discourse of science. The mathematical question below was posed to students in a reading comprehension test in SCOM. The question was based on the following sentence in the reading text: "One in four young adults in South Africa is infected with HIV, and of these, up to two thirds may <u>also</u> be infected with TB" (*SCOM*, September Test, 2011: 3)

Question: According to Reading Text 2, up to what percentage of young adults in South Africa may be infected with both HIV and TB?
Expected Answer: 1 in 4 = 25% of which up to ⅔ may be infected with TB = 16.7%. Rounded off 16.7 or 17% may also be accepted. (*SCOM* September Test Memo, 2011: 3).

To be able to answer this question accurately, students would have had to display quantitative literacy competence at problem solving and the application of basic arithmetic operations. The statistics on students' responses to this question showed that students were unable to answer the question. Only 2% were able to work out the correct answer. An analysis of the students' answers indicated that they had difficulty interpreting the question. It was clearly a problem with the interpretation of mathematical language. Students did not pay attention to the use of *'also'* in the sentence in the text and the word *'both'* in the question and the fact that the question called for the number infected with *'both HIV and TB'*. A number of students worked out the number of young adults in South Africa as a whole (4 out of a 100 = 25%) rather than looking at the fact that 1 in 4 young adults in SA is infected with HIV and, of these, two thirds may be infected with HIV and TB. Students did not pay attention to the words *'of these'* in the sentence either and also ignored the statistics: two thirds. Therefore, they were unable to work out two thirds of 25% - which is 16.7%. A number of students gave the answer 'two thirds' despite the question calling for a percentage. In this regard, the students merely lifted this answer from the text. Some students looked at the wrong information in the test such as the following sentence in the text: "In a group of 53 patients identified with XDR-TB, all but one died within an average of 25 days from the point when drug-resistant TB was first suspected. Forty-four of the 53 patients were tested for HIV and all were found to be positive" (*SCOM* September Test: 2011: 4) and consequently, calculated two thirds of 53 (thus arriving at the answer of 35%; while others calculated the percentage of 44 out of 53 from the same sentence, thus arriving at the final answer of 83%). Other students calculated those that were infected with HIV and those infected with HIV and TB and arrived at varying percentage results.

An explanation of this mathematical scenario has indicated that the students had trouble reading and interpreting the information in the text and solving the problem logically. This is an essential skill in mathematics especially since "mathematical texts are hierarchical and cumulative, such that understanding each statement is necessary for understanding subsequent statements; [O]verlooking or misunderstanding a particular step has severe consequences for overall comprehension" (Bohlmann and Pretorius, 2008: 44) as was the case in this example and the other cited in the preceding paragraphs.

The example above shows the challenge associated with quantitative literacy. This has been raised by researchers such as Prince *et al.* (2008) and Frith and Prince (2009). Prince *et al.* (2008) pointed out that in a quantitative literacy test administered to entering medical students in 2008, 50% could not read a ratio (expressed per 100 000) off a table and convert the value to a percentage. Frith and Prince (2009) conceptualize quantitative literacy as a social practice.

According to Frith and Prince (2009), "[q]uantitative literacy events cannot be successfully engaged with, without also engaging in some of the practices of the disciplines of mathematics … themselves" (87). For example, in the interview with Cindy, I was informed that in situations where mathematics problems appeared in reading texts[93] in SCOM, the tutors involved in its teaching needed to explain both the language and mathematical connotations of the problem. This is mainly when the texts contain mathematical units (such as 'miles'; 'feet' and/or 'inches') that may be unfamiliar not only to ESL or EAL students or even foundation students but to South African students in general (who are accustomed to the metric system). Cindy referred to the following mathematical question included in the SCOM course manual to illustrate this point:

> Paragraph 18 states that in a study in Hong Kong, people living in the smaller houses had only 20 square feet per person. Choose the figure from the list of answers below which is closest to 20 square feet. (Note that 1 foot = 12 inches; 39 inches = 1 metre).
>
> a. 2 m^2
> b. 20 m^2
> c. 3 m^2
> d. none of the above (*SCOM*, 2011: 33)
> Expected Answer: a. 2 m^2

Cindy explained that in a problem of this nature, the comprehension aspect of the question had to be understood before its mathematical component could be handled. This meant that students would have had to understand the use and meaning of the preposition *'per'* and the fact that the answer that they needed to choose was not the accurate answer but rather the one *'closest'* to 20 square feet; in other words, the approximate answer. In this question, the

[93] Reading texts in SCOM were extracted from science journals and textbooks. The content of the texts may not necessarily pertain to South Africa.

problem had to be fully comprehended before the mathematical application could be done. Cindy explained that students who had not read the question carefully and had overlooked the word *'closest'*, would have been misguided in assuming that because none of the mathematical answers in the options was accurate, the correct answer from the set of distractors would have been "*none of the above".*

Examples such as the one discussed above are problematic for EAL students and who would have had to *"understand the way in which English words are used in mathematical problems"* (Cindy). This example has illustrated that students are challenged by the English words used in a mathematical text, even though the mathematical problem may be simple to calculate or solve. It is non-technical words that are most troublesome and which result in students' misunderstanding in science (Cassels and Johnstone, 1985), more often problematic for students for whom English is a second language (Clark, 1997). The example discussed above illustrated that, for comprehension to occur, careful reading of both questions and texts is absolutely necessary as "mathematics discourse is characterised by precision, requiring close attention to detail" (Bohlmann and Pretorius, 2008: 43). Added to this, is the point by Orton (1992) that mathematics texts cannot be read quickly, for every word might be crucial and every symbol essential in the extraction of meaning (133).

The examples above have highlighted that understanding mathematics requires some level of proficiency in the LoLT and discipline. An analysis of the difficulties presented in understanding mathematics in light of Gibbs and Orton's (1994) view of linguistic, cognitive and contextual dimensions of mathematics discourse (explained in Chapter 4) highlights issues of reading, interpreting and reasoning. Students struggled with reading and understanding the linguistic dimensions in the mathematical texts, mainly the use of vocabulary and grammar and they were challenged in applying the cognitive dimensions of logic and reasoning.

The data cited so far depict the challenges of problem solving. Problem solving skills are linked to intensive reading proficiency which in turn requires adequate reading comprehension abilities. Problem solving skills enable students to infer and predict. Students need to be able to apply academic knowledge or theory in new contexts to solve problems. If the HE sector is to produce graduates with skills and competencies required to meet the demands and needs of the country, then, as stipulated in the NPHE in South Africa (2001), graduates need to "demonstrate a strong array of analytical skills" (27).

Of Showalter's (1974 cited in Rubba and Anderson, 1978: 450) seven dimensions on a scientifically literate person, the first three dimensions are particularly relevant:

1.) understands the nature of scientific knowledge;
2.) accurately applies appropriate science concepts, principles, laws, and theories interacting with his universe and;
3.) uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe.

Students need to acquire the discourse practices of science. Within the field of science, students need to display scientific knowledge by being able to contribute to scientific discussion and engage in scientific enquiry which involves the ability to question, predict, evaluate and to reason scientifically. Besides, Street's (1984) view of literacy as a social practice is relevant.

7.1.6 Vocabulary in science

In an observation of Josh's tutorial session where students were expected to have read through the marine theme readings, students understood the technical words such as '*invertebrates', embryos', 'cephalopod', 'embryos', 'filtering'* and *'bivalves'*. This conclusion was drawn from the students' correct responses to questions posed to them which made particular reference to their understanding of the technical words in the context of the sentences below (where the technical words have been deliberately underlined in this study to indicate emphasis). Many of the questions posed to the students were simple and straightforward and could have been answered from students' learned understanding of concepts common to the discipline of biology, for example: 'What is an invertebrate?' or 'Give me an example of an invertebrate'.

However, some students were unclear about the meanings of some words commonly used in the English language [which I have italicized in the extracts below]. These words were used in science in meaningful, but changed and unfamiliar ways. A few of the students were bold enough to query the meanings of words such as *sophisticated* and *case* which were adequately explained by the tutor.

- "The anemone seems to recognize its *resident* clown fish."
- " ... these eight-armed octopus is among the most *sophisticated* of

all invertebrates" (39)

- "Most cephalopod eggs are *richly laden* with yolk and the embryos undergo its complete development within the egg *case* ..." (40)
- "The major *drawback* of the efficient filtering system of bivalves is that they collect and *concentrate* pollutants and toxic organisms" (47)
- " ... and ends in a stiff tail fan, which the crab *employs* to wedge it in the shell" (52)

(*Foundation Biology* Readings, 2011)

However, I noticed that not all of the common words in the extracts were clarified even though their contextual meanings in the sentence contributed to an understanding of the technical words, e.g. *drawback* and *employs.* Alternatively, the texts could have been adapted or rewritten or scaffolded to facilitate both reading and comprehension.

This type of situation with regard to vocabulary usage in science is not uncommon in other foundation disciplines, as expressed by Jessie who teaches foundation chemistry: *"The students actually have a better grasp of the scientific language because we introduce it to them slowly; it is with some of the everyday language that they battle* [struggle]*".* For example, in foundation chemistry where students conducted an experiment to separate pure alum from crude alum, one of the experimental procedures read: *"Open the tap to the pump, swirl the solution containing the crystals"* (*Foundation Chemistry*: Practical Manual, Semester 2, 2011: 3). In the observation of this practical, the laboratory demonstrators[94] who assisted with the practical, noticed students 'shaking' the solution, rather than "swirl[ing]" it. Only upon correcting their actions was it discovered students had assumed that 'shaking' a solution was the same as 'swirling'. For them, they construed 'shaking' and 'swirling' as denoting the same action. They had not understood that 'swirl' meant a 'twisting or spinning motion'. They had assumed that to 'swirl' was to 'shake'. The misunderstanding of such fundamental actions would have implications for the way in which the procedure/method of the experiment is reported in the scientific report.

Iqbal reported from a personal point of view that it was only in the second semester of teaching students in the FP that he had realized his folly in assuming that students had understood the meanings of common nouns used in science discourse. Iqbal claimed that when faced with unfamiliar words, students are most likely to guess their meanings. Evidence relating to this statement was the use of the word "livelihood" in the following

[94] A laboratory demonstrator is a postgraduate student who helps FP students with laboratory/field experiments.

sentence taken from a test: “Farming is the **livelihood** of roughly 70% of the population and 40% of all exports are agricultural products” (*SCOM*, 2011: 2). Students were asked to explain the meaning of ‘livelihood’. The statistics showed that 90% of the students had been unable to explain the meaning of this word when asked to do so. Below is a sample of the students’ answers which show some measure of guesswork or conclusions about the meaning of the word drawn from the derivative, ‘live’:

- livestock like cows and goats
- lifestyle
- the way of living life.
- something that keeps people alive.

Questions dealing with vocabulary are best tested where students can at least negotiate meanings from the text. If students are expected to infer the meanings of words from texts, then there should be context clues for them to be able to do so. Context clues in texts can take the form of “direct definitions, synonyms, or precise descriptions” (Schatz and Baldwin, 1986: 441). Iqbal subsequently explained that in the review of the test, not only was the word ‘livelihood’ a problem, but students had difficulty understanding the meaning of ‘roughly’. “*There was such astonishment when they* [the students] *were told that ‘roughly’ was synonymous with ‘approximately’ – I mean they all knew the meaning of ‘approximately’”* (Iqbal).

Although students were encouraged by the DSs to use a suitable English or even a scientific dictionary or to make ample use of technology such as internet search engines to find the meanings of technical and non-technical words used in their course content, a very large proportion of students (which, in the opinion of the DSs, is at least 75%) hardly takes the initiative to do so, relying heavily on guess work and assumptions. The examples that were cited show how students construe their own meanings of words which are often dictated by the experiential or ideational metafunction (Martin and Halliday, 1993), representing their own experiences of the world.

From the course notes in the science disciplines in the FP, I had noticed that idioms, colloquialism, figurative expressions and highly descriptive language sometimes feature in science and should be explained in order that the science behind the language is understood, for example:

- 'Wind pollination is a hit-or-miss affair' (*Foundation Biology* Tutorials, 2011: 18);
- 'A life-raft is equipped with rations …' (*Foundation Mathematics,* 2011: 23);
- '… thereby cushioning the driver from the impact' (*Foundation Chemistry:* Tutorial Book, 2011:12);
- '… assumes the earth as a perfect sphere without any topographic relief' (*Foundation Physics,* 2011: 34) and;
- 'disasters occur when hazards meet vulnerability' (*SCOM,* 2011: 19).

These expressions are not necessarily the norm in scientific writing which is characterized by precise, literal, objective and unambiguous language. However, students need to be inducted into the register that is more appropriate for science. According to Cindy, it is for reasons such as these that the articles used in the SCOM course are often rewritten and most of the idiomatic language is removed and *"those that remain are generally explained in class"* (Cindy). (See Appendix 1 for an extract from an original text and a revised version of the same text used in SCOM). Furthermore, with science texts being rather dense and heavily nominalised, "the absence of idiomatic language means that there is one less level of meaning to be unpacked by the [students] … who are unfamiliar with such language … and have had little contact with English speakers ... and [t]hey are therefore unfamiliar with the idiomatic language" (Parkinson *et al.* 2007: 449).

A similar language difficulty had surfaced in a foundation physics tutorial conducted by Petrus that I had observed. The students had to work out the answer to the following physics problem:

> If the coefficients of static and kinetic friction between the box and the floor are 0.46 and 0.40 **respectively**, determine:
> (a) whether the crate will move; and
> (b) the minimum horizontal force required to move the crate at constant velocity
> (*Foundation Physics* Tutorial*:* Newton's Laws of Motion, 2011: 24).

In this particular instance, out of 33 students who were present at the tutorial, 6 students were able to calculate the correct answer without assistance; 15 students raised their hands to enquire either the meaning of **"respectively"** [my emphasis] in the question or to find out which of the two given coefficients go with each of the frictions mentioned in the question. After Petrus had ironed out the confusion by giving an explicit explanation of the word "respectively", the students were able to apply their knowledge on the topic to calculate the answer. This particular situation in the foundation physics class shows the significance of a single common English word which maintains its meaning in the context of science but, if misinterpreted, can result in students calculating wrongly.

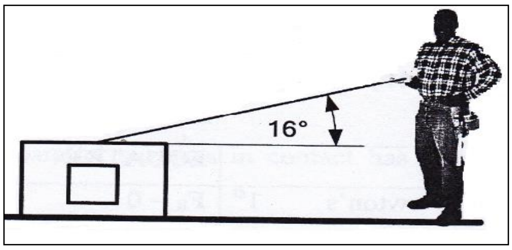
These examples cited have illustrated that EAL students can be confronted with the challenges of common English words used in science questions. It also points to the importance of close reading of any text in the sciences so as not to miss or overlook important semantic clues or nuances of meaning in a question or text which can result in misinterpretation, and can impact on students' performance.

A similar situation was apparent in the foundation physics classroom where students' challenges with fully understanding the meanings of commonly used English words in science impacted on their conceptual understanding of science content. In foundation physics, the students were given the definition of "constant movement" (quoted below) in their course notes which they were expected to use to interpret the concept 'constant velocity' which they needed to understand for a tutorial session on Newton's Laws of Motion':

> Constant movement is movement with an even pace: not speeding up or slowing down (*Foundation Physics*: Kinematics Notes, 2011: 8).

However, in the foundation physics tutorial, I noted that despite the above definition being given, students were still challenged by the concept "constant velocity". As per this definition, 'constant velocity' indicates "even pace: not speeding up or slowing down"; hence where there is 'constant velocity', there is no acceleration. The students needed to apply this conceptual understanding of there being 'no acceleration' to solve the following problem:

> A huge wooden crate of mass 60kg lies on a concrete floor. A man ties a rope to the crate, such that the rope makes an angle of 16^0 to the horizontal, as shown in the diagram, and he pulls on the rope with a force of 50 N. If the coefficient of static and kinetic friction between the box and the floor are 0.46 and 0.40 respectively, determine: (a) whether the crate will move; and,
> (b) the minimum horizontal force required to move the crate at constant velocity



(*Foundation Physics:* Newton's Laws of Motion, 2011: 24).

During the tutorial session, some students asked the tutor and laboratory demonstrators if they were required to calculate the value of acceleration while others queried if the value of acceleration was omitted in the given problem. Their sole focus was that constant velocity meant keeping a consistent pace but they failed to realize that this, in turn, meant that acceleration was at zero. In this example, the students who had queries could not understand that 'constant velocity' meant that there was 'no acceleration'. Had students deconstructed the definition in their notes closely, they would have been able to grasp this concept[95]. This example shows how a problem with discipline-specific literacies can impact on conceptual understanding.

This study has highlighted difficulties with vocabulary common to science and everyday English. The example found in this study was the tendency for students to use 'mass' and 'weight' interchangeably, as synonyms although in the context of science, each has its own specific meaning. These everyday words are "deliberately" (Miller, 1999: 11) used as science words and have new meanings [in science] in addition to their everyday meanings (Sutton, 1992). The question below appeared in a foundation physics test:

> Question 11:
> A scheming business man buys gold by weight at a higher altitude (height above sea level) and sells it at a lower altitude at the same price per weight. Write a brief explanation to the public protector on how the business man is making a profit. (*Foundation Physics:* August Test, 2011: 2)

According to the results in the test, 28% left the answer blank, 20% scored full marks (i.e. 3 marks), 17% scored less than 1½ marks (their explanations showed that they confused the meanings of 'mass' and 'weight'), 6% showed calculations but offered no explanation and 29% scored zero (of this, 25% discussed 'mass' rather than 'weight'). Annah explained that students confused 'mass' and 'weight' and used them as synonyms which were actually

[95] "Constant movement is movement with an even pace; not speeding up or slowing down" (*Foundation Physics*: Kinematic Notes, Semester 1, 2011: 8).

inaccurate because each has a different meaning in science. In this example, the students needed to understand that 'weight' changes with altitude because of gravity. A constant mass of gold will have a smaller weight at a higher altitude due to less gravity. Alternatively, a constant mass of gold will have a larger weight at a lower altitude due to more gravity. Hence, 'weight', not 'mass', changes with altitude.

This study has shown that it is not only the use of task words that have been challenging for the students in the FP. Another factor was the tendency to use specific phrases and expressions which, judging from students' answers, have indicated a lack of familiarity with them. For example the phrase, "[c]*onsider their lifestyle"* in the question below which appeared in the foundation biology practical:

> Question:
> Like all cnidarians, sea anemones are radially symmetrical.
> Consider their lifestyle, and explain what advantages this has for them.
>
> Expected Answer:
> The radial symmetry of sea anemones allows them to
> capture food, and defend themselves from predators in all directions around them.

The major issue with the answering of the question above was students' difficulty with the phrase '[*c*]*onsider their lifestyle'*. In answering this question, 60% of the students were unable to comment on the function of "radial symmetry with regard to the lifestyle of the anemone", i.e. the 'need' to capture food and defend themselves "from all directions around them". This study has shown that of this 60%, 35% of the students merely focused on the phrase "radially symmetrical" in the question and therefore lifted the following extracts from the glossary[96] in the course manual and the foundation biology readings which made specific references to this phrase:

> **"Radially symmetrical** (emphasized in bold in manual) a body plan where the body parts are arranged symmetrically around a central axis (body can be divided in any direction to give two equal parts that are mirror images of each other)" (*Foundation Biology* Course Manual, Glossary: Semester 1, 2011: 5).
>
> "All have a simple sac-like structure with two cell layers, radial symmetry, a single opening and specialised stinging cells" (*Foundation Biology* Readings: 2011: 5).

Student responses to this question illustrate they had trouble understanding the phrase '[*c*]*onsider their lifestyle'* a phrase easily heard in everyday language. This indicates that it

[96] See Appendix 33 for an extract from the glossary included in the Foundation Biology course manual.

is not only technical words or academic words that can be a problem for students, but also non-technical words or phrases that are usually considered ordinary ‘everyday’ words.

7.1.7 The problem of plagiarising

In this study, the tutors involved in the teaching of SCOM have stressed that one of the issues that they encountered in their course was the tendency for students to copy verbatim from texts in the course manual and internet sites. Students in the FP have difficulties expressing content in their own words, making plagiarism a major issue. The intensity of plagiarism in the sciences was put forward by a foundation biology specialist: *“... they* [the FP students] *are kind of mimicking the discourse; whether they actually understand it completely or not, I wouldn’t know. And their* [the FP students] *argument is ‘I could never write like this* [the way the text is written] *that’s why I have to copy’”* (Josh).

The comment above where students have substantiated copying verbatim is exactly what research has stated about plagiarism: students may find it “far easier to copy someone else’s apparently fluent interpretation than to devise their own halting, cumbersome prose” (Brogan and Brogan, 1982: 127) or “if students have something to say but do not know how to say it, what better way to try to communicate than to mimic the ‘voice’ of those they know have authority” (Shay *et al.* 1994: 29). Rabia explained in the interview that in SCOM students were constantly urged to attempt to *“explain in their words and* [try to] *paraphrase*” where they could and the more difficult words were often discussed in class as part of the scaffolding approach. Rabia’s claim is supported by questions based on texts in SCOM where students are asked to paraphrase, write/explain in their own words and are given explicit instructions in assignments and tests to do the same, as shown in the extracts which have been incorporated in the table below:

“(A) Paraphrase the following information that you have found in a textbook” (*SCOM*, Semester 1, 2011: 15).
“4. In your own words, summarise the findings of the researchers” (*SCOM*, Semester 1, 2011: 52).
<u>Assignment instructions</u>: “Before you start this topic, remember it is never acceptable to copy word for word from the texts provided or from other texts or from the internet or textbooks. You must always write in your own sentences” (*SCOM*, Semester 2, 2010: 47).
<u>Instructions on essay writing in test</u>: “Write in your own words and avoid lengthy quotations from the articles. Your essay must include in-text references and a reference list” (*SCOM* Test, Semester 2, 2011: 5)

Rabia also stated that a number of students assume they are not plagiarizing "*if they have changed an odd word or two in a text lifted from a reliable source"* (Rabia). In a study of plagiarism by native and non-native speakers of English at a South African university, Angélil-Carter (2000) uncovered a range of strategies which could be identified as plagiarism. These were "paraphrasing through synonym substitution, repeating selected sentences from a source, and alternating between repeated language and independently written language" (Angélil-Carter, 2000: 96). The example in the table below illustrates how an original paragraph had remained fairly intact except for the superficial adjustments to vocabulary such as the use of synonyms or "*changing* [the] *odd word or two*" (as communicated by Rabia) by a submission by a FP student. Words and phrases used to substitute those in the original text have been underlined:

Original text	Paragraph extracted from student's scientific report
As the climate changes, extreme events such as storms, floods, drought and heat waves are expected to become more intense and unpredictable. Healthy ecosystems play a crucial role in mitigating the impact of climate-induced disasters. For example, a biologically diverse and healthy forest ecosystem has a high capacity to absorb torrential rain. It provides tree cover and undergrowth that can reduce the erosive impact of intense precipitation, slow down the surface run-off and support the seepage of rain water into the soil and lower rock beds" (*SCOM* Manual, 2011: 84)	When the climate changes, extreme climate conditions such as storms, floods, drought and heat waves can become more heavy and unpredictable. Healthy ecosystems play a important role in making less the impact of disasters that are caused by climate. For example, a biologically diverse and healthy forest ecosystem has a high capacity to absorb lots and lots of rain. It provides tree cover and undergrowth that can reduce the erosive impact of intense rain, decrease the surface run-off and support the seepage of rain water into the soil and lower rock beds" *(Joe)*

In academic writing students need to display an understanding of content knowledge and they need to be able to use the correct conventions enabling them to be apprenticed as members of a particular discourse community. For students who struggle to do so, the situation is exacerbated when the LoLT is not their native language. Thus, reliance on plagiarism or any other form of textual borrowing is likely to be indicative of the fact students in the FP are encountering problems with academic writing in science.

7.1.8 Challenges accompanying the Report Genre

For students pursuing science degrees to be accepted into the discourse community of science, as advocated by NLS, they would have to acquire the literacy practices of the discourse community, which in this case is being able to acquire and communicate the discourse of science through specific genres of science. Martin (1993) states that "literacy in science has to be considered both from the point of view of field (the knowledge that is being constructed) and genre (the global patterns of text organization that package this knowledge)" (201). One of the genres needed in science is the scientific laboratory report which, according to research by Jackson *et al.* (2006), confirms it to be "the most important genre of writing assigned to science students" (260). This study has shown that this genre was one of the ways through which students in the FP were apprenticed into science.

"The writing of a lab report requires a complex mixture of writing skills such as summary, paraphrase, seriation, description, comparison and contrast, cause and effect, interpretation of data, analysis, and the integration of mathematical and scientific data into a text" (Braine, 1989: 10). According to the data, students in the FP generally grappled with composing the discussion section of the scientific report even though they were guided through the "Discussion' section in an article; and they were also given specific guidelines in their course notes on how to formulate the discussion section in the scientific report. (Chapter 6 has already shown extracts from students' scientific reports, indicating the challenges associated with formulating the discussion section. Appendix 17 contains the ways in which SCOM helps students with formulating the discussion section). One of the major weaknesses that had emerged in students' scientific reports was the tendency to comment on the method or procedure of the experiments or to repeat the scientific data rather than interpreting, integrating and analyzing it. In a foundation biology test, students were expected to use the given text to answer the following question for 5 marks:

> Question 1.8: Write as full a discussion as possible for this investigation.
> (August test, 2011: 2).
>
> Expected Answer:
> Must refer to numbers and relate findings to experimental procedure and background knowledge originally given. E.g. Only 56% of the normal maize seedlings survived the infection ✓whereas 77% of those seedlings that had the resistant gene survived✓. This suggests that the genetically modified maize might be a more productive crop. ✓ However light intensity was not properly controlled and this may have influenced results significantly; it is worth

> rerunning the experiment ensuring that this variable is better controlled. ✓ Also the experiment doesn't give an indication of how healthy the seedlings are that have survived, and some measure of biomass produced as an indication of growth may be able to better inform final conclusions made. ✓ In addition, these are only preliminary investigations into the suitability of this genetically modified crop- much more research is needed before decisions are taken to use the genetically modified variety as a crop (e.g. the effect of the genetic modification has on the maize cob produced is crucial) (*Foundation Biology,* August Test: Memo, 2011: 3).

The analysis of the data revealed that 10% left the question unanswered; 20% scored zero; 45% scored below 2½ marks; 20% scored 2½ - 4½ marks and 5% scored full marks. Below are some excerpts of students' answers accompanied by a short reason for the loss of marks. In the answer below, the student (Joe) explained the method instead of discussing the results; furthermore the entire method was copied verbatim from the reading text in the test:

> Joe's answer:
> "These mays were infected with a pathogen and allowed to grow for three months in a green house. The plants were grown in 3L plastic pots filled with sterilized potting soil at 26^{o}C and 50% humidity. Each seedling was given 100ml of distilled water every second day" (2011).

In the answer below, Sanjay lost marks because instead of discussing results in detail, he merely wrote out a conclusion:

> Sanjay's answer:
> "It was found that the number of survival maize plants depended on the resistant gene that was found in one of the variety of the maize plants. It was found that the number of survival of the maize plants with the resistant is actually greater than the number of maize plants without the resistant genes" (2011).

In the answer below, Silas was awarded 2 marks for the first 2 sentences which had some reference to results. The student was penalized for the inclusion of irrelevant information on variables but was not penalized for poor use of language.

> Silas's answer*:*
>
> "In the results it was found that resistant gene does not survive same as normal. The resistant gene was survive 77% and the normal survive 55%. That means that resistant gene was survive better. The null hypothesis was rejected. The dependent variable was number of plants surviving after three months, Independent variable was maize variety and controlled variables were 3L plastic pots, 100ml of distilled water and 3 months in a greenhouse" (2011).

7.1.9 Grammar in science

In this study, DSs have recalled instances where students' poor understanding of grammar has contributed to lack of epistemological access in science. In this regard, Susan referred to the following example in foundation physics:

> "*I would say to the students: 'You would notice that the object sinks. We call this displacement'. I took the use of '**this'*** [Susan's emphasis] *in the sentence for granted, assuming students would understand that I was referring to a phenomenon, but I was wrong – they were confused about the use of "this" in my explanation".*

The above example is an indication of the inability to understand the use of the demonstrative determiners (which also act as demonstrative pronouns) in science discourse. Biber *et al.* (2002a: 99) explain that the demonstrative pronouns 'this' and 'these' are most frequent in academic writing for textual linkage. In Susan's example in foundation physics, the students' difficulty lay in realizing that *'this'* referred to 'displacement'; highlighting the inability to make connections between the elements in the discourse. Similarly, in an observation of Nancy's foundation chemistry lesson on 'Energy and Matter', the demonstrative pronoun 'this' was used in two different instances as "textual linkage" (Biber *et al.* 2002a: 99) on the same topic:

> Instance 1:
> Eventually the temperature of the solid reaches the value called the melting point [underlined in the text]. **This** [my emphasis] is the specific temperature at which the solid melts (*Foundation Chemistry*: Lecture Notes, 2011: 13).
>
> Instance 2:
> When the temperature of a solid is raised, the particles vibrate more and more violently until they are moving to such an extent that they can no longer be held in an ordered arrangement by the forces of attraction. When **this** [my emphasis] happens the solid melts (*Foundation Chemistry*: Lecture Notes, 2011: 13).

In fact, the students comprehended the use of 'this' in Instance 1 (above) far quicker than they had done in Instance 2. In response to Nancy's question, students were quick to display an understanding of 'melting point'. In Instance 1, the sentence preceding 'this' is short, containing a simple fact; 'this' refers back to a specific noun phrase antecedent ('melting point'). But, the students struggled to understand the use of 'this' in Instance 2 which was used to "refer back to a more extensive piece of text" (Biber *et al.* 2002a: 99). In the observation of Nancy's lesson, there was more discussion around the meaning of the chemistry concepts in Instance 2. The explanation was read aloud, and through careful, deliberate questioning, the students were able to comment on factors such as ‘increased temperature, properties of solids, vibration of particles’. These were listed on the chalkboard and with the help of illustrations Nancy was able to successfully explain the use of ‘this’ in Instance 2. This type of difficulty can also be attributed to the challenges with reading. Bohlmann and Pretorius (2002) explain that “skilled readers perceive these relations, albeit unconsciously, and this enables them to see the connectedness between items of information in the texts as they read” (198).

As a result of the challenges with the understanding of sentence construction and grammar, students often conveyed scientific information incorrectly. In the following example, students extracted content from texts without realizing that due to incorrect transcription, the sentences in their laboratory reports were either grammatically or semantically incorrect and in some instances, a change in syntax had drastically altered the semantics of the sentences. In the example below, sentence (b) appeared in the original text but the student incorrectly transcribed it as (c) without realizing that displacing the adverb had altered the meaning of the sentence.

> (b) Wine is made by crushing **carefully** selected grapes in a machine.
> (c) Wine is made by **<u>carefully</u>** crushing selected grapes in a machine.
> (Lungelo, 2011).

Besides syntax and semantics, students pursuing science studies need to become familiar with what Lemke (1990) calls “grammatical preferences of science” (21) where there is a lot of use of the passive voice (e.g. ‘*wine is made’*), abstract nouns in place of verbs (e.g. *‘reduction’* in place of *‘reduce’*), excessive use of complex clauses separated and linked by words such as *‘then’* and *‘although’*

A number of the DSs teaching in the foundation programme have been doing so for a number of years. They thus anticipate difficulties with grammar which generally arise each year. This view was conveyed in this study by two DSs who, in separate interviews, drew attention to the exact same problem that students experience in foundation physics each year:

> “*If I’ve marked the exercise and a third of the class is having the same sort of problem, then I go back to class and explain, simplify, even re-explain it to them – and that one about ‘constant’ and ‘constantly’ comes up every year so I try and pre-empt it. In physics, we say describe the motion. It is constant. What’s constant? The position ... velocity or the acceleration*” (Susan).

> "*For example, if something has increasing velocity, they* [the students] *might say it's a 'constant increasing velocity' which is a contradiction of the term. What they mean is it's a 'constant***ly** [participant's emphasis of syllable] *increasing velocity' but they don't understand the difference*" (Shane).

In the example cited above, students' difficulty lay in distinguishing between the adjective, *"constant"* and the adverb, *"constantly"*. In everyday language, *"constant"* refers to 'unvarying or uninterrupted'. Therefore, in the phrase *"constant increasing velocity"*, the word *"constant"* is contradictory to *"increasing"* as outlined by Shane. In everyday language the meaning of *"constantly"* is 'without variation or change', but includes an emphasis on time, viz. frequency. In essence, the students needed to understand that the use of the time adverb *"constantly"* in the phrase *"constantly increasing velocity"* was correct as it showed the frequency of the increase (i.e. of velocity). In this example, students were challenged by understanding the grammar used in the phrase, i.e. identifying and understanding parts of speech and the English derivational suffix (*-ly)* which changed the adjective to an adverb, which impacted on their conceptual understanding of 'velocity' in the foundation physics class.

Having isolated the challenges that the FP students experience with the language of science and the discipline-specific literacies in science, the next part of this Chapter explores the ways in which DSs help the FP students to acquire the literacy practices required in the disciplines of science and aims to field data in respect of critical research question 3: *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

7.2. Acculturating FP Students into the Discourse of Science

Each academic discipline has its own discursive practices within which knowledge is imparted. Students need to acquire and use the distinctive language and the appropriate discourse conventions and practices peculiar to a discipline in order to gain competence in the particular discipline, develop an identity and become a member of the discourse community. Students are not only socialized into "ways of using language" but into "Discourses", which are "ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing" (Gee, 2012: 3). This is the acculturation of students into the discipline where they learn the conventions of knowledge and thinking as well as the language base.

Students in the FP in science need to acquire the disciplinary competences, the discourses of reading, writing, doing and speaking science. In essence, DSs and ALSs serve as agents who convey such discourses. If scientific literacy enables individuals to develop sound understanding of scientific facts and scientific inquiry process, and an awareness of the relationships among science, technology, and society (Bauer, 1992), then it is important to ascertain the efforts of DSs in assisting FP students to become scientifically literate and the way in which they pay attention to the discipline-specific literacies to achieve such aims. It is within this understanding that this study explored the DSs responses to critical question 3: *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

The acquisition of literacy as social practice, as decreed by the ideological model of NLS (Street, 1984, Gee, 1990) and the need to become a member of a discourse community, to become part of the culture and take on the values (Gee, 1990) have been highlighted earlier in this dissertation (Chapters 3 and 6). However, for students to gain the "sub-culture" (Clanchy and Ballard 1995: 19) of a particular discipline, they require explicit guidance or at least some assistance from the DSs as they cannot acquire the discourses through what O'Toole (1994) terms "intellectual osmosis" (cited in Barker, 2000: 2). Henceforth, follows a discussion of the approaches and strategies used by the DSs teaching in the FP to assist the students in the acquisition of discipline-specific literacies required for science with the acquisition of science.

7.2.1 Vocabulary Acquisition

Engagement with the DSs in this study indicated that some measure of attention was being paid to promote discipline-specific literacies in science in the FP by using different methods and approaches to assist students to acquire these in science. The data in respect of the discipline-specific literacies required for science (which was addressed in Chapter 6) indicated reference to the lexical and grammatical features of reading and writing.

In response to critical research question 3, this study has illustrated that the DSs placed emphasis on spelling and vocabulary acquisition, as conveyed in Shane's comment '[w]*ell, if a language issue comes up – like a word they don't understand or can't spell, we discuss it".* This study has shown that 70% of the DSs considered assisting the FP students to develop control over the specialized vocabulary as being an important part of their instructional role. Since the language of science is made up of technical words and non-technical words, the DSs' attention to vocabulary could not be disregarded.

An observation of Lisha's foundation biology practical, 'Mode of Life', showed her paying specific attention to technical words (e.g. 'algae'; 'octopus', 'kelp'; 'corals'; 'anemones'; 'Cnidaria'; 'cephalopod') that were context-specific to marine organisms; and technical words (e.g. 'detritivore'; 'phylum'; 'chromatophores'; 'heterotrophic') that were discipline-specific. Appendix 32 offers an observation of two of Lisha's lessons which are indicative of this taking place in the class. Students acquired relevant scientific technical vocabulary necessary to access the science content. This was done as they conducted the laboratory practical which involved interaction among peers; the DS and laboratory demonstrators. This teaching and learning methodology maximised the objective of acquiring the discourse practices of "knowing" science, "doing" science and "talking" science (Lee and Fradd (1998: 15). The knowledge of the marine organisms gained in this practical was also essential for the students' field research trip to the rocky shores after which they were expected to formulate and submit a formal scientific report. Almost all the students present at the practical displayed an understanding of the definitions of the words which they provided in response to prompts from Lisha.

Most of the technical words that Lisha paid attention to were included in the foundation biology course manual and students had little trouble comprehending these specialized technical words. In this study, the glossary has been used a mechanism to help students grasp the field-specific register is that is essential for them to appropriate the specific disciplinary discourse. According to Lara, the idea to incorporate a glossary into the foundation biology course manual arose in 2006 when the students experienced problems with the large volume of terminology in the course. Lara explained that the glossary functions as *"an easily accessible mechanism to extend, acquire and reinforce scientific technical vocabulary specific to biology"*. According to other DSs teaching the foundation biology course, besides informing students of the meanings of words in the context of science, the glossary was also intended to "*correct the misconceptions that might have been conveyed to students at school level"* (Josh) and aimed at encouraging students to *"take the initiative and extend it as they encountered new and unfamiliar words"* (Lisha). Likewise, the insertion of a glossary in the foundation mathematics course manual was meant to help students grasp words (such as ‘respectively’) frequently used in the discipline. Raj stated that the words in the glossary in the foundation mathematics course manual were explained thoroughly at the start of the academic year and it was an expectation that it be used by FP students as a guide, making constant reference to it throughout the year. However, Raj expressed the following concern: *“Students don’t read this* [glossary] *on their own. They should be reading it several times, they need to get used to it and talk about it. We find that students expect us* [DSs] *to read and explain it to them”.* One of the ways in which this problem can be addressed is by not providing students with a comprehensive/exhaustive list of mathematical concepts and symbols. Alternatively, they could be provided with a few of these concepts and symbols at the start of the academic year. As the year progresses, students can be encouraged to add to the glossary as they engage with additional concepts and symbols, for example the use of *define’, ‘prove’, ‘show’* and *‘verify’* which are commonly used to test mathematical knowledge and which were not included in the list of frequently used words in mathematics (shown in Chapter 6).

Although the focus on technical words in science can be helpful, research such as that by Kirkwood (2007) has shown that it is not always technical words that cause problems in reading texts; students struggle with general academic words, and words usually considered as ordinary everyday words. The focus on everyday words in the context of science can be helpful. The focus on the use of everyday words in science is relevant as research by Cassels and Johnstone (1985) shows that these words can have precise and different meanings in a scientific context. In this study, Josh recounted the approach used to link an everyday word to the context of science.

> *“For example, I wanted to find out if they* [the students] *knew the meaning of ‘efficiency’. No one really knew and it was such an important concept* [for the section on ‘Enzymes’]. *If they don’t understand a particularly significant word in a topic then they won’t conceptualize anything else around it”. So I wrote the word on the board, explained the spelling and pronunciation ... I showed them the different forms of the word and I discussed its meaning*”.

Although the word ‘efficiency’ is not a technical word but a common, everyday word, Josh’s need to clarify its meaning was necessary to facilitate the understanding of the catalytic efficiency of enzymes and the role of enzymes in chemical reactions. Josh had demonstrated how a common word can take on a specialized meaning in the context of science. According to Lemke (1998), in science every word is rich with meanings, meanings that accumulate as [we] encounter it in many different contexts.

In terms of the strata of the SFL model, Josh explained the word, 'efficiency', in terms of its phonology, morphology, and semantics. The recount by Josh is suggestive of a teacher-centred approach to teaching vocabulary (as conveyed by the constant reference to 'I'). As much as such an approach might have been useful in making students aware of meanings of words used in the context of science, it is hardly effective in encouraging student responses to the lesson. Although Josh used an opportunity to extend students' vocabulary for epistemological access, his teaching methodology lacked student-engagement. The students should have been given an opportunity for greater involvement in the lesson by way of prompts for, as stated by Lemke (1998), teaching is a dialogue.

Other DSs used different approaches to teach everyday words whose meanings change when they feature in scientific contexts. Nancy, for example, relied on integrating students' everyday understandings of words with that of science, more especially, foundation chemistry. In attempting to convey the contextual meaning of the word 'agitate[d]' in a laboratory practical, Nancy first used the word in a sentence to convey its meaning in everyday language: "The sound of the thunder <u>agitated</u> the child" which conveyed the notion of 'the child being disturbed [agitated]'. She encouraged students to comment on their understanding of the word; approximately least 90% responded in unison that it meant 'frightened". She then elaborated on its meaning in the context of chemistry, using the following sentence as an example: "The chemistry tutor <u>agitated</u> the solution with a stirring rod" which, in the context of chemistry, means to 'disturb [agitate] the chemical environment of the solution'. The explicit approach that Nancy used to reinforce vocabulary that had specific meanings in science was a way of assisting students to gain access to the discourse of science. The effectiveness of the teaching strategy adopted by Nancy was a way of enabling students to perform a crucial procedure in a laboratory practical (i.e. "agitate the solution") correctly. While students were engaged with the discipline-specific activity of conducting a laboratory experiment, Nancy used the chance to teach both science and the language of science. In terms of SFL (Halliday and Martin, 1993), the participants i.e. both the students and the DS (Nancy) were engaged in the laboratory practical activity [field], Nancy occupied a more dominant role [tenor] and language was used as the interactive medium to facilitate understanding and learning [mode].

Although this study explores issues of discipline-specific literacies in science in the research site where the LoLT is English, understanding the FP students' reliance on isiZulu, where necessary, was significant. Observation of lectures, tutorials, practicals and field trips has demonstrated that the FP students often communicated with each other in isiZulu when they were involved in group work or discussion. According to the data from this study some of the DSs who were fluent in isiZulu resorted to code-switching as a pedagogic practice to explain science concepts; to encourage students to respond and participate (in discussions); and to promote the understanding of science content. The excerpt below illustrates the purposeful way in which Lara used isiZulu to teach a topic in science:

> "*... because there are terms* [concepts] *which students will never understand no matter how you try and explain it to them in English and you can only think of the word in isiZulu, for example when we're discussing plants and we use the isiZulu name to identify the plant, students understand so much better and respond saying, 'Oh, I've got that plant in my garden!' ".*

This study has shown that FP students do experience difficulties with the understanding of specific everyday words commonly used in the English language. The following observation of a foundation physics practical illustrates how FP students relied on isiZulu to understand an everyday word. In a foundation physics experiment on 'Static Friction', at least 40% of a total number of 60 students were confused with the meanings of the antonyms *broad* and *narrow* used in two steps of the method, viz.:

- Place a wooden block lying on its broad side on a given plane.
- Repeat the experiment using the narrow side of the block.

(*Foundation Physics*, Static Friction Experiment, 2011: 3).

As I walked from group to group in an observatory capacity, I watched students debating over which side of the wooden block was *"broad"* and which was *"narrow"*. Some of them perceived 'broad" as 'big' and 'narrow" as 'small'. There were discussions among student groups about the translation of these words into isiZulu, which was '*encinyane'* for *narrow*. Since the students were unclear about the isiZulu translation of "broad" (and its meaning in English), they opted to use the word 'wide', referring mainly to *ebanzi*, its translation in isiZulu. Students construed their own interpretations of the words. Language was also construed by social and cultural contexts. A few students chose to ask the laboratory demonstrator for clarification. The meanings of the words were eventually conceptualized by the DS, Annah, who, besides resorting to using isiZulu herself, relied heavily on simple sketches and analogies to everyday occurrences such as a 'broad/wide/narrow street; broad shoulders and narrow hips' to convey the meanings of the words used in the context of physics.

In the situation cited above which took place in the foundation physics laboratory, Annah (besides relying on isiZulu) used a visual cue of drawings in addition to the practice of scaffolding to explain discourse. This involved using students' understanding of the meaning of commonly used words in English (i.e. broad and narrow) to convey conceptual knowledge. Annah built on field, i.e. students' everyday knowledge (e.g. a 'broad/wide/narrow street) to assist with educational knowledge. Through scaffolding, she identified a 'gap' in students' understanding, helped them bridge that gap and move into a new ZPD. SFL here was used to show language as a social meaning system where text is situated in context (Halliday, 1985). This is an example of one of the "orientations of SFL: the focus on the solidary relations between texts and social contexts" (Halliday, 1993: 22). However, the challenges experienced by the FP students in understanding these words in English are indicative of the authoritative role of the LoLT on the students' understanding. The examples cited above are an indication that the students were forced to use, what Bourdieu (1977) calls the "educated" language. In this case, it was the understanding of specific words in English – the dominant language – that posed a barrier to the students who speak EAL. In the case with Annah's lesson, students were able to continue with the experiment as soon as the words were clarified in isiZulu. Although this study has made reference to ordinary or non-technical English words that the FP students can (and do) misconstrue (for example, the use of 'swirl' and 'agitate' discussed earlier), the examples cited above refer mainly to English words that have different meanings in the students' home language, isiZulu.

7.2.2 Encouraging oral communication

Lemke (1990) advocates "learning to talk the language of science" (1) which can help to communicate scientific knowledge. Raj outlined the role of oral discourse in foundation mathematics:

> "*I am a great believer of peer teaching and learning. The type of students we generally get are reserved, they lack confidence. To develop their confidence, when we do examples, I ask them to take turns to go to the* [chalk] *board and explain their answer to the class. It helps me to understand how they are*

> *thinking and whether the application is correct and to iron out any problems I can identify by clarifying or re-teaching. Or sometimes their peers can explain where they have gone wrong. I found that the students learn well in this way*".

The pedagogic practice implemented by Raj allows the students to show understanding through active engagement. It is useful in that it encourages oral communication in the discipline of foundation mathematics by encouraging students to communicate with the DS and with each other. In addition, it helps to support students in their acquisition of mathematical knowledge. The approach to encourage students to explain is a way of boosting confidence and enabling them to 'speak' mathematics. Verbalising shows how the students are thinking about the problem and how they are solving it. It also helps to correct any misconceptions and inaccuracies ("*whether the application is correct and to iron out any problems"*). Since mathematics is cognitively demanding; students require CALP and since it needs to be explained with clarity and precision, they require secondary discourse. By encouraging students to verbalize their knowledge of mathematics, Raj is engaging students, enabling them to "share their [mathematical] understanding with others" (Lee and Fradd, 1998: 17), i.e. between peer and peer where they learn from each other; and, between student[s] and the tutor (Raj) where the latter helps to *"clarify and re-teach"* (Raj). The approach adopted by Raj enables students to demonstrate "conceptual understanding, strategic competence and adaptive reasoning" (Kilpatrick *et al.* 2001: 116).

The situation in Raj's class reflects the student[s]' progress through ZPD: learning begins with guidance by a competent other [the tutor or peers] to aid with developing new concepts and understanding [by means of *"clarifying or re-teaching"*] with the eventual aim of acquiring knowledge and skills independently, i.e. *"I found that the students learn well in this way"* (Raj). Raj's adoption of peer teaching and learning is an impressive pedagogic practice. He is focusing on one of the students' strengths – to be able to teach and learn from each other. Students are less likely to feel intimidated and threatened when they are corrected by their peers, rather than the tutor.

Exasperated with students' reluctance to read in foundation biology and concerned about the challenges of comprehension[97], Josh relied on the strategy of an informal oral quiz to

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[97] The following verbal response in the semi-structured interview with Josh supports this comment:
VP: In foundation biology, do they (the FP students) have to pre-read before your lectures?
Josh: *We ask them to but they don't really. That's why I introduced this little quiz.*
VP: What's the purpose of the quiz?

encourage reading; to test comprehension; and to help students verbalize what they had read. An observation of the lecture based on the topic 'Cell Biology' illustrated that Josh's strategy ensured whole-class participation by ensuring that each student in the class was asked a question and was given a chance to respond orally – a sample of which appears below[98]. Where necessary, the students were encouraged to explain their answer, using the chalkboard. The quiz fostered competition among students, with many being bold enough to challenge each other. At the end of the quiz, through rapid questioning, Josh was able to summarise the main points of the reading topic. According to Josh, the primary aim of the quiz was "*to see whether they* [the FP students] *have been understanding the material and quite a bit is whether they've read up on it"* (Josh).

7.2.3 The focus on reading

This study has already isolated reading as being a key literacy in the disciplines of science. This is especially since students are expected to synthesize information from readings for class discussions and laboratory reports; and recall content knowledge in tests and examinations. As a way of focusing on reading and reading comprehension, the DSs in foundation biology have amended the course to include the scaffolding approach (See Appendix 34). Teresa explained the changes that have been implemented in the foundation biology course to assist students in the acquisition of the literacies required for science discourse *"But all our notes have been refined. We had to simplify the language, scaffold the tasks and write shorter sentences so they can deal with one thing at a time ... Our content is a vehicle for skills development. It's just more biological."*

The foundation biology course notes (2011) adopted a workbook-like approach[99] consisting of a glossary of technical discipline-specific terminology; short notes with relevant

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Josh: *To see whether they've been understanding the material and quite a bit is whether they've read up on it. You see, the quiz makes them read.*

[98] Range of questions asked: "*Ok, give me the names of the 3 main parts of most cells. Right – here's a clue: This is the outer living boundary of the cell, what is it? 3rd student there: Give me a description of the cytosol. Now, this next question is a bit trickier: What can you tell me about the prokaryotic cells? Even trickier: How do membranes ensure compartmentalization? – one or two of you in this row – give me a reason. And now you guys, here: tell me what you read about microfilaments and microtubules – each one in the group give an answer"*.

[99] See Appendix 34 for excerpts from the course manual. Appendix 33 has the glossary.

technical words in bold print followed by leading questions/reading tasks; and diagrams and tables requiring annotations. These are the linguistic support structures that have been included to assist the students to be able to read through and comprehend the conceptual content. This contributes to the meta-cognitive knowledge required for effective academic reading, which according to Anderson and Armbruster (1984), involves an understanding what needs to be studied (task awareness), the ability to process and focus on the information by relying on the linguistic cues, to encode/decode information and retrieve what is needed (strategy awareness); and to be able to affirm whether learning and understanding have taken place by performance in the assigned reading tasks (performance awareness).

The purpose of using the technique of scaffolding in the foundation biology notes is to provide students with support to read complex academic texts, to enable them to work on and complete a task that would otherwise have challenging to complete. Appendix 34 shows the type of scaffolded tasks that are found in the foundation biology course. The scaffolded tasks help to guide the students through the biological concepts. According to Teresa and Josh, 70% of the students indicated in the foundation biology course evaluations that the scaffolded notes were very accessible. These tasks enable the students to reach Stage I of the ZPD (Vygotsky, 1978a) where they get guidance and direction from the DSs and tutors to perform the task. This is qualified by the comment, "*Well, they've got to read the tasks and interpret the tasks. We do give them some guidance but once they are left on their own, they've got to do it themselves"* (Josh).

According to the data, 25% of the DSs teaching foundation science modules use their contact teaching time to enforce or practise reading while 31% focused occasionally on reading, more especially when they needed to draw students' attention to specific concepts or terminology in texts or notes. This also included the need to read for clarification or to locate answers. Forty four percent did not focus on reading due to lack of time, voluminous content and the expectation and responsibility of students to read independently.

Lara related that foundation biology has extensive reading texts that students need to go through and absorb for the laboratory practical, which incorporated theoretical knowledge.

Lara explained how a portion of the time allocated for practical work was utilized to pay attention to the reading literacies necessary in foundation biology:

> "*Sometimes students complain that they don't know where to get the answers so I read a paragraph with them – kind of show them how to read ... and together we highlight each important phrase and then they will look for points about feeding, habitat, movement etc. about the organism. If you do it with them and show them how to get the answers, it will help them. They can then see that it is not impossible to get the answers, like they usually think. Then they can do it on their own. Actually, with time, they will learn to find the answers on their own*".

Lara's approach is characteristic of "learning to read and reading to learn" (Rose, 2005b). One of the benefits of Lara's approach is that she is explicitly modelling two significant literacies for the students: reading and reading for comprehension. Lara's focus goes beyond fluency and articulating the written word; it is based instead on the ability to comprehend. Lara's method helps students to jointly distinguish between essential and peripheral information (*"we highlight each important phrase");* and to organize information into specific categories (*"then they will look for points about feeding, habitat, movement etc. about the organism"*). Lara helps to guide students and apprentice them into the discourse of science. The approach adopted by Lara shows how students can progress through ZPD. The students in the situation are at Stage I of ZPD (Vygotsky, 1978a) where they have limited understanding of "*where to* [find] *the answers"* (Lara) in the text. Lara, the more competent other, guides the students through the learning process of reading, comprehending and extracting answers from the texts to enable them to complete the task. Lara models learning, "*show*[ing] *them* [the FP students] *how to get the answers",* enabling the students to reach Stage II: "[t]*hen they can do it on their own",* without assistance. It is between these two stages that the ZPD (Vygotsky, 1978a) occurs. Lara is hopeful that with time, "*they will learn to find the answers on their own",* and completing the task will become internalized and a learnt process. Through the strategy of devoting time to reading and showing students how to locate answers in more difficult texts, Lara has helped students to progress from "other-assistance to self-assistance" (Gallimore and Tharp, 1990: 183).

Dennis who has been involved in foundation teaching for almost a decade created an interactive learning atmosphere by urging students to *"read aloud and to rephrase the* [foundation chemistry] *content in their own words"* as part of the discussion process in class. This RP explained that, on an elementary level, the implementation of this approach was multi-faceted as it forced students to confront and engage with texts and also helped to develop their confidence in reading and speaking and gave an indication of their reading proficiencies. On a higher level, it reflected their reading comprehension abilities in science. This approach enabled Dennis to address confusion, misinterpretations and inaccuracies by further "*unpacking what was read, repackaging it and clarifying it so it could be understood."* This was a way of ensuring that students acquire the discourse of a discipline, to help them become members of the discourse community; spurring them towards "talking science" (Lemke, 1990: 1).

This study has already highlighted the views held by DSs, such as Kenneth, who attributed challenges in solving word problems in foundation mathematics to the lack of careful reading. The following word problem was discussed during an observation of Kenneth's foundation mathematics tutorial session: "**Two years ago** a mother was **twice** as old as her daughter. How old is the daughter?" Kenneth drew attention to the words in the problem by reading it out in a slow, deliberate manner, emphasizing the textual clues of "two years ago" and "twice". This was followed by an explanation of the meanings of these words and similar others such as 'thrice'; and 'four times' commonly used in mathematics. The manner in which Kenneth read the question tied up with his response during the interview: *"You will find that the question is not answered fully because they* [the FP students] *did not read it fully or properly. That's why I read the whole question out aloud. And I say to them, if I read and you follow, then you can begin to process what the question is asking you to do".* According to Pretorius and Bohlmann (2003), the linguistic dimension in mathematics [texts] can cause problems: problems at the receptive level (e.g. the reading of mathematics) will affect the productive level (e.g. writing, discussing)" (228). Kenneth's reliance on the "think-aloud strategy" (Davey, 1983) where he modelled the ways to unravel the meaning of the question to help make sense of it, seemed to have helped ease students' understanding and enabled them to practise with similar examples using the same strategy.

In this study, Seema related the way in which she focused on reading in her foundation chemistry classes: *"I mean I have designated readers in class and the rest of the class listens and follows. The student will read a paragraph and I will explain it".* With probing, Seema elucidated that her "*designated readers were the good readers – they read fluently*". Seema's reading method reduces reading to a mechanical activity. The good readers use their "decoding skill which involves rapid word recognition and relatively fluent oral reading" (Pretorius and Machet, 2004: 133). This method is less effective in testing students' comprehension of the subject matter because *"the designated readers"* are merely tasked with reading aloud while the explanation of content was done by Seema. The students were thus reduced to being passive listeners. Seema overlooked the opportunity to develop and test students' reading comprehension. Furthermore, Seema's practice of asking her *"designated readers"* to read means that the other students in the class group were deprived of the opportunity to read aloud or acquire practice at reading aloud; and to gain and/or demonstrate reading confidence.

7.2.4 Providing written explanations

In an effort to curb *"memorising of equations and formulae that students just plug in without understanding"* (Annah), and to rule out the perception that physics is about learning fixed rules and equations that can be applied to a question, the following question that tested students' conceptual understanding was set in a foundation physics test:

> Question 11:
> A scheming business man buys gold by weight at a higher altitude (height above sea level) and sells it at a lower altitude at the same price per weight. Write a brief explanation to the public protector on how the business man is making a profit. (*Foundation Physics:* August Test, 2011: 2)

Annah justified the reasoning behind the inclusion of this type of questioning, i.e. instructing students to provide an explanation for their answer:

> "*That is the major issue in* [foundation] *physics. They bring in the concepts of mathematics into physics. They are very happy if you write the equation on the board. But at some point, with some questions, you have to explain your answer. I usually emphasize that once they have done their calculations they have to explain their answer at the end ... Students need to understand why they are doing the calculations*".

Justifying answers was one of the ways of demonstrating conceptual knowledge and reasoning, showing evidence of understanding or *mis*understanding. This is the Comprehension Level II of Bloom's Taxonomy (Bloom *et al.* 1956). Van Heuvelen (1991) states that students could learn to think like physicists when given opportunities to reason qualitatively and make use of translations from verbal [and pictorial] representations. This comment points to the notion of helping students to become members of the discourse community through written explanations. This is also one of the ways of encouraging writing in physics especially in light of the earlier comment by Susan in Chapter 6 that writing in foundation physics is minimal.

7.2.5 Scaffolding as an Instructional Strategy

This study has already discussed the scientific report as being one of the key genres in science and has drawn attention to the differing expectations and variations in respect of the compilation of this genre of each of the foundation disciplines in science (in Chapter 6). One of the ways in which students in the FP have been apprenticed into the scientific report writing conventions has been through the process of scaffolding. In foundation biology, scaffolding is used as an instructional strategy to teach students how to compose and produce scientific reports, a genre that is a "goal-oriented activity" (Martin, 1984: 25). The scientific report, explained from the SFL perspective, involves both theoretical and practical work. It uses procedural language to explicitly and objectively describe a scientific phenomenon, using data that they generally collect themselves.

This study has shown that some of DSs have been implementing practices to foster learning in science. In light of the scientific report being a key genre in science and in consideration of the challenges that its compilation poses to students in the FP (as outlined earlier in this Chapter), one of the approaches used in foundation biology was the practice of explicit modelling as a form of scaffolding. A type of micro level scaffolding (Wells, 1995) used to teach students to understand the specific task of scientific report writing was implemented by providing students with *"examples of good and bad* [scientific] *reports"* (Lisha). (An excerpt from each of these reports can be accessed in Appendix 35). The following excerpt from the course manual outlines the reasons for including sample 'good' and 'bad' scientific reports:

> Examples of both badly written and well written reports are given in the following pages. The well written report will give you a good example to model your own report writing on. In tutorial groups you will have to identify all the mistakes in the badly written report.
> (*Foundation Biology,* 2011 Semester 2: 47)

Furthermore, in foundation biology there has been evidence of explicit attention being paid to the necessary literacies required to compose the scientific report. This has included explicit definitions of specific scientific terminology (e.g. 'hypotheses', 'variables') with appropriate short tasks to test understanding of such terminology. An example of this appears below.

2. Testing the null hypothesis

Once you have formulated the null hypothesis, **you need to carefully design an experiment** to test it. You need to take into account all the factors that may possibly have an influence on the results. **Anything that could influence the results of an experiment is called a variable.** So the first step is to **identify all the variables** in your experiment.

There are 3 types of variables:

3. Independent variable
This is the variable that **you change deliberately** to see the effect that it has.

4. Dependent variables
These are variables that **you measure** as they change in response to the independent variable i.e. these are variables that **depend** on the independent variable.

5. Controlled variables
These are factors that must be **kept constant** so that they do not interfere with your experiment and affect the results by mistake.

Task 7

For **each** of the experiments described below, write down the:

a. **Independent variable**
b. **Dependent variable**
c. **Controlled variables**

Experiment 1
The rate of photosynthesis was measured in Elodea plants over a range of carbon dioxide concentrations. The temperature of the water was kept at 25°C and the light intensity was maintained at a constant level. **(3)**

Experiment 2
The animal species composition of the high, mid and low sea shores of the East Coast was investigated. The number of animal species in each shore was counted during spring tide in summer in 2007. **(4)**

Experiment 3
The amount of lung tissue damage from a number of heavy smokers was investigated by studying X-rays of their lungs. X-rays were taken from subjects who had been smoking for 5; 10; 15 and 20 years. Subjects were male, smoked between 15 and 20 cigarettes a day, were well nourished and were in good general health. **(4)**

(*Foundation Biology*, Semester 2, 2011: 35)

The advantage of explicit modelling is that it guides, supports and apprentices students into the academic discourse community. In essence, it mediates learning. With the science report genre being identified as one of the core writing focuses in SCOM, the strategy adopted in foundation biology to reinforce this genre within a discipline satisfies the call for transfer of learning and the need to make discursive practices visible and meaningful. This is one of the ways of acculturation; apprenticing students into the discourse community of science.

7.2.6 Paying attention to grammar in science

The scientific report genre is a key writing task in all the foundation modules in the FP, except for foundation mathematics. Students are expected to present the method/procedure of an experiment in a methodical, logical manner. The reliance on the use of the passive voice and the past tense are important when compiling the scientific report as a way of teaching students that science needs to be written objectively, in an impersonal manner where the author has to distance the self from the text. These aspects of grammar in science have been included in the foundation biology course manual. One of the ways in which the passive voice and past tense have been reinforced in foundation biology is the inclusion of a short, clear explanation and simple examples as shown below:

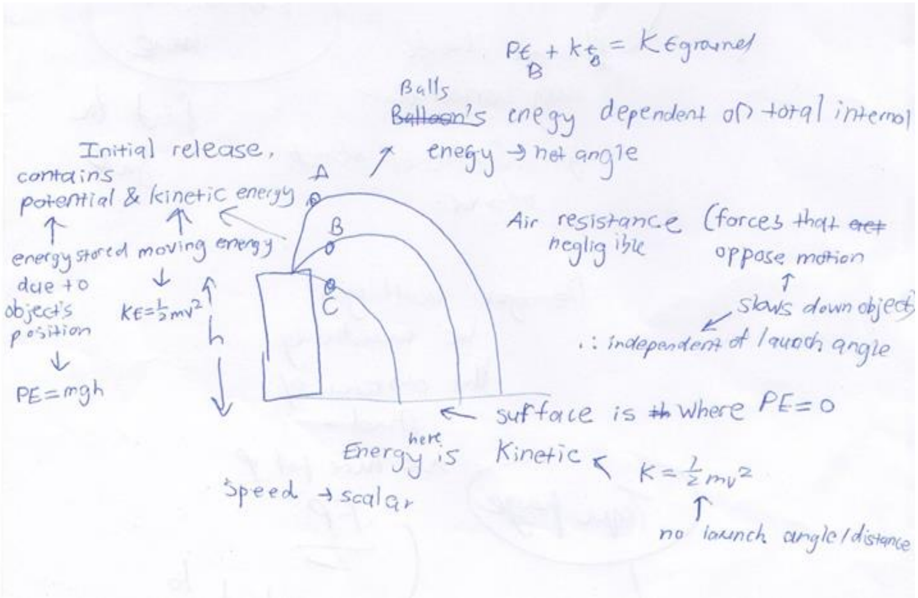
> "The experiment that you are reporting on has already been conducted. Therefore, you should write most of the report in the **past tense.** It would be wrong to write your report as a set of instructions to be carried out. For example: "Place the mouse in the respirometer chamber" should read "The mouse was placed in a respirometer chamber". The report findings should not depend on who conducted the experiment. For this reason, the report is written **impersonally**. For example, it would be wrong to write: I poured water into the measuring cylinder". Instead, what should be written is: "Water was poured into the measuring cylinder". No personal pronouns such as "I", "we", "you", 'they" are thus used in report writing. This is called the **passive voice**" (*Foundation Biology* Practicals, Semester 2, 2011: 44).

In addition to merely providing an explanation of the above, the inclusion of an exercise on passive voice and past tense use would have been useful to test students' understanding of the functional use of these aspects of grammar in scientific report writing.

7.2.7 Visual-graphical literacy in science

Lemke (1998) states that the natural language of science is a synergistic integration of words, diagrams, pictures, graphs, maps, equations, tables, charts, and other forms of visual and mathematical expression. In this study, responses from the DSs and a survey of the course manuals showed that diagrams accompanying questions and problems are commonplace in foundation physics. Susan uses the diagrams to engage the FP students in the discourse of the discipline of physics and to reinforce conceptual understanding in physics. This is achieved by *"annotating the diagram ... to help direct students' thinking; a kind of deconstructing or unpacking so that the diagram becomes a tool to convey information"* (Susan). Below is Susan's example of an annotated diagram in foundation physics:

<u>Question 2.</u> [6] In the diagram, three balls are tossed from a height *h*, all with the same speed but different launch angles. Which one has the highest speed on reaching the ground? Explain. Ignore air resistance.



According to the DSs, one of the techniques also used in foundation physics to engage students and to help mediate their learning was the strategy of teaching students to rely on concept mapping[100] as a way of extracting and understanding relevant concepts in physics texts and synthesizing information into simple, meaningful summaries. This approach was essential because *"physics can be abstract"* (Shane), with a significant number of key concepts which students need to *"acquire, understand, learn"* (Susan).

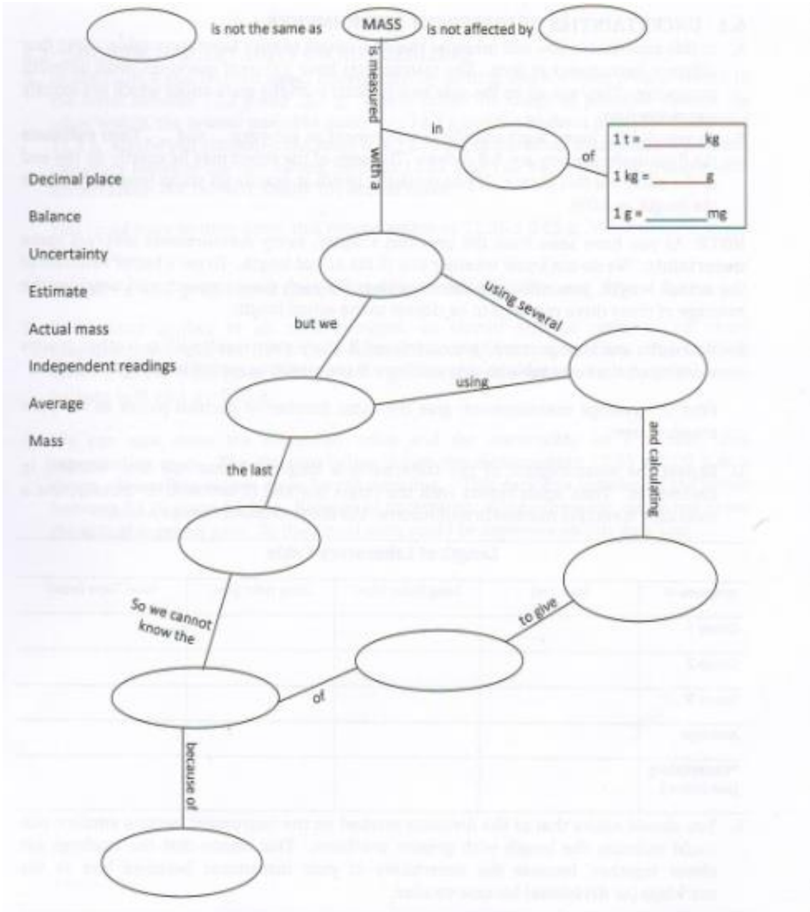
Petrus explained that in foundation physics, concept mapping was *"a form of visualisation"* that helps students to create a summary of key concepts. In an observation of his lesson on 'Mass and Other Balances', Petrus used the concept mapping task (see below) to link the relevant concepts that students had learnt in the topic. The progression of the lesson exemplified that of Vygotsky (1978): Petrus worked with the students to mediate their understanding of the concepts and construction of knowledge, then allowed for interaction with other students and finally encouraged students to continue doing so on

[100] Concept mapping is also referred to as: "cognitive mapping; tree diagrams; semantic mapping or mindmapping" (Angélil-Carter, 1994: 125).

their own. They were also encouraged to do so with any other topic in the course. The concept mapping strategy assisted students to demonstrate understanding of key concepts. All the concept maps attempted by students were correctly done which Petrus attributed to the task being a synthesis of learned knowledge on a topic that spanned a few periods. Although the concept mapping task was a summary of learnt concepts, Petrus, however, missed the opportunity to transform this visual representation into a written summary.

5.5 SUMMARY OF SECTION 5:

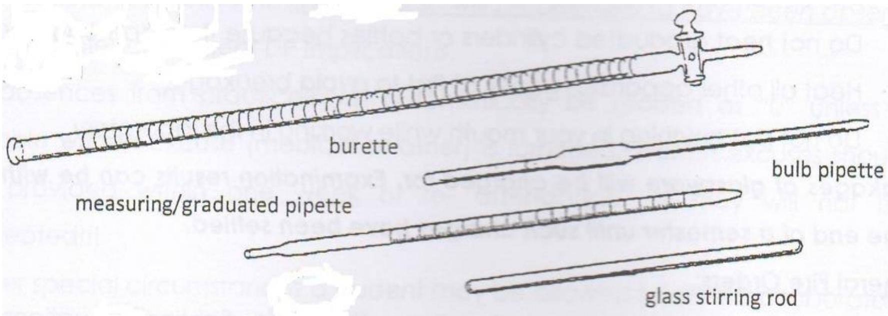
A useful way to check your understanding is to make a concept map. The links in these maps are most important; the words which fit into the blank shapes will make sentences when you read across or downwards. For example "Mass is measured with a balance". Other words are given at the bottom of the page. With your partner, discuss what you have learned about them and where they will fit onto the map. You may want to add more links to the map.

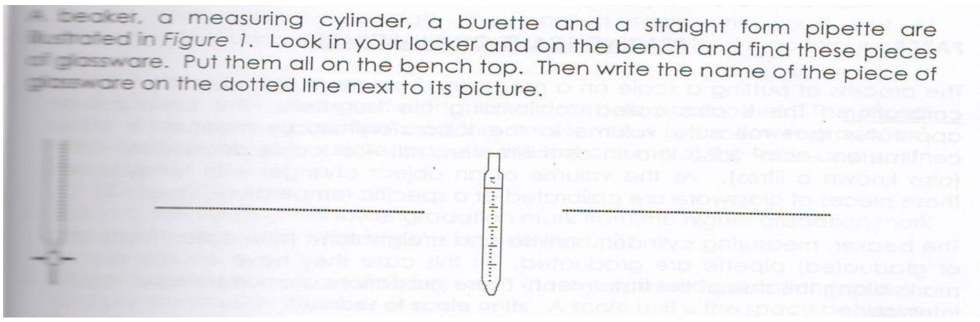


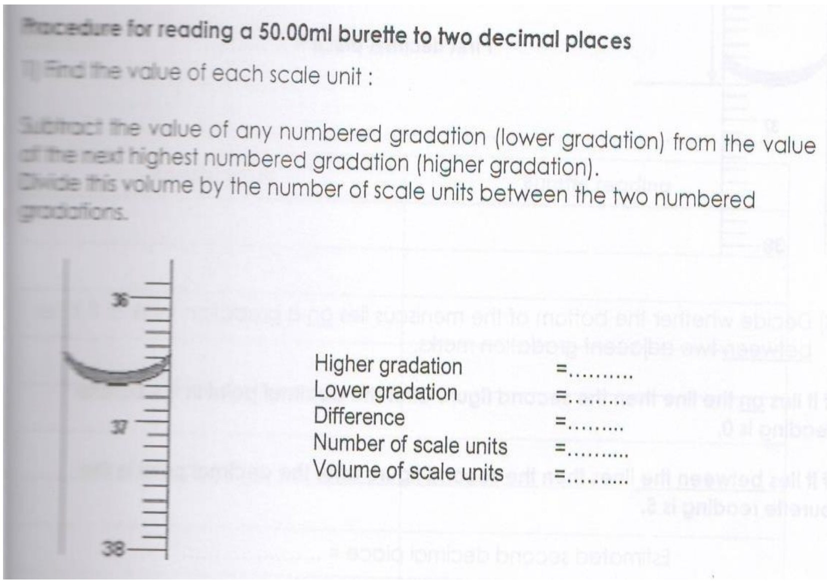
Concept Mapping task (*Foundation Physics*, Semester 1, 2011: 25)

The advantage of concept mapping is that it "allows the [tutor] to see what kind of conceptual categories and links the [student] is generating, and thus helps [him] to ascertain the actual level of development so that [he] can work within the ZDP to push that development” (Angélil-Carter, 1994: 132). The advantage of teaching students to use concept mapping as a learning tool is that, with practice, students can eventually rely on it as a learning tool, applying it to other learning domains.

The discourse of science is conveyed through pictorial, graphical and mathematical representations. Discipline-specific literacies are not only applicable to written texts but to illustrations/diagrams, graphs and tables. The FP students’ educational backgrounds are quintile 1-3 schools that are “under-resourced schools where there was non-availability of resources such as laboratories” (Dempster and Reddy, 2007: 908). Therefore, the introductory practical lesson in foundation chemistry where students were familiarized with common laboratory equipment was useful. Seema expanded on the reason for this: *“Sometime we* [DSs] *take the markings on … say, a burette ... for granted. But when we’re dealing with students who might not have had labs at school, then we have to show them a burette … and point out the markings too”.* In addition to this being done in the laboratory practical, the inclusion of pictorial and graphical forms in the foundation chemistry course manual (see diagrams below) aimed at helping students to identify and label laboratory equipment; and to complete tasks on reading and calculating measurement using laboratory glassware to help students to conceptualize their learning.







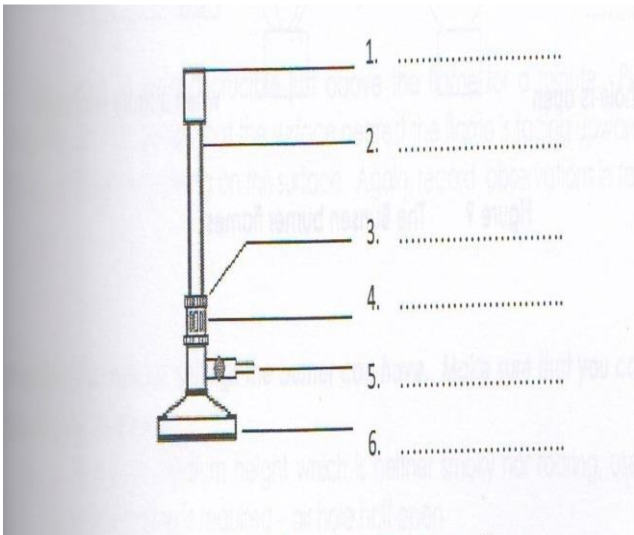
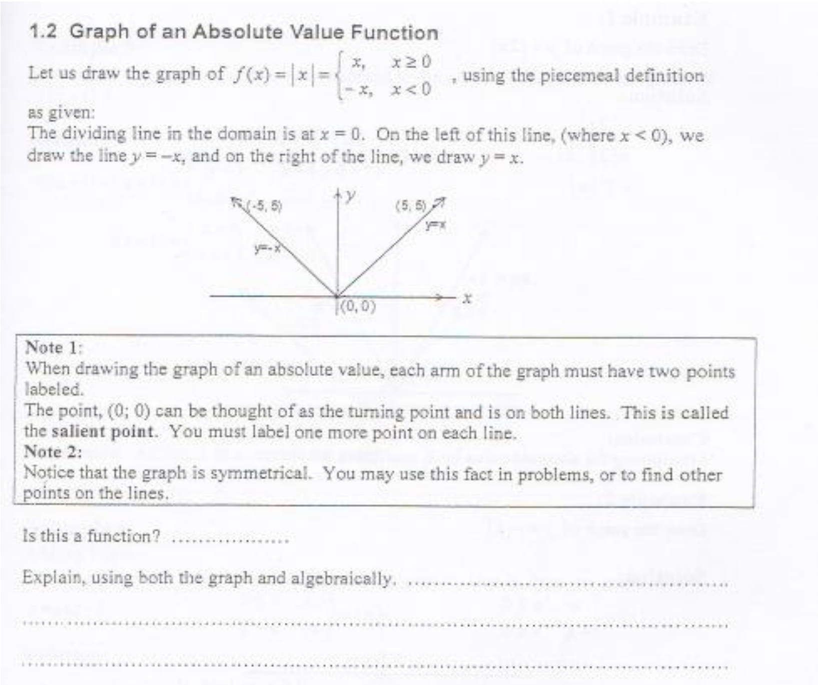


Figure 8 The parts of the Bunsen Burner

(*Foundation Chemistry*, Semester 1: 2011: 2, 7, 9, 18)

Students require an understanding of commonly used mathematical terms and phrases. They also need to be able to read, interpret and use information in tables and graphs. In this regard, data in this study has shown substantial assistance provided in some of the foundation disciplines. In foundation physics, for example, one of the lessons incorporated in the course manual was ‘Introduction to Graphs’ which offered a thorough explanation of drawing and interpreting graphs. This included an annotated graph that highlights commonly used mathematical terms such as *axis*, *scale*, *units*, and *intervals* (See Appendix

36). In response to this, Annah stated that the foundation physics tutors *"go through this section in the manual thoroughly because it teaches the students how to interpret graphs, what to look for"*. With graphs being an integral component in mathematics, the DSs teaching foundation mathematics have placed emphasis on the interpretation of graphs. The following hints on 'Graphs of Absolute Value Function' were included in the course manual in the discipline of foundation mathematics:



1.2 Graph of an Absolute Value Function

Let us draw the graph of $f(x) = |x| = \begin{cases} x, & x \geq 0 \\ -x, & x < 0 \end{cases}$, using the piecemeal definition as given:

The dividing line in the domain is at $x = 0$. On the left of this line, (where $x < 0$), we draw the line $y = -x$, and on the right of the line, we draw $y = x$.

Note 1:
When drawing the graph of an absolute value, each arm of the graph must have two points labeled.
The point, (0; 0) can be thought of as the turning point and is on both lines. This is called the **salient point**. You must label one more point on each line.
Note 2:
Notice that the graph is symmetrical. You may use this fact in problems, or to find other points on the lines.

Is this a function? ....

Explain, using both the graph and algebraically. ....

....

....

Hints on 'Graphs of Absolute Value Function
(*Foundation Mathematics* Course Manual, Semester 2, 2011: 4)

In this study, observation of the foundation biology practicals showed attempts at apprenticing students into the discourse community of science. The observation of the foundation biology field research practical 'Plant Species Richness' showed specific references being made to the specialized discourse of the topic. For example, the excerpt on the following page (Textbox 7) from Lisha's practical involving a group of six students[101] shows how she used students' understanding of the topic, 'Ecosystems', to convey the knowledge of a field sampling technique required for the field research practical. She then explained the need to draw a table with relevant data that students would need when formulating a scientific report.

[101] In the field research practical, students were divided into groups of 5-6 students. The practical was conducted with the DSs and the assistance of laboratory demonstrators.

Lisha: So, what are we supposed to do here? *(reference to outdoor area in research site)*
Teboho: to collect data
Lunga: sampling
Lisha: Good. Now, from your readings you learnt about biomes which is …
Almost all the students *(answer promptly)*: particular groups of plants and animals in a Specific region.
Lisha: Ja, and those specific regions would be like tropical rainforests, deserts, and so forth, right. Okay, now you do know what the biomes are divided into?
Veena: Ecosystems
Lisha: Which are?
Veena: a system formed by the interactions of a community of organisms with their physical environment.
Lisha: Yes. Now, ecologists can't collect data on really such large ecosystems so they divide it into samples. Now, from the data from the samples, they will make their conclusions. Now, remember all scientific investigations depend on the **accurate** *[emphasized]* collection of data. So, what you're doing today, you're looking at Species in 3 different habitats: one, grassland *(like right where we are);* two, herbs and shrubs – that's small plants, right and the last habitat is closed canopy, like sampling under a tree *(points to an area with lots of trees).* You understand?
Lisha: There are different sampling techniques for different environments and purposes. But, today we're doing quadrat sampling technique. What this is that we sample a particular area … using this quadrat *(shows students a square botanical quadrat).*
Lisha: What do I do with this quadrat?
Sihle: Throw it.
Lisha: Yes, the first step is to fling it across; then look for and count the species within the quadrat. Remember, you need to count the different type of species, not how many of the same. Make sure you record your data.
Lisha: Don't select specific sites. You need to do what we call random sampling. Anyone knows why?
Sihle: To avoid bias
Lisha: Excellent. So, how can we do this today?
Sihle: Close your eyes and throw it.
Zinhle: and count where it lands. *(Students practise)*
Lisha: Very nice. If your eyes are closed then you can't cheat, hey. Now random sampling ensures accuracy. It prevents bias. Remember I said your data must be accurate … so you can be believed as a scientist, your data must be truthful. Besides that you will have to do your sampling more than once – replicate it, to …
Veena: to get correct results
Lisha: Ja, for reliability of data. Now, also remember when you throw that quadrat you need to work out among your group if an organism is 'in' or 'out'. That's called the **edge effect** *(emphasizes the word).*
Lisha: Record your data in a table with the headings – Habitat; Type and number of species. Total the species and work out the mean. You will need this data … to discuss it when you're doing your write-up – the report.

Textbox 7: Lesson Observation G

Lisha's mode of delivery showed how the development of scientific knowledge involves "knowing" science, "doing" and "talking" science (Lee and Fradd, 1998: 15). Lisha attempted to apprentice students into science by helping them to acquire science (biological) knowledge; scientific inquiry practices and values. The lesson on sampling helped the students to collect data using the botanical quadrat with ease in a field trip to the rocky shores. According to the data on the rocky shores practical students displayed adequate understanding of the scientific practices/methods such as sampling and making careful observations. The observation of a group of students overseen by Josh showed them having achieved Levels I to IV in terms of Bloom's Taxonomy (Bloom *et al.* 1956) as they were able to answer questions correctly.[102] The following excerpt is a sample of questions – according to Bloom's Taxonomy (Bloom *et al.* 1956) – that Josh posed to his allotted group of approximately 10 students on the field trip to the rocky shores: *What organism is this?*(Level I); *Is it sedentary or sessile?; How do you know?(*Level II); *Why are you sampling here more than once?(*Level III*); Is there evidence of dessication here? I want reasons – thorough reasons!(*Level IV). The students were able to identify and comment on the features of different marine organisms; and integrate this with their understanding of the rocky shores environment and comment on species richness.

In foundation biology, the focus on the compilation of tables and the construction of graphs was discussed in the topic 'Interpretation and Presentation of Data'. It offered a comprehensive outline of the relevant 'practical and thinking skills' (*Foundation Biology*: Practicals, 2011: 14) that students should be able to acquire from the lesson. This topic was heavily scaffolded: the rules for the compilation of graphs and tables as well as technical language used in interpreting and presenting data in science were explained simply but thoroughly; accompanied by useful examples and appropriate illustrations; and relevant assessment tasks for students to attempt and submit (as noted in the excerpts below):

RULES FOR TABULATING DATA

- Tables must be **numbered**.
- There must be a brief, descriptive **title**, written at the **top** of the table, and underlined.
- The **independent** variable is listed in the **first** column of the table.
- The **dependent** variable/s (and their repeats) are listed in the remaining columns of the table.
- The information in the first column must apply to the whole row.
- If the table has repeated measurements, then the **last** column is for **means**.
- The units being used to measure the dependent variable must be the same as the units for the mean.
- Conclusions can only be based on comparing the mean values.

[102] Field trip to the rocky shores: Josh's questions according to Bloom's (1956) taxonomy: *What organism is this?*(Level I); *Is it sedentary or sessile?; How do you know?(*Level II); *Why are you sampling here more than once?(*Level III*); Is there evidence of dessication here?(*Level IV)

Task 3

Use the rules above to draw up a table of the following raw data. Be sure to include a column for the means.

A study was done to investigate whether the average size of shad caught off the KwaZulu-Natal south coast had changed over time.
Records of anglers were investigated and showed that during a competition in **1975**, the following sizes of shad were caught: 1.75 kg; 1.85 kg; 2.00 kg; 1.40 kg and 1.5 kg.
During the same competition in **1985** the following sizes of shad were caught:
0.95 kg; 1.20 kg; 1.00 kg; 0.90 kg; 1.30 kg. **6 marks**

3. Graphs

a. Graphs are an effective way to present **summarised data**. The advantage of a graph is that results and trends can be seen at a glance – you do not have to wade through lots of numbers before being able to make sense of the data. Trends are clearly shown, which helps you to interpret and analyse the results of the investigation.

b. Different types of graphs are used depending on the specific **purpose** of the graph and on the **type of data** to be plotted. Common graphs are:

- line graphs
- bar graphs
- histograms
- pie diagrams

c. A graph shows the relationship between the independent and dependent variables. The variables must always be labelled on the graph axes.

- The **X-axis** (horizontal) always represents the **independent** variable.
- The **Y-axis** (vertical) always represents the **dependent** variable.

d. The type of data you have will influence the type of graph you draw. You need to look at the **independent** variable which may be:

3.1 Line Graph

a. A line graph shows the relationship between two variables where the **independent variable is continuous.**
A line graph always has **predictive** value. This means that you can read off the graph to determine values which you have not measured directly.

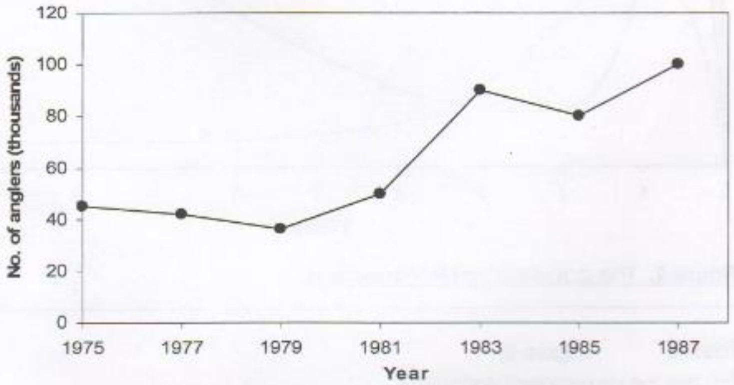


Figure 1. Annual trends in angler participation in KwaZulu-Natal

Excerpts from: 'Interpretation and Presentation of Data' (*Foundation Biology*: Practicals, Semester 2, 2011: 17-18)

7.2.8 Collaboration with SCOM

At the outset of this write-up, the role of SCOM was defined as the "induction of students into the scientific writing community of practice. Thus, they are designed around the 'process' of reading, writing and other scientific communication" (Kioko, 2009: 23). One of the ways in which the DSs teaching foundation biology assisted students to acquire the literacies essential for compiling a scientific poster on ‘Recycling for Sustainability’ was the attempt at collaborative teaching with the ALSs teaching SCOM.

The advantage of the collaborative teaching between SCOM and foundation biology was to combine the linguistic competence gained via SCOM and the cognitive demands of a discipline-based topic, ‘Ecology’ in foundation biology. In this collaborative teaching approach, the scientific poster task was conceived of, designed and assessed as a joint task between the two disciplines. The reading texts were provided by the DSs teaching foundation biology while reading and reading comprehension literacies were devised by the ALs. The scientific poster had the dual purpose of being used as an instrument for a formal oral presentation in SCOM. The poster was assessed in respect of science content (sustainability/ecology and recycling); visual literacy, language and referencing. (The poster assessment grid can be accessed in Appendix 37). This collaboration enabled the reinforcement and transfer of common literacies taught in each of the modules. The collaborative teaching approach satisfied the attempt at assisting students to acquire the literacies of reading (the assigned texts), writing (compiling the poster) and speaking (an oral presentation of the poster). It was able to bring together “language, content and context” (Hyland, 2007: 150). The collaborative teaching enabled students to acquire scientific content knowledge in foundation biology which was presented in the scientific poster. The oral discourse allowed students to “talk the language of science” (Lemke: 1990: 1) and, to share their understanding of the topic with the tutor and their peers.

In Lara’s view, the collaboration attempt was very useful as it enabled both the DSs and the ALS “*to reinforce the same literacies because both disciplines speak the same language”.* Responses from the RPs in this study have indicated support for collaborative teaching. Josh argues that *“for too long people have been kept in their narrow specialist box without giving and taking, learning and growing from collaboration ... a way of ensuring joint responsibility*”. Josh clarified that the reference to “*joint responsibility”* meant that “*the AL staff develops the reading and writing skills* [for the poster] – *like the language for science and we* [the DSs teaching foundation biology] *develop understanding of the content* [sustainability/ecology and recycling]*”.*

Although the success of the collaborative approach in science as a pedagogy is not the scope or purpose of this study, an important point that has been raised via this collaborative partnership has been some measure of engagement between the ALs and the DSs who teach foundation biology. In addition to this, a context was provided for students to integrate disciplinary knowledge and discipline-specific literacies in science. Students had to display their learnt understanding and discourses of sustainability/ecology, simultaneously adhering to the conventions of the scientific poster genre. In a discipline-specific activity such as the scientific poster, students were able to learn science and the language of science, enabling the integration of content and language. This conforms to the SFL view of “how science lexis and grammar correlate with science texts and contexts” (Mohan and Slater, 2006: 305) and how students are assisted in acquiring situated meanings (Gee, 2001).

Furthermore, the scientific poster, like the scientific report, is one of the genres in science. The collaborative teaching initiative gave students the opportunity to practise the scientific poster genre within the disciplinary context of foundation biology while the necessary literacies were made explicit in the context of the academic literacy classroom. It accommodated the characteristics of genre pedagogy where the emphasis was on both language and contexts. The choice of the genre was derived from the course objectives of SCOM (the formal scientific oral presentation) and foundation biology (the scientific poster). Students’ reading was scaffolded and the literacies required for the writing task were explicitly outlined in the course manual and facilitated by the ALSs while the disciplinary content knowledge was taught by the foundation biology DSs. The FP students were expected to demonstrate content knowledge through the submission of the scientific poster for assessment and an oral presentation, both of which would require proficiency in CALP. The scientific poster genre was based on common subject matter (field) and used for two different channels of communication (mode) but the register for each was the same.

Conclusion

In this Chapter, the DSs have isolated reading as being one of the literacies considered a major challenge facing students in the FP. This was based on factors such as the lack of reading preparation (and/or initiative) ahead of lectures, tutorials and practicals. However, such a challenge needs to be considered in the context of the FP students' disadvantaged educational backgrounds which were characterised by lack of specific attention being paid to reading and reading practices; and the point that they hail from largely oral cultures. Furthermore, the challenges of reading need to be seen in light of the nature of the reading texts that characterise science, i.e. texts that are lexically dense, heavily nominalised, abstract, and are reliant on technical and non-technical words to convey scientific information.

In consideration of the nature of the language of science, another challenge isolated in this Chapter was the comprehension of textual material in science. According to the data, there were challenges with interpreting questions and fulfilling the requirements of task words that feature in assessment tasks and tests across the modules offered in the FP. These challenges were mainly associated with higher-order questions – in terms of Bloom's taxonomy (Bloom *et al.* 1956) – which required critical thinking, inferring, justifying and evaluating.

With the LoLT at the research site being English, an EAL for the FP students, challenges with understanding words that do not feature in their home language (for example, isiZulu) are, as shown in this Chapter, both real and problematic. (At the time of this study, 1.93% of the FP students' home language was English as opposed to 86.04% whose home language was isiZulu).

Included in this Chapter was data showing that literacies such as reading and reading comprehension were particularly significant in the foundation disciplines of science. An example of the challenge experienced with the comprehension of word problems in foundation mathematics has been discussed in this Chapter. Another significant challenge raised was that of quantitative literacy in contexts other than foundation mathematics, for example in SCOM.

Included in this Chapter was the challenge associated with the FP students writing in their own words, thus highlighting the issue of plagiarism. This Chapter also made reference to the challenge associated with being able to write science, with particular reference to formulating the discussion section of the report genre. Another area of concern, according to the data, was the use of grammar in science.

In this Chapter, there has been reference to the need to acculturate the FP students into the discourse of science. There was thus the need to explore the ways in which the DSs assisted the FP students to acquire the discipline-specific literacies required for science discourse. The data has shown the tendency by some of the DSs to pay specific attention to technical, discipline-specific words, to the neglect of everyday non-technical words. Data has illustrated that some of the DSs test students' understanding of science content by focussing on and encouraging oral communication. According to the data gathered, the readings in modules such as foundation biology have been scaffolded as a way of assisting students to understand the content. This Chapter has shown, too, how some of the DSs use specific reading strategies to help students engage with the reading texts included in the module. With modules such as foundation physics and foundation mathematics relying heavily on numerical/computational skills to test conceptual knowledge, the data has shown some of the DSs taking the effort to encourage writing in these modules as a way of testing understanding and curbing mere memorising. In this Chapter, there were recounts of how the DSs relied on the strategy of scaffolding to teach FP students to compose a scientific report, including some examples of the reference to specific grammar such as the passive voice necessary in scientific reporting. The data has also shown attention being paid to visual-graphical literacy in science, especially in the way in which students are taught to present scientific information in concept maps, graphs and tables. This Chapter concludes with reference to the recount of an inter-disciplinary teaching engagement in the FP, i.e. one example of collaboration between SCOM and foundation biology in respect of a science topic and assessment task/s.

Chapter 8 offers an explanation of the conclusions that emerge from the data; makes suggestions arising from the data and offers the scope for the possibility for further studies.

CHAPTER 8

CONCLUSIONS; SUGGESTIONS AND SCOPE FOR FURTHER RESEARCH

Introduction

The point of discussion at the start of this dissertation is that the higher education sector in South Africa needs to go beyond merely embracing transformation discourse to actively devising tangible strategies to implement and realize it. Such strategies need to involve practical measures devised to rectify the injustices, inequalities and imbalances of the country's apartheid past and usher in educational equity. The establishment of ASPs and AD, among other institutional measures, represents attempts to realize such ideals. One particular HE institutional strategy targeting educationally disadvantaged students to cope with higher education studies, or the medium of filling-in the school/university articulation gap, was the provision of the foundation programme.

It is with regard to the foundation programme in science at UKZN that this study was conducted. The criteria for acceptance into this FP in science at UKZN are that a student needs to be from a disadvantaged school background and would have attained NSC with lower matriculation points (as explained in Chapter 1). One of the purposes of the foundation programme in science is that it is an attempt at satisfying the shortage of black graduates in the fields of science, technology and engineering in South Africa. This statement is especially relevant for this study in light of the fact that at the time of data collection, the student distribution by ethnic group in the FP comprised 98.83% black African students. The FP in science is not exclusive to UKZN; it is offered at various HEIs in South Africa (as explained in Chapter 1). It is within the context of the FP at UKZN that this study set out to understand the discipline-specific literacies that students in the FP in science at UKZN require for science. This was mainly guided by the following factors:

- the students in the FP had to learn science through the medium of English which is the LoLT at UKZN. The LoLT is an EAL for the FP students. At the time of this study, 1.93% of the FP students' home language was English;

- the students had to become familiar with the language of science as well as the discipline-specific literacies in science.

It is from this perspective that the formulation of research questions arose:

- *What discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by the students to learn science?*

- *What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 (Foundation) programme?*

- *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

This Chapter offers the conclusions drawn from the study; offers recommendations arising from the study and suggests the scope for further research.

8.1 Conclusions arising from the study

In seeking to explore the research participants' perceptions of the students they teach, evidence yielded through semi-structured interviews reveal the disciplinary specialists construct students as a problem rather than the pedagogic approaches they adopt. In this regard, a particular response conveys the notion of the university being unaccustomed to receiving non-traditional students and the notion of the university being ill-prepared to cope with such a changing student profile. However, with the dismantling of the shackles of apartheid; the desegregation of universities in South Africa, and, with massification (Reddy, 2004; Gibbons, 1998), the HE landscape is currently characterised by a diverse student population (as is the case at UKZN) whose race, gender, religion, ethnicity, language, socio-economic class, educational/schooling experiences and level of preparedness for tertiary study differ. Institutional responsibility to accommodate some of these variables is crucial.

A conspicuous response gleaned from the data is that, when students enter the university environment, there exists the expectation by some of the disciplinary specialists is that the students would adjust to this new world of academia. However, in the light of the FP students' educationally disadvantaged background, this is unrealistic. In consideration of the articulation gap between school and university, FP students need to be inducted into the HE sector and into the respective disciplines of study. It is therefore an obligation of the research participants who teach one of the modules in the FP to convey the appropriate discourse practices to the students. It is clear from the research findings that students need to be guided into the use and assimilation of these practices.

As stated by Council on Higher Education (CHE) (2004), "[a]s student bodies become increasingly diverse, so HEIs need to respond by adapting their curricula and teaching and learning practices to the needs of their students" (4). It is from this type of perspective that this study sought to engage the RPs' thinking with regard to changes that were implemented in the modules in the FP and to probe the reasons behind any such changes.

Data analysis, furthermore, has indicated the change in the type of students admitted into the FP over the period of time as being one of the deciding factors for modular changes in, for example, foundation biology. However, the overall interpretation of data reveals that modular changes were a consequence of students' inability to cope with science content. Thus, changes to foundation biology involved reducing the voluminous, dense content and paying attention to 'literacies' that had been sacrificed in favour of content. According to the data, this study has not been able to confirm the evidence of changes to foundation chemistry as the content in the course manuals over a period of time has remained relatively unchanged. As a measure of helping students cope with content, the foundation module of mathematics was simplified to the extent of being an extension of secondary school knowledge. In an effort to ease students through the foundation year, changes implemented in foundation physics involved removing repetitive content, reinforcing essential concepts that had been neglected at secondary school level, reinforcing skills and rewording content to facilitate conceptual understanding. The major changes in SCOM have been a consequence of the challenges of being able to cope with formulating the scientific report genre. In light of the scientific report being a fundamental genre in the foundation modules of biology, chemistry and physics, and in scientific writing at tertiary level, apprenticing students into the discourse of science is a way of providing students with the discourse practices needed for science.

In light of the RPs' understanding of the FP students' educationally disadvantaged backgrounds, amending curricula to facilitate understanding and to promote learning is more likely to be educationally sound, rather than compromising assessment standards. The implication of such changes has been acutely expressed by HESA in an inaugural issue of *Insight* (2009) which contains the executive summary of the HESA Strategic Framework entitled "Pathways to a Diverse and Effective South African Higher Education System" which expresses its views on the challenges and opportunities facing HE in South Africa during the next ten years or so:

> This period [the institutional restructuring programme launched by Government in 2002] has also seen some undoubted advances in HE, particularly in relation to achieving greater levels of equity in access to HE ... However, some major challenges remain ... a particularly daunting challenge faced by HE during this period, and one which seems set to continue facing HE for the foreseeable future, concerns the inadequate levels of preparedness of school leavers for HE study. This has resulted in most HE institutions entrenching school level education functions within their HE mandate which could have negative long term consequences for HE and for education in South Africa in general (5).

As stated earlier in this dissertation, lowering standards as a form of remediation can equate the FP with a bridging module; the implication being that the students cannot cope with 'real' academic work. This further conveys the perception of the students as being 'deficient'.

At this point, I would like to draw attention to the responses from RPs (discussed in Chapter 6) who attributed changes to course content as being a consequence of the FP students' inability to read the texts and/or course notes provided. As pointed out earlier in this dissertation, any reference to the FP students' perceived aversion to reading and/or challenges with reading needs to be understood within the framework of the following factors:

- the students' personal and past educational experiences (over which they had little control considering the nature of inequities that were characteristic of South Africa's historic past);
- their lack of exposure to reading materials at home;
- the reading practices that had characterised their teaching and learning at school level;
- the nature of the reading texts that they are expected to engage with at tertiary (FP)level; and,
- the extent and levels of support structures within the FP that facilitate reading and/or reading comprehension.

All these factors can contribute to the perception of reading as a challenge to FP students in their first year, i.e. the transition year, of tertiary studies. It is a perception that needs to be taken into consideration, rather than viewing the FP students from a 'deficit' perspective. The impact of these factors on the articulation gap and the students' reading abilities and initiatives need to be taken into consideration.

One of the purposes of this study was to elicit responses to the following question: "*What discipline-specific literacies do academic literacy specialists and disciplinary specialists who teach in the BSc4 (Foundation) programme believe are required by the students to learn science?* With regard to the discipline-specific literacies needed by the FP students, the ALSs have paid specific attention to the relevance of teaching students to read and comprehend science texts and, in doing so, familiarize them with the language/register of science; to be able to write scientifically, with specific emphasis on the scientific report genre. According to the data, this study has shown that SCOM assists in apprenticing students into the discourse community of science. This is in accordance with Street's (1984) ideological model of NLS which views "literacy practices as being embedded in social practices such as those of a particular educational context" (Street, 2003: 78). In other words, this is the view of the contextual nature of literacy practices and the fact that literacy is socially constructed. It also satisfies the notion of "literacy as a socially-constructed practice" (Gee, 1990). In addition to being able to read and write in science, SCOM provides students with a platform for oral communication in the disciplines of science.

In comparison to all the foundation modules in science offered in the FP, the responses from the DSs involved in teaching foundation biology have shown a greater reliance on literacies such as reading and writing primarily because the module is descriptive and language-dependent. Documentary evidence in this study has indicated specific references to the need for discipline-specific literacies such as designing and conducting a science experiment, integrating theoretical knowledge with practical work ; drawing conclusions from practical/experimental observations; and being able to listen for specific detail/content (from an audio-visual science documentary).

One common response to this question was the tendency by RPs to define literacy in its traditional mode, i.e. the ability to read and write. It is on account of this that the DSs who teach foundation chemistry have been unable to acknowledge the discipline-specific literacies required in the module, primarily because their module is regarded as one with minimal reading and writing as the course is designed with greater emphasis on visual-graphical representation. Similarly, reading and writing in foundation physics were considered to be minimal as the discipline-specific literacies required for foundation physics were the ability to calculate and, to a lesser extent, to be able to offer explanations to questions as a way of testing/confirming understanding. One of the key areas in foundation mathematics which relies on the discipline-specific literacies of reading and reading comprehension was that of word problems.

The responses of the DSs need to be understood in terms of their not being entirely familiar with the multiple understandings of literacy which include not only reading (of science texts) and writing (of mainly science laboratory reports) but listening, speaking and the inclusion of visual literacy and quantitative literacy. Science relies heavily on visual representation such as pictures, photographs, charts, images, models, diagrams, illustrations, figures, graphs, symbols, calculations, equations, formulae and abbreviations to convey, test, and present scientific knowledge. This has been evident in the course notes; laboratory practical manuals; science laboratory practical/field research reports; and tests used in each of the modules offered in the FP. However, the DSs interviewed did not seem to consider such visual representations as a form of literacy *of* or *in* science. Visual literacy in science is one of the practices that can help immerse the FP students in the discourse of science and since the FP students are likely to pursue studies and perhaps careers in science, then they would need to become familiar with the various ways that scientific knowledge can be transmitted. Furthermore, science is not only about reading and writing, it is about observing, interpreting, doing and talking too.

This study has also shown that a number of the DSs interviewed have a sketchy understanding of the discipline-specific literacies in science, primarily because they considered any reference to reading and writing science to be the task of the ALSs employed to teach SCOM. The DSs conveyed the view that their task was primarily to teach science and they were thus not sufficiently qualified to teach what they commonly refer to as ‘language issues in science’. This illuminates their perceived notion that ‘language’ (i.e. literacies) and ‘content’ are separate entities, and that each can be taught in isolation. Evident, too, was their misguided understanding of (discipline-specific) literacies in science as being the same as ‘skills’ that characterise the SCOM syllabi and practices. This explains why their responses to critical question one leaned towards the study skills model of academic literacy and the view of literacy within an autonomous model (Street, 1984) that views literacy as decontextualised skills and independently of its social context. The consequence of this view ties up with their belief that the teaching of literacies associated with science is not the job of DSs, but that of ALSs. This could be understood in the light of their academic/professional qualifications to teach science. Such a view, however, is problematic for the following reasons:

- the foundation science modules and SCOM are all components of the BSc(4) Foundation;

- SCOM has been devised and structured within the FP to assist students to acquire discipline-specific literacies in science that can – and ideally – should be transferred to the foundation modules of biology, chemistry, mathematics and physics; and,

- if the intention of the FP in science is to satisfy the calls of NPHE (2001) to "address the critical shortage of (black) graduates in science and to produce graduates with the ability to analyse, write, present and communicate" (27); then it is imperative that the discursive space for meaningful engagement between the academic literacy domain and the disciplines of science is created and maintained. This could benefit the FP students by easing the articulation gap, helping them to become acculturated in the HE environment, and allowing for them to acquire appropriate discourses, conventions and literacy practices in science so as to take their place as members of the discourse community in science.

In addition, this study has illustrated the way in which the DSs construe SCOM as a module where the FP students' weaknesses with reading and writing are remedied. This type of perception constructs the FP students as having a form of deficit, thus simultaneously insinuating that the AL classroom is in fact a remedial centre. It is such perceptions that perpetuate the notion among the DS that it is not their task to pay attention to discipline-specific literacies in science.

This study, furthermore, has revealed factors that the RPs believe could have contributed to the FP students' perceived challenges in the foundation modules in science. These were disadvantaged schooling, gaps in knowledge of and exposure to science as a consequence of poor and/or inappropriate teaching and/or learning strategies that characterised their educational experiences.

In this study, data in response to the second critical research question formulated for this study was sourced from semi-structured interviews, observation and documentary evidence. This part of Chapter 8 draws conclusions from the data in respect of critical research question two: *"What are the perceived challenges that emerge in the use of the language of science and the discipline-specific literacies in the modules offered in the BSc4 foundation programme?"*

As stated earlier in this dissertation, RPs isolated the ability to read as one of the major challenges. This was more so when the FP students were forced to engage with independent reading of texts; especially with non-scaffolded reading of texts that were cognitively demanding. This meant comprehension of the content required possession and mastery of CALP (Cummins, 1979) as, in such readings, lexical density and nominalisation featured prominently. Students were expected to make sense of the "elaborated code" (Bernstein, 1971), and in the "educated language" (Bourdieu, 1977). The consequence of this was that students were reluctant to engage in the reading process expected and/or required of them.

Data in respect of the FP students who have studied secondary school English as an additional language has already been alluded to in this dissertation. This study has shown that students display a reasonable sound understanding of technical words that feature in science, but are challenged by non-technical and/or unfamiliar words that are used in the context of science. With proper guidance, support and modelling, students in the FP can be apprenticed into reading. Closely aligned to reading is reading comprehension. The data in this study has isolated reading comprehension as one of the challenges in science. In foundation mathematics, for example, there has been evidence pointing out that the challenges of answering word problems lay in reading the mathematical text and being able to infer what is expected, in other words, accurately converting the written text into mathematical form.

This study has revealed numerous examples of the way in which the FP students were challenged by the way in which questions were constructed. Although much of such limitations impacted on the ways in which these questions were answered, a particularly salient point that needs to be mentioned is the oversight by DSs to induct students into the questioning types and techniques that are commonplace in the disciplines of science. Although this study has shown evidence of students having performed well in the lower order levels of Bloom's Taxonomy (Bloom *et al.* 1956), it is imperative that students are exposed to each of the other higher levels, but this process needs to occur gradually; and exposure to questioning frames needs to be explicit, intensive and constantly revisited and reinforced.

An important issue that had surfaced in this study is the danger of the DSs' assumptions that students can understand and answer the way the questions are formulated in class activities and notes, laboratory practical worksheets and tests. DSs, more especially those for whom English, the LoLT at UKZN, is their first language, would need to constantly remind themselves that the greater majority of the FP students speak EAL. At the time of this study, 1.93% of the FP students' home language was English as opposed to 86.04% whose home language was isiZulu; and 11.98% whose home language was one of the various other official South African languages. Since questions serve to measure and improve student learning, it is essential that students are able to interpret questions posed to them. This could help the DSs to distinguish whether poor performance in assessment tasks is a consequence of lack of conceptual knowledge in science or the inability to deconstruct and/or interpret question types.

This study has shown that of the science modules offered in the FP, writing is done on a greater scale in foundation biology (and in SCOM) than in the other foundation modules in science. One emerging challenge was the tendency to plagiarize. When students enter the university fold, they leave behind their secondary school literacy practices and become exposed to academic writing which is more specialized, abstract and is heavily reliant on CALP and context-reduced communication (Cummins, 1979) to convey knowledge. If the DSs expect students to make sense of academic readings and be able to rely on academic texts to produce their own writing tasks using the appropriate discourse, genres, writing conventions and register used in science, then they would have to alert students to these practices, providing the necessary support and opportunity to encourage academic writing. As long as students are unfamiliar with the ways to deconstruct texts and use the information from the texts to produce an academic task that conforms to academic standards, they are likely to plagiarise. In the absence of sufficient practice at writing tasks in the foundation modules of science such as the compilation of short abstracts, summaries and paragraph writing, there is a remote chance of attempting to root out plagiarism. From the NLS (Street, 1984) perspective, literacy is a social practice. If students are to develop an identity in science, then they need to be apprenticed into the literacy practices relevant in the context of science. As much as this can be attempted in the SCOM classroom, an ideal environment would be from the DSs themselves who, as science educators and/or academics, should be able to make explicit the discourses, conventions and practices that they use and confront in their own science niche.

This study has highlighted that students studying science in the FP at UKZN require discipline-specific literacies in science that would enable them to read, write, speak and do science. However, as explained thus far, the acquisition of the discipline-specific literacies in science and the language of science are not without challenges. This study explored whether the FP students are offered any assistance with the acquisition of the discipline-specific literacies in science, hence, the formulation of critical research question three: *How do the disciplinary specialists assist the BSc4 (Foundation) students in the acquisition of discipline-specific literacies required for science discourse?*

One particular mechanism that some of the DSs use is the reliance on visual literacy as a way of conveying science discourse when they teach. This has been noted in the observation of tutorials and laboratory practicals, especially in situations where students' mis/understanding of science concepts was negotiated through the use of visual literacy such as drawings and sketches. The reliance on visual literacy has featured prominently in the course and laboratory manuals in the foundation modules of biology, chemistry, mathematics and physics. This included the way in which students had to compile tables, draw and interpret graphs (which was also a way of teaching and testing quantitative literacy). The reliance on visual representation as one of the mechanisms to teach the discipline-specific literacies in science was not explicitly conveyed in the semi-structured interviews with all the DSs conducted in this study (except for Susan). This does indicate that the DSs are focusing on the relevant discipline-specific literacies required for science while teaching and during laboratory practicals, and when compiling their course notes, but they associate these with the way in which the epistemology of science is conveyed rather than these being identified as one of the mechanisms linked to literacies in science. This illustrates too that the DSs are satisfying NLS by creating the space and understanding of contextual nature of literacy practices (in the disciplines of science). This is one of the ways in which the DSs are making the literacy practices explicit, perhaps unconsciously. Similarly, the data has shown that DSs rely on strategies such as the use of concept mapping as a way of organising science information which was incorporated in both science lessons and in the course manuals. There was evidence, too, of students being assisted with the understanding of reading texts. There was the conscious effort of illustrating to students the way to read texts and, in the process, extract relevant answers. This concerted effort at modelling/micro modelling was useful in that students were made aware of the strategies used to deconstruct texts. This was an ideal way of learning by imitation, with a heavy reliance on Vygotsky's (1978a) ZPD. Another prominent way in which students are assisted with science discourse is through the process of scaffolding, which was particularly prominent in the course notes, more especially in foundation biology.

This study, moreover, has revealed evidence of the DS (Raj) making a concerted effort to apprentice students in the discourse of science by attempting to encourage student participation in class. This has been cleverly devised as a strategy to promote peer learning, test students' conceptual understanding and to reveal areas of weakness that require re-teaching or reinforcement of conceptual knowledge. There is further evidence in this study of the need for some of the DSs' to rely on isiZulu as a mechanism to teach and reinforce concepts in science that presented problems to students, especially in instances where students experience major hindrances with understanding non-technical, technical and ordinary words used in English, more especially if these words do not feature or have no equivalent translation in the dominant home language (i.e. isiZulu) of the students in the FP Although it is not the intention of this study to explore either the practices of code switching or the reliance on teaching science through the medium of isiZulu, but where this was used in the classroom/laboratory, it appeared to be effective in allaying misconceptions and facilitating understanding of specific scientific concepts and vocabulary used in English.

This study has illustrated that the students in the FP are perceived in a deficit light. This is primarily on account of the DSs' references to the students' underpreparedness for tertiary level science. This study has highlighted repetitive references to the FP students entering the HE environment with inadequate skills or knowledge in science; inappropriate learning strategies as a consequence of their disadvantaged schooling experiences; disinclination to speak up in class and answer questions relating to science; poor reading and comprehension abilities; the tendency to avoid reading; and the difficulties with writing science. One of the factors that could contribute to the deficit mode of thinking is the fact that the FP in science at UKZN is primarily targeted at students from educationally disadvantaged backgrounds, making it thus almost impossible to eradicate the association of 'disadvantage' and its accompanying labels of 'underpreparedness' and 'deficiency'. Furthermore, students in the programme are generally referred to as 'foundation' students. This, against the description 'mainstream' has uncomplimentary connotations. It is thus suggested that as a way of shifting from the deficit mode of thinking associated with the provision of foundation programmes, such programmes should not only be accessible to students from educationally disadvantaged backgrounds. Even though the admission into the FP at UKZN is not determined by race, the ratio of black African students against any other racial grouping is quite evidently the majority in the FP. Foundation Programmes have long been contextualized as a form of redress; as "special programmes for students whose prior learning has been adversely affected by educational and social inequalities" (Kloot *et al.* 2008: 800). The perception of the FP should now be changed.

Universities in South Africa are currently confronted with a heterogeneous population. There has been much research on the challenges of the transition between school and university (Paras, 2001; Matoti and Lekhu, 2008; Potgieter *et al.* 2008; Volkwyn *et al*. 2010). The issue of student underpreparedness for university studies has been well-documented (Cox, 2000; Haiden, 2000; Lowe and Cook, 2003; Hay and Marais, 2004; Nel *et al.* 2009; Jansen, 2009; Wilson-Strydom, 2010; Bradbury and Miller, 2011; Marshall *et al*. 2011). In addition, there has been research on student underpreparedness for tertiary level science (Crewe, 2009; Potgieter, M. 2010; Selvaratnam, 2011). In light of the vast research on student underpreparedness for HE studies and for tertiary studies in science, it is suggested in this study that access to foundation programmes as an institutional strategy be made accessible to a more diverse student population. This would then shift the focus of the FP as a means of redress. It should then serve to address the country's need for graduates to fulfil "[the] present and future social and economic needs" (DoE Education White Paper (1997b) 2.6). For this to be done, however, there needs to be extensive research into the success of current foundation programmes in science at tertiary institutions in South Africa so as to measure their potential, as an intervention programme to significantly mitigate the school/university articulation gap; to adequately prepare students for tertiary studies; to enable student success and contribute to an increase in the graduate output.

8.2 Suggestions arising from the conclusions

Responses from the DSs in this study have made several references to the FP students' poor reading abilities and their lack of initiative to read. At the same time, this study has shown that some of the reading texts that the FP students are forced to engage with are heavily nominalized and lexically dense. This study has shown, too, that some of these reading texts are not scaffolded. It is suggested that when students enter the FP, an appropriate reading test be administered to gauge the students' levels and pace of reading. This could help the DSs to pitch their reading texts at a level appropriate for the students they admit. This could contribute to addressing the challenges of reading isolated in this study.

As stated earlier, the inclusion of the SCOM module in the FP in science has been strategic as the data has revealed that it provides the platform for the FP students to become familiar with discipline-specific literacies in science; to engage with reading of scaffolded science texts; to gain practice through the academic writing process – especially the science genres; and the opportunity to speak the discourse of science in oral presentations. If these are the teaching/learning goals of the SCOM, then it is essential that the DSs use SCOM more extensively than they currently do, especially if what is learnt in SCOM can contribute to the acquisition and discriminate use of literacies essential for science. This statement is primarily based on the evidence from this study that there is hardly any engagement between SCOM and the foundation disciplines of science. This study has illustrated one instance of collaborative teaching between SCOM and foundation biology. Collaborative teaching between SCOM and the other foundation modules in science is non-existent. The lack of meaningful collaboration across SCOM and the foundation modules in science within the FP could possibly account for the perceptions held by the DSs of SCOM and the admission by some of the DSs of being uninformed of AL practices and/or what goes on in the SCOM classroom. Greater engagement and collaboration between the academic literacy discipline in the FP and the foundation modules of science is vital, especially if one of the goals of the FP in science is to apprentice students in science discourse and to produce graduates in science who satisfy the demands by employers that graduates "demonstrate a strong array of analytical skills and a solid grounding in writing, communication and presentation skills" (UNESCO/World Bank Report, 2000:85, cited in NPHE, 2001: 27). In addition, greater engagement between the ALSs and DSs could contribute to a better understanding of the function of the ALSs in the FP and the goals and objectives of SCOM in the FP and could serve to dispel any misconception/s about the purpose of an academic literacy course in a science programme.

One area in which collaboration and/or engagement between SCOM and the foundation modules of biology, chemistry and physics would have been appropriate is with genre writing, specifically the scientific report genre. It is "goal-oriented purposeful activity" (Martin, 1984) which brings together language, content and context (Christie and Martin, 1997). Thorough teaching of the scientific report facilitates enculturation into the disciplines of science since it is a key discipline-specific literacy based on laboratory practicals or field research in each of the afore-mentioned foundation modules. Evidence from the data has shown differing expectations across each of the afore-mentioned foundation modules and SCOM with regard to the composition of the scientific report. Meaningful engagement between the ALSs and the DSs could contribute to the ALSs acquiring a holistic understanding of the discipline-specific literacies across the foundation modules in science.

If the ALSs can use SCOM to help equip the FP students with the discipline-specific literacies *in* and *for* science that can be used in the context of the foundation modules in science, and if the DSs can reinforce these, then learning does not occur and remain in a vacuum and the transfer of literacies is likely to take place. Both the ALSs and the DSs need to be involved in a collective effort to develop the FP students' discipline-specific literacies in science. One of the ways in which SCOM can be used more meaningfully in the FP is if topics chosen in SCOM are linked to those done in the foundation modules in science. This would assist the FP students with engagement with relevant reading texts which could help with the acquisition of both technical and non-technical vocabulary. This, and the tendency of SCOM to scaffold reading texts, would help facilitate comprehension and ease students' way into being able to write scientifically.

Even with collaboration, DSs need to take responsibility to make their discourses and literacy practices explicit to the students in the FP. Gee (1990) describes Discourse, as ways of behaving, interacting, valuing, thinking, believing, speaking, reading and writing that identify one as belonging to a particular discourse community. According to NLS (Street, 1984), the literacy practices and discourses of academic disciplines are best acquired by students when embedded within the contexts of such disciplines. Gee (1990) describes "Discourse as a 'sort of identity kit' with 'instructions on how to act, talk, and often write, so as to take on a particular social role that others will recognise" (127). They also need to guide, support and assist students to understand the language of science. Although scientific texts are complex, dense and heavily nominalised, the DSs should provide texts that are suitable for students, for whom English is an additional language, especially the texts that require independent reading. In situations such as these, such texts need to be re-written and /or adapted or heavily scaffolded for EAL students.

When designing questions in assessment tasks, the DSs need to take cognisance of readability and comprehensibility. This is especially critical in situations where the students' home language differs from the LoLT, as in this study. To facilitate the comprehension of questions and the way in which students formulate their answers; and to avoid students being disadvantaged by the language barrier, it is essential that the DSs use language that is clear, concise, straightforward and unambiguous, especially since their students speak English as an additional language. Questions that are multi-layered, complex, lengthy and double-barrelled should be rephrased and/or shortened.

An essential issue that this study has highlighted is the tendency of the FP students to rely on rote learning/memorisation in the foundation modules of science, for example, foundation mathematics and foundation physics. The implication of this practice is the challenge of judging whether students actually understand what they have written. It is thus imperative that students are expected to write more intensively in these modules, as a way of testing understanding. The discipline-based course manuals which are akin to workbooks need to include more tasks that engage students in writing. One example could be the inclusion of summary writing; however, such tasks should not only be confined to classwork alone. They could, where necessary, be included as a component of formal assessment.

As important as being able to read, write and do science, is the ability to "talk science" (Lemke 1990: 1; Lee and Fradd, 1998: 15). The responses from the DSs in this study illustrated the FP students' reservation to become involved in talking, i.e. in explaining or justifying science content knowledge. To encourage student participation in academic discourse, DSs can include an oral component as a compulsory assessment task in the foundation module that they teach. Another area in which involving students to talk science can be implemented in the FP in science is during the laboratory practical sessions. The laboratory is traditionally the place where students learn science by "doing" science. However, such laboratory practical sessions should not only be the place where students read the pre-practical guidelines, conduct experiments, observe phenomena, record data and then write and submit their scientific reports. They should be encouraged to engage in dialogue – to explain, reason, predict and interpret (orally). This then links students' conceptual knowledge with the oral discourse, forcing students to verbalise; to talk the language of science; to talk like a scientist. In doing so, students are inducted into the language of science, in the context of science. It can also provide the opportunity to correct misconceptions and confusions, simultaneously allowing the students to clarify and refine their understanding and thinking. This could serve as laying the foundations for their roles beyond the university doors – as science graduates in the workplace.

8.3 Scope for further study

There are three possible areas of further research around salient issues that arose in this study which can contribute to a better understanding of these issues:

8.3.1 Exploring and addressing the school/university articulation gap in mathematics and science

This study has made reference to the issue of the 'underprepared' student, which had been used in the context of students whose educational experiences had rendered them underprepared for tertiary studies. South Africa's education sector has seen major transformation since the birth of democracy in 1994 and students' underpreparedness for university studies has been thoroughly documented (Cox, 2000; Haiden, 2000; Lowe and Cook, 2003; Hay and Marais, 2004; Nel *et al.* 2009; Jansen, 2009; Wilson-Strydom, 2010; Bradbury and Miller, 2011; Marshall *et al*. 2011) as well as students' underpreparedness for university science (Crewe, 2009; Grayson, 2009). Much of this underpreparedness has been attributed to the articulation gap between school and university (Paras, 2001; Matoti and Lekhu, 2008; Potgieter *et al.* 2008; Volkwyn *et al*. 2010). An area that is suggested for science-related research is an in-depth study into mathematics and science at school level; areas that should be explored are teaching pedagogy, methodology, curricula and assessment practices. It is envisaged that isolating any shortcomings in these areas and suggesting and guiding the teachers into implementing constructive strategies that impact on the teaching/learning/testing process of these subjects at school level could contribute to easing the articulation gap for students studying mathematics and science at tertiary level. There needs to be greater co-ordination and engagement between the school and university. Mathematics and science educators at school need to gain some insight and knowledge of the disciplinary demands of these subjects at tertiary level and they need to understand their role in laying a suitable mathematics and science foundation at school level which is essential for student preparation in these fields when the students exit the school gates and enter the university.

8.3.2 An insight into the transfer of learning across disciplines at university

This study has highlighted the need to encourage students to transfer literacies. Mestre (2002) defines transfer of learning to mean the ability to apply knowledge or procedures learned in one context to new contexts. Mestre (2002) also distinguishes between near transfer and far transfer:

> Near transfer consists of transfer from initial learning that is situated in a given setting to ones that are closely related. Far transfer refers both to the ability to use what was learned in one setting to a different one as well as the ability to solve novel problems that share a common structure with the knowledge initially acquired (3).

Ideally, students should be able to transfer what has been learnt in one discipline to a new one. However, research (Bassok and Holyoak, 1993; Perkins and Salomon, 1998; Boughey, 2000) has shown that active transfer would only take place if students are reminded to do so. Encouraging students to practice the transfer of learning across disciplines means that they are not keeping their learning compartmentalized or bound to a particular context. A possible study undertaken at tertiary level around the issue of transfer of learning is to explore common disciplines within a faculty where conceptual knowledge can be transferred; factors that influence/limit transfer of learning; the strategies students use to transfer such learning; and mechanisms to better facilitate such active transfer to promote learning beyond a single discipline.

8.3.3 A comparative study of the foundation programmes in science offered at universities in South Africa

This study has described a foundation programme in science as a mechanism that aims at providing students from educationally disadvantaged backgrounds the opportunity and support to pursue their studies in science. Foundation programmes in science are also offered at various HEIs across South Africa (as stated in Chapter 1 in this study) and it is suggested that a comparative study into the foundation programmes in science be conducted across these HE institutions with the foci on philosophy, pedagogical practices; support structures (such as academic literacy and counselling); and student performance and success. One of the purposes of such research is to determine the efficacy of the foundation programme in science that is delivered and an attempt at developing the most viable, functional and meaningful model.

8.4 Final word: What do I personally take from this study?

As an academic literacy facilitator, venturing into the territories of the domains of the sciences in the foundation programme has been a disciplinary crossing-over for me. I had been keen to open wide the window to the foundation disciplines of sciences and get a close-up view of the discipline-specific literacies needed *in* science and *for* science. In doing so, I, too, had to unravel the complexities of scientific texts, listen attentively for clues to improve *my* understandings of scientific and mathematical knowledge, throw on my safety shoes and loaned laboratory coat so I could conform, '*do'* and 'observe' laboratory practicals as a science 'student' should. I, too, had to understand the 'language' of science. For the duration of this study, I had been able to become reasonably acculturated into the discourse community of science. But, *I* have had one 'slight' advantage ... the LoLT was my home language.

Venturing into the disciplines of science has enabled me to reflect on my own understandings and practices in the teaching of discipline-specific literacies in science, knowing full well that close, continuous and meaningful engagement across disciplines in the foundation programme in science at UKZN is a key to helping the students to improve their learning and a way to help them to become members of the community of science.

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APPENDIX 1

Sample: Original Text

The Emerging Crisis of Drug-Resistant Tuberculosis in South Africa: Lessons from New York City

The rise of multidrug-resistant tuberculosis (MDR-TB) and extensively drug-resistant tuberculosis (XDR-TB) in South Africa among patients with HIV infection is a grave and urgent threat. As South Africa takes steps to respond, there are important lessons to be drawn from New York City (NYC), where, 2 decades ago, drug-resistant tuberculosis also emerged among patients with HIV infection [1, 2]. It is striking that many of the same conditions that fueled the rise of drug-resistant tuberculosis in NYC also underlie the current epidemic of MDR-TB and XDR-TB in South Africa. These include a large and undertreated HIV-infected population, inadequate infection control in hospitals and clinics, and a public health infrastructure not equipped to ensure that patients complete treatment courses. Although important differences should not be minimized, the experience of NYC provides potentially important insights for South Africa as it shapes its own unique response.

MDR-TB AND XDR-TB IN SOUTH AFRICA

When I arrived in KwaZulu-Natal, South Africa, in August of 2006, it was already apparent, from published reports, that drug-resistant tuberculosis was deeply embedded in the province [3]. But the dimensions of the crisis on the ground were not apparent to me until one day in January 2007, when I met Precious Cele (fictitious name), a 35-year-old woman with HIV infection who, 2 months before, had received a diagnosis of smear-positive pulmonary tuberculosis. It was her first episode of tuberculosis, and she had been prescribed standard 4-drug chemotherapy, which she had dutifully taken. However, during treatment, her cough persisted, and her weight fell by 7 kg (15 lb). The day I met her, the laboratory confirmed that she had MDR-TB (defined as infection with *Mycobacterium tuberculosis* with resistance to isoniazid and rifampicin), and we sought urgent initiation of second-line tuberculosis treatment at the only public hospital in the province where it was available. However, we learned that in front of her were ~100 other patients also waiting for initiation of treatment for MDR-TB and XDR-TB.

Although South Africa has committed substantial resources to respond to the growing crisis of drug-resistant tuberculosis, for doctors and nurses caring for patients with drug-resistant tuberculosis in clinics, major barriers undermine prompt diagnosis and referral. To improve the outlook for patients in South Africa with drug-resistant tuberculosis, the NYC experience suggests some crucial investments that should be considered in the

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short term, including (1) the creation of enough MDR-TB and XDR-TB treatment capacity such that, after microbiological diagnosis, therapy can begin immediately; (2) the development of improved laboratory capacity to guarantee rapid, accurate, and accessible results of culture and susceptibility tests; (3) the creation of a public health infrastructure capable of ensuring that patients complete tuberculosis therapy; and (4) the institution of measures in hospitals and clinics to decrease the nosocomial transmission of drug-resistant tuberculosis.

EXPANDING TREATMENT CAPACITY

One very important lesson from the NYC outbreak of MDR-TB was that, in HIV-infected hosts, MDR-TB follows an accelerated course and has a very high case-fatality rate [2]. However, evidence from the NYC epidemic also shows that outcomes, at least for patients with MDR-TB, can be better when active, second-line agents are promptly initiated [2, 4]. Although not yet well studied, XDR-TB (defined as infection with *M. tuberculosis* with resistance to isoniazid and rifampicin as well as resistance to any fluoroquinolone and 1 of the second-line injectable agents) in patients with HIV infection may follow the same essential principle. It is therefore vital, during the short window of time when second-line tuberculosis therapy can improve clinical outcomes—for patients such as Precious Cele—that it not be delayed.

A particularly urgent issue in South Africa involves how to expand second-line treatment capacity to prevent potentially avoidable deaths and ongoing transmission from untreated disease. If the inpatient model is used, expansion of capacity will be slow and expensive, and queues may remain the mechanism by which second-line treatment is allocated. An important alternative model for South Africa to consider for selected patients is community-based treatment of drug-resistant tuberculosis. Compelling data that support community-based treatment for drug-resistant tuberculosis—by use of peer support and multidisciplinary teams—have been generated in other resource-constrained settings, which suggests that such a model can be both cost-effective and efficacious [5]. Furthermore, outpatient models can be scaled up quickly as the need escalates and can include antiretroviral therapy (>60% of patients in South Africa with tuberculosis have concomitant HIV infection), and resources can be reallocated for other purposes once the crisis abates.

IMPROVING LABORATORY INFRASTRUCTURE

The rapid initiation of second-line treatment for patients infected with drug-resistant *M. tuberculosis* in South Africa will depend on a close relationship between doctors and mycobacterial laboratories. Although South Africa has the benefit of more facilities for culture and sensitivity testing than any other sub-Saharan African nation, the increased demands created by the current epidemic of drug resistance have stretched this hard-working sector and have highlighted its limitations. Currently, delays in the reporting of results and difficulties in locating data for individual patients hinder the early diagnosis and rapid referral of patients for treatment of MDR-TB and XDR-TB, which directly affect patient outcomes. As the epidemic escalates, the number of clinical specimens that South African laboratories will receive will vastly increase. Investments made now will help laboratories to handle this elevated demand more efficiently and accurately. If clinical laboratories are supported and improved, they can also become important platforms for testing various novel diagnostics that may ultimately shorten the time needed to diagnose drug-resistant tuberculosis.

ENSURING TREATMENT COMPLETION

Leading up to the growth of drug-resistant tuberculosis, both NYC and South Africa experienced an underinvestment in the vital public health infrastructure needed to ensure completion of tuberculosis treatment among patients [6]. The implications of this underinvestment in NYC were vividly illustrated by a study at Harlem Hospital, conducted early in the outbreak, which showed that, among 178 patients discharged with standard tuberculosis treatment in 1988, only 11% completed it [7]. Similarly, each year, South Africa reports >400,000 cases of tuberculosis, but high rates of default and loss to follow-up result in a low treatment-success rate of only 70% [8]. The lowest rates of treatment completion are found in the province of KwaZulu-Natal—not coincidently, the apparent epicenter of drug-resistant tuberculosis in South Africa [3]. Indeed, for patients with resistant disease, the need for intensive adherence support and close patient follow-up is especially great because second-line therapy is associated with more adverse effects and requires a longer treatment course. Moreover among patients with MDR-TB and XDR-TB, the implications of treatment default for both the individual and society are particularly grave.

In NYC, the expansion of directly observed therapy with community-outreach workers and intensive case management was associated with marked improvements in the incidence of tuberculosis and rates of drug resistance [9]. At the clinic level, programs that were particularly effective were "patient-centered" and included relevant incentives and peer-based support [10, 11]. Likewise, an improvement in treatment adherence and a reduction in the number of new cases of drug-resistant tuberculosis in South Africa will require a strong commitment from central health authorities and a rethinking of the way in which tuberculosis therapy

Sample: Revised Text **READING 4** *Clinical Infectious Diseases*, 46:1729–32 (April 2008)

The Emerging Crisis of Drug-Resistant Tuberculosis in South Africa: Lessons from New York City

Richard A. Murphy

South Africa must rededicate itself to the task of tuberculosis control and treatment with a rapid, multifaceted approach. Priorities include expansion of second-line treatment capacity, investment in clinical laboratories, a system to ensure supervised treatment for all patients, and enhancement of infection control procedures. In New York City (NYC) where drug-resistant tuberculosis emerged 2 decades ago, similar steps were successful in leading to the rapid decrease in rates of drug resistance among tuberculosis isolates.

As South Africa takes steps to respond to this epidemic, there are important lessons to be drawn from NYC, where 2 decades ago, drug-resistant tuberculosis also emerged among patients with HIV infection. It is striking that many of the same conditions that fuelled the rise of drug-resistant tuberculosis in NYC also underlie the current epidemic of MDR-TB and XDR-TB in South Africa. These include inadequate infection control in hospitals and clinics and a public health infrastructure not equipped to ensure that patients complete treatment courses.

To improve the outlook for patients in South Africa with drug-resistant tuberculosis, the NYC experience suggests the following crucial measures that should be considered in the short term: (1) the creation of enough MDR-TB and XDR-TB treatment capacity such that, after microbiological diagnosis, therapy can begin immediately; (2) the development of improved laboratory capacity to guarantee rapid, accurate, and accessible results of culture and susceptibility tests; (3) the creation of a public health infrastructure capable of ensuring that patients complete tuberculosis therapy; and (4) the institution of safety measures in hospitals and clinics to decrease the chances of contracting the disease as a result of being hospitalized.

Evidence from the NYC epidemic also shows that outcomes for patients with MDR-TB, can be better when active, second-line therapy drugs are initiated. The rapid initiation of second-line treatment for patients will depend on a close relationship between doctors and mycobacterial laboratories. Currently, delays in the reporting of results and difficulties in locating data for individual patients hinder the early diagnosis and rapid referral of patients for treatment of MDR-TB and XDR-TB. If clinical laboratories are supported and improved, they can also become important platforms for clinical testing that may ultimately shorten the time needed to diagnose drug-resistant tuberculosis.

Patients infected with drug-susceptible strains who enter health care settings can be reinfected with drug-resistant strains. Although no longer in existence in NYC, tuberculosis wards remain common in South Africa. Outpatient clinics are another key setting where drug-resistant tuberculosis can be transmitted. At clinics and outpatient departments in South Africa, it is common for immuno-compromised patients to line up for hours in poorly ventilated rooms. The transmission of drug-resistant tuberculosis in hospital wards and outpatient clinics is undoubtedly contributing to the current crisis in South Africa. It is imperative that current tuberculosis infection-control protocols in South Africa be redesigned in cost-effective ways. This should include: the implementation of basic environmental controls in wards and waiting areas to ensure the circulation of outside air (or the treatment of recirculated air); the isolation of patients with suspected or definitive drug-resistant tuberculosis, and the provision of respiratory protection devices for medical staff involved in the care of patients with tuberculosis.

In the face of MDR-TB and XDR-TB, South Africa must rededicate itself to the task of tuberculosis control and treatment. This must include expansion of second-line treatment capacity, investment in clinical laboratories, assurance of supervised adherence support for all patients, and enhancement of infection control procedures. In NYC, similar steps were successful in leading to the rapid decrease in rates of drug resistance.

(*SCOM*, Semester 2, 2011: 2)

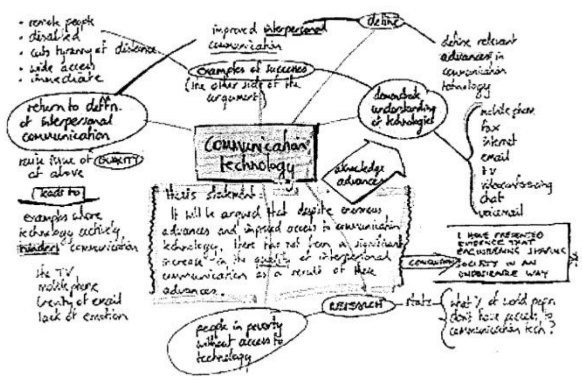
APPENDIX 2

Using a mindmap to help you write your essay

As someone who needs to write an essay, you are faced with a number of articles as sources of information. You may find information in two or more articles on the same subtopic. A mindmap can be used to help you collect together all relevant ideas from all your readings, to organise your ideas form all the different articles into subtopics, thus helping you concentrate your ideas and organise them at the same time.

- Start with the central idea or image - start from the centre and radiate outwards.
- List the main organising ideas/subsections.
- Use hierarchy and association - your main orgainsing ideas are embodied in thick lines radiating from the centre; the ideas radiating from the individual organising ideas have thinner lines.
- Use images and colour
- Use keywords, or short point form notes in your own words. Never copy word for word from the articles
- Use symbols and codes.
- Use arrows to denote links between ideas.
- Edit your mind map, numbering the branches in the order you want to write about or present the topics.
- Do individual mind maps of particular sections.
- Do a first draft, revising your mind map as necessary, and doing a new mind map for difficult parts of the draft or when you get writer's block.

Example of a mindmap used to plan an essay:



http://www.jcu.edu.au/studying/services/studyskills/mindmap/sampleessay.html

28

(*SCOM*: Semester 2, 2009: 28)

On the Delta's eastern border, in Port Said, an empty **stone plinth** is all that remains of a statue of Ferdinand de Lesseps, the man who built the Suez Canal; somewhere along the Delta's westernmost reaches, the long-lost **tomb** of Cleopatra lies buried. With such a rich history of foreign rule, it's only natural that **the latest hostile force knocking at the gates should be couched in the language of occupation**.

> Explain what the writer means in the last sentence of this paragraph? Focus on making meaningful sense of the bold and underlined sections.

"Egypt is a graveyard for occupiers," observes Ramadan el-Atr, a fruit farmer near the **antiquated** town of Rosetta, where authorities have contracted a Chinese company to build a huge wall of concrete blocks in the ocean to try **to save any more land from melting away**. "Just like the others, the sea will come and go – but we will always survive."

> Why are some parts of this paragraph in quotation marks?
>
> Rewrite this paragraph without the quotation marks while keeping the meaning exactly the same.

Scientists aren't so sure. Two years ago, **the Intergovernmental Panel on Climate Change declared Egypt's Nile Delta to be among the top three areas on the planet most vulnerable to a rise in sea levels**, and even the most optimistic predictions of global temperature increase will still displace millions of Egyptians from one of the most densely populated regions on earth.

> Rewrite the underlined bold section of this sentence in your own words.

The Delta spills out from the northern stretches of the capital into 10,000 square miles of farmland fed by the Nile's branches. It is home to two-thirds of the country's rapidly growing population, and responsible for more than 60% of its food supply: Egypt relies unconditionally on it for survival. But with its 270km of coastline lying at a dangerously low elevation (large parts are between zero and 1m above sea level, with some areas lying below it), any melting of the polar ice caps could see its farmland and cities – including the historical port of Alexandria – transformed into an ocean floor.

> Note down what you have learned about the Nile Delta in this paragraph:

(*SCOM*: Semester 1, 2010: 25)

Reading and Writing Task 2

Read the following extract from a review.

Note down in keywords and phrases what you are learning as you read along; you may use the blank text boxes on the right hand side of the page to record these words and phrases.

Summarise the key issues you have gained from the article. Try to do this in complete sentences.

Proceed to answer the questions in the exercise at the end of the article.

THE NEW YORK REVIEW OF BOOKS

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The Question of Global Warming

By Freeman Dyson

A Question of Balance: Weighing the Options on Global Warming Policies **by William Nordhaus Yale University Press, 234 pp., $28.00**

Global Warming: Looking Beyond Kyoto **edited by Ernesto Zedillo Yale Center for the Study of Globalization/Brookings Institution Press, 237 pp., $26.95 (paper)**

There is a famous graph showing the fraction of carbon dioxide in the atmosphere as it varies month by month and year by year [see the graph below]. It gives us our firmest and most accurate evidence of effects of human activities on our global environment. The graph is generally known as the Keeling graph because it summarizes the lifework of Charles David Keeling, a professor at the Scripps Institution of Oceanography in La Jolla, California. Keeling measured the carbon dioxide abundance in the atmosphere for forty-seven years, from 1958 until his death in 2005. He designed and built the instruments that made accurate measurements possible. He began making his measurements near the summit of the dormant volcano Mauna Loa on the big island of Hawaii.

(*SCOM*: Semester 2, 2009: 40)

APPENDIX 3

FACULTY OF EDUCATION
SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

UNIVERSITY OF
KWAZULU-NATAL

Research topic: ***On Making Sense of Science Discourse: The Role of the Foundation Programme in a South African University***

Researcher: Mrs Vasanthie Padayachee
Ethical Clearance No.: Protocol Reference Number: HSS/0082/10D
Supervisor: Dr. Emmanuel Mgqwashu

QUESTION GUIDELINES FOR SEMI-STRUCTURED INTERVIEWS

The researcher will use a series of questions to evoke responses from <u>disciplinary specialists</u> with regard to the issues of language literacies* in science.

1. How long have you been involved in the teaching of your module to students registered in the foundation programme in science?

2. How important are language literacies in the foundation modules in science?

3. Are there any experiences of issues relating to language literacies in the teaching of science foundation modules that you would like to recount?

4. From your own teaching experience, are there any particular factors to which you would attribute the difficulties students in the foundation programme in science experience with regard to language literacies?

5. Do students experience difficulties with reading? Have these difficulties impacted on their acquisition of science content in the module that you teach?

6. What are your perceptions of the purposes of the Academic Literacy module?

7. What strategies can you propose to foster reading and writing of science content in the module that you teach?

8. Are there any mechanisms that you would like to implement to improve students' use of language literacies in science?

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Ethical Clearance No.: Protocol Reference Number: HSS/0082/10D
Supervisor: Dr. Emmanuel Mgqwashu

QUESTION GUIDELINES FOR SEMI-STRUCTURED INTERVIEWS

The researcher will use a series of questions to evoke responses from academic literacy specialists with regard to the issues of language literacies* in science.

1. How long have you been involved in the teaching of your module to students registered in the foundation programme in science?

2. How important are language literacies in the science foundation modules?

3. Does the academic literacy module you teach contribute to students' acquisition of language literacies in science? Can you please elaborate?

4. What are your views about the purposes of the Academic Literacy module offered in the foundation programme in science?

5. Are there any experiences of issues relating to language literacies in science that you would like to recount?

6. What are your views around the issue of accountability for the teaching of language literacies within the foundation programme in science?

7. From your own teaching experiences, are there any particular factors to which you would attribute the difficulties students in the foundation programme in science experience with regard to language literacies?

8. Are there any strategies that you can propose to foster reading and writing that can contribute to the acquisition of science content in the foundation programme?

** The use of this word has subsequently been changed to 'discipline-specific literacies' in this dissertation.*

APPENDIX 4

FACULTY OF EDUCATION
SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

Doctor of Philosophy
Researcher: Mrs Vasanthie Padayachee [031- 2607234]
Ethical Clearance: Protocol Reference Number: HSS/0082/10D
Supervisor: Dr Emmanuel Mgqwashu [031-2603549

Observation Schedule
Institution: **Date:**
Module:
Lesson Type:
Number of students:
Lecturer:
Topic:
Task:

1. Seating arrangement

2. Communication between lecturer and students

3. Who dominates discussions in the lesson?

4. Does the lecturer pay any attention to language literacies* in science?

5. Do the students raise any questions relating to language literacies in science?

6. How do students answer questions posed to them?

7.How does the lecturer facilitate students' understanding of concepts and terminology in science and/or ordinary 'everyday' words?

8. How does the lecturer assist students in acquiring language literacies required to understand science lesson?

9. What is the nature of the activity or task which students are expected to do in the lesson?

10. How is the lecturer's understanding of language literacies in science discourse reflected in tasks assigned to students?

11. How does the lecturer assist students in acquiring language literacies required to do the task assigned in the lesson?

* *The use of this word has subsequently been changed to 'discipline-specific literacies' in this dissertation.*

APPENDIX 5

FACULTY OF EDUCATION

SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

UNIVERSITY OF KWAZULU-NATAL

Doctor of Philosophy

Researcher: Mrs Vasanthie Padayachee [031- 2607234]
Ethical Clearance: Protocol Reference Number: HSS/0082/10D
Supervisor: Dr Emmanuel Mgqwashu [031-2603549]

Dear student

Consent to Participate in Research

I am studying towards a PhD which examines the language literacies used by science disciplinary specialists to impart science discourse in the Foundation Programme. I seek your consent to observe lectures, practicals and tutorials in the courses for which you are registered and to use your tests, assignments, exercises and projects as part of my research data. I respect the issue of confidentiality and undertake not to reveal your identity in the research.*

Yours faithfully

Vasanthie Padayachee
Researcher
Ethical Clearance No.: Protocol Reference Number: HSS/0082/10D

CONSENT

I, ……………………..………………………………………………, Student No.: ……………………………… hereby consent to the observation of the lectures, practicals and tutorials in the courses for which I am registered. I also consent to the use of my tests, assignments, projects and workbooks for the purposes of educational research. I understand that my right to confidentiality will be respected and my identity will not be revealed in the research.

----------------------------------- ------------------------------------
Signature Date

* *The use of this word has subsequently been changed to 'discipline-specific literacies' in this dissertation*.

APPENDIX 6

FACULTY OF EDUCATION
SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

UNIVERSITY OF KWAZULU-NATAL

Doctor of Philosophy

Researcher: Mrs Vasanthie Padayachee [031- 2607234]
Ethical Clearance: Protocol Reference Number: HSS/0082/10D
Supervisor: Dr Emmanuel Mgqwashu [031-2603549]

CONSENT TO PARTICIPATE

I, (full name) ……………………..……………………………………………, hereby confirm that I understand the contents of this document and the nature of the research study and I consent to participating in the study. I am aware that data for this research is to be collected through the use of research instruments such as semi-structured interviews, classroom observation and documentary evidence. I understand that participation is voluntary and that I am at liberty to withdraw from participating in the research study at any time.

----------------------------------- ------------------------------------
Signature of Participant Date

APPENDIX 7

Scientific Writing

You will also be allocated marks for following the correct format for the report and for communicating your findings effectively.

- Are you sure that you have included only the **relevant** information in each section? E.g. make sure you do not explain or discuss results when you should be describing them in the 'results' section; make sure the 'introduction' does not include your results or conclusions etc.
- Have you used the passive voice and the past tense?
- Do your paragraphs and sentences make sense? Have you kept your sentences short and simple? Do you have one idea in one sentence? Does each paragraph have a topic sentence? Do your ideas link together?
- Have you written full sentences (starting with a capital letter and ending with a full stop); have you used correct punctuation; is your grammar correct; is your spelling correct? **(3)**

Mark Summary

Report	Marks
Title	1
Abstract	3
Introduction	4
Methods	8
Table	6
Graph	8
Paragraph	3
Discussion	6
Conclusion	2
References	1
Writing skills	3
Total	**45**

(*Foundation Biology*, Semester 1, 2011: 45-46)

APPENDIX 8

FACULTY OF EDUCATION
SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

UNIVERSITY OF KWAZULU-NATAL

5 March 2010

Prof. Deogratius Jaganyi
Dean: Faculty of Science and Agriculture
University of KwaZulu-Natal

Dear Sir

Request to Conduct Research in the Centre for Science Access

I am currently teaching an Academic Literacy module in the Foundation Programme at the Centre of Science Access within the Faculty of Science and Agriculture. I am also pursuing a PhD degree through the Faculty of Education at the University of KwaZulu-Natal. My research topic is entitled **"On Making Sense of Science Discourse: The Role of the Foundation Programme in a South African University."** My research supervisor is Dr Emmanuel Mgqwashu.

I hereby seek permission to conduct research within the Centre of Science Access. My research sample will comprise of the disciplinary specialists involved in the teaching of the science foundation modules of biology, chemistry, mathematics and physics on both the Westville and the Pietermaritizburg campuses of the University of KwaZulu-Natal. The participants have been selected purely on the basis of their involvement in the teaching of the science foundation modules within the foundation programme of the Centre for Science Access.

The research instruments used to acquire data for this study include semi-structured interviews, classroom observation and documentary evidence. Documentary evidence used will take the form of prescribed reading materials, student writing requirements and assessment criteria used by disciplinary specialists to impart science content.

The aim of my research study is to:

- research the language literacies* needed in science;
- determine the difficulties associated with language literacies in students' writing and/or assessment tasks implemented in the science foundation modules and to explore the impact of such language literacy difficulties on students' understanding and written expression of science discourse;
- investigate the strategies used by the disciplinary specialists to address students' ability to use science discourse;
- allow for shared discourse between the academic literacy practitioners and disciplinary specialists with regard to the issues of using language in science;

It is hoped that participation in the research study would contribute to an understanding of the acquisition of language literacies within the context of specific science disciplines.

The results of this research are intended to benefit the acquisition of science discourse using language strategies by future students registered for the foundation modules in the Foundation Programme, and promote engagement with disciplinary specialists teaching foundation modules to students at the University of KwaZulu-Natal.

I have familiarized myself with the guidelines regarding the ethical principles of conducting research. I am also aware that participation in this study, if granted, is voluntary and the participants may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey. There will be strict confidentiality and anonymity of records identifying any individual as a participant in this research. The data gleaned from this research study will also be securely locked for a period of five years. Thereafter, all data will be destroyed through the processes of shredding and/or incineration.

It would be appreciated if permission to engage in this research study is granted.

Yours faithfully

Vasanthie Padayachee
Researcher
Ethical Clearance: Protocol Reference Number: HSS/0082/10D

* *The use of this word has subsequently been changed to 'discipline-specific literacies' in this dissertation.*

APPENDIX 9

FACULTY OF EDUCATION
SCHOOL OF LANGUAGE, LITERACIES
AND MEDIA EDUCATION

UNIVERSITY OF KWAZULU-NATAL

Doctor of Philosophy

Researcher: Mrs Vasanthie Padayachee [031- 2607234]

Supervisor: Dr Emmanuel Mgqwashu [031-2603549]

Dear Respondent

Request to Participate in Research

I am currently pursuing a PhD Degree through the Faculty of Education, in the School of Language, Literacies and Media Education at the University of KwaZulu-Natal. My research topic is entitled "**On Making Sense of Science Discourse: The Role of the Foundation Programme in a South African University**."

You have been selected as a research participant purely on the basis of your involvement in the teaching of the science foundation modules within the foundation programme of the Centre for Science Access. It would be appreciated if you would kindly consent to participating in this research study.

The aim of this research study is to:

- research the language literacies* needed in science;
- determine the difficulties associated with language literacies in students' writing and/or assessment tasks implemented in the science foundation modules and to explore the impact of such language literacy difficulties on students' understanding and written expression of science discourse;
- investigate the strategies used by the disciplinary specialists to address students' ability to use science discourse.
- allow for shared discourse between the academic literacy practitioners and disciplinary specialists with regard to the issues of using language in science.

Through your participation in the research study, I hope to understand the acquisition of language literacies within the context of specific science disciplines in the Foundation Programme in Science.

The research instruments used to acquire data for this study include semi-structured interviews, classroom observation and documentary evidence. Documentary evidence used will take the form of prescribed reading materials, student writing requirements and assessment criteria used by disciplinary specialists to impart science content.

The results of this research are intended to benefit the acquisition of science discourse using language strategies by future students registered for the foundation modules in the Foundation Programme, and promote engagement with disciplinary specialists teaching foundation modules to students at the University of KwaZulu-Natal.

Your participation in this study is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey. There will be strict confidentiality and anonymity of records identifying you as a participant in this research. The data gleaned from this research study will also be securely locked for a period of five years. Thereafter, all data will be destroyed through the processes of shredding and/or incineration.

If you have any questions or concerns about participating in this study through the means of responding to a questionnaire or being interviewed, you may contact me or my research supervisor.

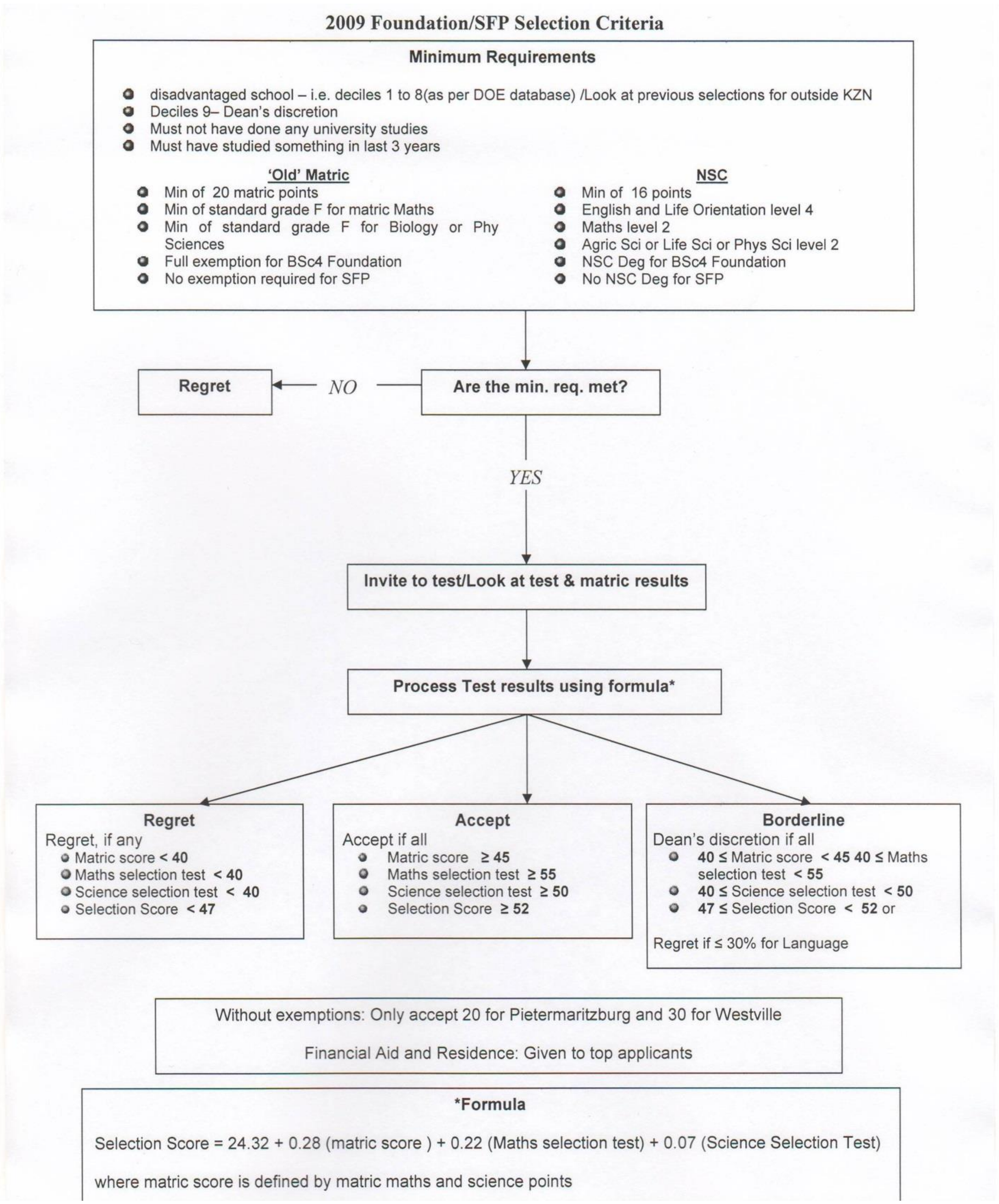
Thank You

Yours faithfully

Vasanthie Padayachee
Researcher
Ethical Clearance: Protocol Reference Number: HSS/0082/10D

* *The use of this word has subsequently been changed to 'discipline-specific literacies' in this dissertation.*

APPENDIX 10


2009 Foundation/SFP Selection Criteria
Minimum Requirements
disadvantaged school – i.e. deciles 1 to 8(as per DOE database) /Look at previous selections for outside KZN
Deciles 9– Dean's discretion
Must not have done any university studies
Must have studied something in last 3 years
'Old' Matric
Min of 20 matric points
Min of standard grade F for matric Maths
Min of standard grade F for Biology or Phy Sciences
Full exemption for BSc4 Foundation
No exemption required for SFP
NSC
Min of 16 points
English and Life Orientation level 4
Maths level 2
Agric Sci or Life Sci or Phys Sci level 2
NSC Deg for BSc4 Foundation
No NSC Deg for SFP
Regret
NO
Are the min. req. met?
YES
Invite to test/Look at test & matric results
Process Test results using formula*
Regret
Regret, if any
Matric score < 40
Maths selection test < 40
Science selection test < 40
Selection Score < 47
Accept
Accept if all
Matric score ≥ 45
Maths selection test ≥ 55
Science selection test ≥ 50
Selection Score ≥ 52
Borderline
Dean's discretion if all
40 ≤ Matric score < 45 40 ≤ Maths selection test < 55
40 ≤ Science selection test < 50
47 ≤ Selection Score < 52 or
Regret if ≤ 30% for Language
Without exemptions: Only accept 20 for Pietermaritzburg and 30 for Westville
Financial Aid and Residence: Given to top applicants
*Formula
Selection Score = 24.32 + 0.28 (matric score) + 0.22 (Maths selection test) + 0.07 (Science Selection Test)
where matric score is defined by matric maths and science points

APPENDIX 11

READING 2

Plants and their Pollinators

The evolution of plant pollinators

Some 200 million years ago, when seed-bearing plants (ancestors of existing gymnosperms and flowering plants) were just beginning to evolve and insects were not as diverse as they are today, wind alone was used to carry pollen from one plant to another. Wind pollination is a hit-or-miss affair, with pollen reaching the ovules of individuals of the same species only by chance. The ovules, which were borne on leaves or within the cones, secreted drops of sticky sap to catch the pollen grains. Insects, probably beetles, while feeding on the sap must have come across the pollen. Pollen is rich in proteins. At some point, insects made the connection between "cone" and "food source". These insects began returning regularly to these newfound sources of food. The plants lost some pollen to insects but they gained a major reproductive advantage - when the pollen-dusted insects moved from plant to plant, they brushed up against ovules of the plant they next visited transferring the pollen. The insects clambering over the cones weren't precision pollinators. But they were more efficient and made more accurate deliveries of pollen grains than the passive air currents alone. The more attractive the plants were to the beetles, and the tastier the pollen, the more frequently they would be visited. This would increase their chances of being pollinated and the more seeds they would produce. The greater the number of seeds produced, the greater the chance of reproductive success. Any changes in the plant that made visits more frequent offered an immediate advantage for selection. Several important evolutionary developments followed. For example, plants that had flowers that provided special sources of food for their pollinators had a selective advantage (they were more attractive and therefore chosen by pollinators). In addition to edible flower parts, pollen and sticky fluid around the ovules, plants evolved floral nectaries, which secrete sugary, nutritious nectar that provides a source of energy for insects and other animals.

In order to ensure reproductive success it is important that specific pollinators visit and pollinate specific flowers, or else the pollen is wasted on a plant of a different species. Angiosperms and their pollinators have been evolving together for 40-60 million years to ensure that their relationships are successful. When one species in a plant-pollinator relationship evolved, the change affected the selection pressures operating between the two, which brought about changes in the other. **This is co-evolution**. Insect pollinators in particular have influenced the evolutionary course of the angiosperms and contributed greatly to their diversification. In turn the diversification of insects is directly related to the diversity of the angiosperms. Today we can correlate many floral features with specific pollinators.

A plant and its pollinator(s) are adapted to one another. They have a mutualistic relationship in which each benefits-the plant uses its pollinator to ensure that cross-pollination takes place, and the pollinator uses the plant as a source of food. This mutualistic relationship came about through the process of co-evolution; that is, the codependency of the plant and the pollinator is the result of suitable changes in structure and function in each. The evidence for co-evolution is observational. For example, floral coloring and odor are suited to the sense perceptions of the pollinator, the mouth parts of the pollinator are suited to the structure of the flower, the type of food provided is suited to the nutritional needs of the pollinator, and the pollinator forages at the time of day that specific plants are open. The following are examples of such co-evolution

Bee-pollinated Flowers

There are 20,000 different species of bees that pollinate flowers. The best-known pollinators are the honeybees. Bee eyes see a spectrum of light that is different from the spectrum seen by humans, the bee's visible spectrum is shifted so that they do not see red wavelengths but do see ultraviolet

(*Foundation Biology*, Readings, Semester 2, 2011: 37)

APPENDIX 12

1. 68 x 94 is equal to

A. 162 B. 884 C. 6392 D. 8084 E. 4214

2. 7128 rounded off to the nearest hundred is

A. 7200 B. 7130 C. 7100 D. 7000 E. 8000

3. 84.456 rounded off to the nearest tenth is

A. 84 B. 80 C. 84.4 D. 84.5 E. 84.46

4. $\frac{1}{2}+\frac{3}{4}-\frac{1}{5}=$

A. $1\frac{1}{20}$ B. $\frac{3}{1}$ C. $1\frac{9}{20}$ D. $\frac{5}{11}$ E. $\frac{3}{20}$

5. The answer to $\frac{6}{10}\div\frac{12}{5}$ **is**

A. $\frac{36}{25}$ B. $\frac{25}{36}$ C. 4 D. 1 E. $\frac{1}{4}$

6. Write $\frac{5}{200}$ **as a decimal.**

A. 0.025 B. $\frac{1}{40}$ C. 0.25 D. 0.005 E. impossible

7. What is 70% of 140 equal to?

A. 98 B. 9800 C. 200 D. $\frac{1}{200}$ E. 42

8. Consider the following number pattern: 1, 1, 2, 3, ...
Determine the sixth term of the above number pattern.

A. 1 B. 3 C. 8 D. 15 E. 13

9. Solve for m**:** $3m + 5 = 12$**.**

A. $\frac{1}{2}$ B. $\frac{3}{7}$ C. $2\frac{1}{2}$ D. $-\frac{7}{3}$ E. 7

10. Simplify $(5x-3)(3x-1)$**.**

A. $\frac{3}{5}$ or $\frac{1}{3}$ B. $15x^2-14x+3$ C. $15x^2+14x+3$ D. $15x^2-4x+3$

11. Factorise $x^5y^6 - x^{10}y^3$**.**

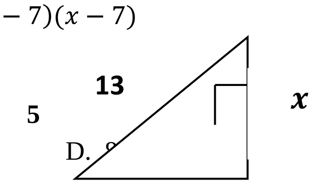
A. $x^5y^3y^3 - x^5$ B. $x^3y^5(y^5-x^3)$ C. $x^{-5}y^3$ D. $x^3y^5(y^5+x^3)$

12. Factorise $x^2 - 49$**.**

A. ± 7 B. $(x+7)(x+7)$ C. $(x-7)(x+7)$ D. $(x-7)(x-7)$

13. In the diagram on the right, the value of x **is:**

A. $\sqrt{8}$ B. 12 C. $\sqrt{194}$ D. 144



14. Solve for x**:** $3x^2 - 2x = 8$**.**

A. $x = 2$ or $x = -\frac{4}{3}$ B. $x = -2$ or $x = \frac{4}{3}$ C. no solution D. 8

15. Solve for q **if** $p + 2q = 7$ **and** $2p - 5q = -9$**.**

A. $\frac{23}{9}$ B. $q = 2$ C. $\frac{9}{23}$ D. $\frac{17}{9}$ E. $\frac{9}{17}$

16. Simplify $\frac{5}{x^2-4} - \frac{3}{x+2}$

A. $\frac{11-3}{(x-2)(x+2)}$ B. $\frac{-3x-1}{(x-2)(x+2)}$ C. $\frac{-3x-1}{(x+2)}$ D. $\frac{2}{(x^2-4)(x+2)}$

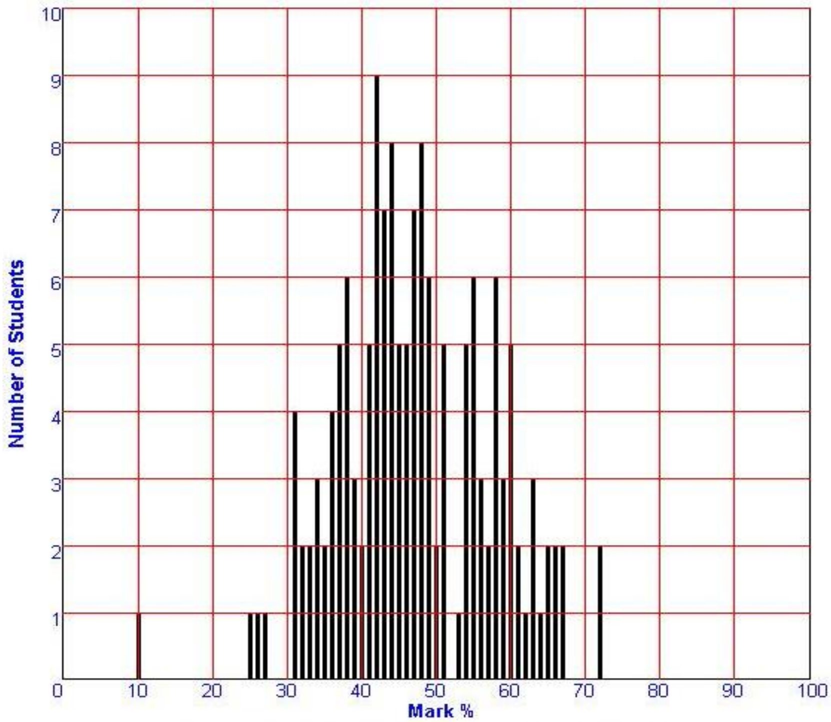
17. The area of a rectangle with length 5 cm and breadth 12 cm is:

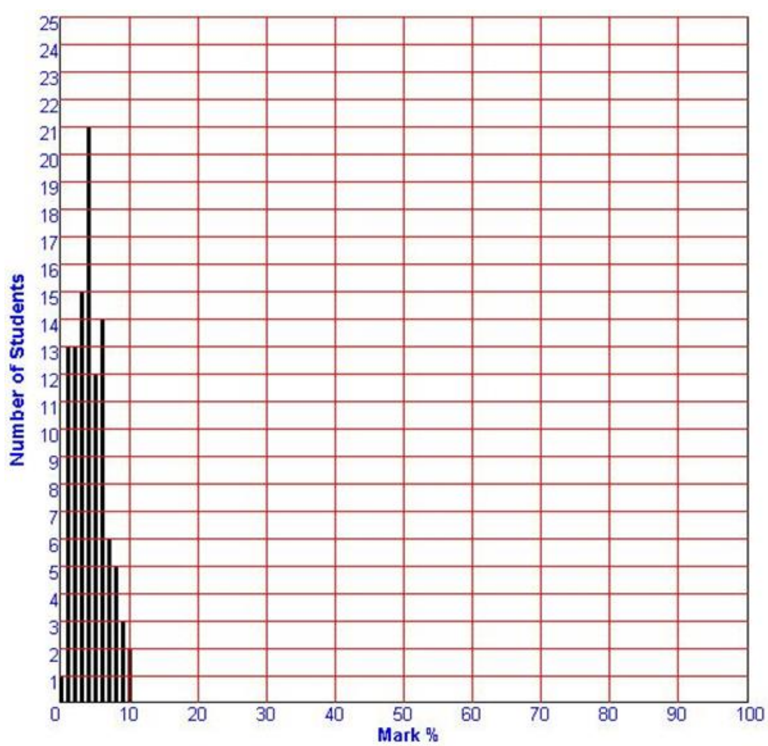
A. 17 cm B. 60 cm^2 C. 17 cm^2 D. 240 cm^2 E. 60 cm^2

18. The area of a circle with radius 8 cm is:

A. 16π cm^2 B. 64π cm^2 C. $8\pi^2$ cm^2 D. 16π cm^2 E. 8π cm^2

Sample Graphs showing performance in skills tests





(*Foundation Mathematics*, 2011)

APPENDIX 13

Let's try one more example together.

Determine the value of $\frac{6}{5} \times \frac{25}{14}$

We notice that each fraction is in simplest form. We proceed to multiply.

$\frac{6}{5} \times \frac{25}{14} = \frac{6 \times 25}{5 \times 14}$ Take a careful look at the new fraction. Do 6 and 14 have anything in common? Do 25 and 5 have anything in common? YES! We think HCF!

Rewriting the fractions we obtain

$$\frac{6}{5} \times \frac{25}{14} = \frac{6 \times 25}{5 \times 14} = \frac{\overbrace{2 \times 3}^{\boxed{\text{Factors of 6}}} \times \overbrace{5 \times 5}^{\boxed{\text{Factors of 25}}}}{5 \times \underbrace{2 \times 7}_{\boxed{\text{Factors of 14}}}}$$

Notice that the numerator and denominator of the new fraction are in factor form therefore it is **safe to cancel common factors**. We thus obtain

$$\frac{6}{5} \times \frac{25}{14} = \frac{6 \times 25}{5 \times 14} = \frac{2 \times 3 \times 5 \times 5}{5 \times 2 \times 7} = \frac{3 \times 5}{7} = \frac{15}{7}$$

Ex. 1.5a

1. Simplify

a) $\frac{2}{3} \times \frac{9}{16}$ b) $\frac{27}{36} \times \frac{25}{125}$ c) $\frac{3}{4} \times \frac{16}{27} \times \frac{81}{48}$

d) $\frac{20}{120} \times \frac{35}{95} \times \frac{21}{49}$ e) $\frac{121}{33} \times \frac{45}{18} \times \frac{36}{48}$ f) $\frac{32}{40} \times \frac{64}{256} \times \frac{\sqrt{196}}{28}$

We now focus on **division of fractions**.

13

(*Foundation Mathematics*: Basic Skills, 2010: 13)

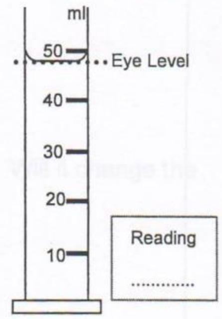
APPENDIX 14

5.4 Using the measuring cylinder

A measuring cylinder has lines drawn on the side to show the volume of a liquid in the container.

☛ READING A MEASURING CYLINDER

When you pour a liquid into the cylinder, it forms a little dip at the top of the liquid, which is called a meniscus.
To read the level of the liquid, always measure from the bottom of the meniscus.
You need to make sure BOTH eyes should be on the same level as this meniscus to avoid the error of parallax. Do not simply turn your head on the side.
You will also need to estimate the last digit between the divisions, as you did for length.
\# Write in the reading onto the diagram.



EXPERIMENT: How many cm^3 will the iron cube with 2cm-sides take up?

A. How many standard 1-cm^3 cubes did you need to model the 2-cm sided cube? (Section 5.2)
_____

B. Did the volume change when you rearranged these cubes into a different shape? (Section 5.3.) _______

C. Fill a measuring cylinder to the 35 ml mark. Gently lower eight of the one-centimetre cubes into the cylinder.
How much does the water level rise? _________

D. What is the relationship between the amount of ml that the water level rises and the number of cm^3 added ?____

EXPLANATION: The lines on a measuring cylinder are numbered to show how many standard 1 cm-cubes could fit in the container below each level.

When an object is placed completely under the water (submerged), some water will be pushed out of the way. As a result the water level rises; we say the water was **displaced.** For each cubic centimetre of material that is submerged one cubic centimetre of water is displaced.
This method of measuring volumes is called the **method of water displacement.** It is another operational definition for measuring volume.

Staff

(*Foundation Physics*, Semester 1, 2010: 38)

APPENDIX 15

PARAGRAPH WRITING

A paragraph is a series of sentences that are well organized and coherent, and are all related to a single topic.

Topic sentences

A topic sentence is the most important sentence in a paragraph and is usually the first sentence. It advises the reader of the subject of the paragraph and thus should clearly state what the paragraph is all about. In some cases, however, it is sometimes more effective to place another sentence before the topic sentence, for example, a sentence providing some background information, or one linking the current paragraph to the previous one.

Elaborating sentences

These are sentences that elaborate upon or explain the topic sentence further by discussing the controlling idea, using facts, arguments, analysis, examples and other information. The supporting sentences of a paragraph should explain or "support" the idea expressed in the topic sentence.

Logical connectors

In order to create cohesion in paragraph writing linking language or logical connectors must be used. Academic writing that is not held together with linking language is not cohesive. Below is a list of different types of logical connectors.

Additive/to show addition: additionally, furthermore, moreover, similarly, likewise

To contrast/ to show differences: but, conversely, however, yet, whereas, although, in contrast, on the other hand, despite, on the contrary

Causal/ to show cause and effect: because, consequently, for this reason, as a result, since, therefore, thus

To exemplify/ to give examples: for example, for instance, that is, to illustrate, by way of example

Sequential/ to signal order: firstly...secondly...thirdly, initially, to start with, subsequently, thereafter, finally, lastly, to conclude, in summary.

PARAGRAPH EXERCISE

In the following paragraphs underline the topic sentence and tick the sentence or phrase which logically completes the paragraph.

1. Rural communities disintegrate if large numbers of people move to urban areas. The population structure is unbalanced when men go away for nine or ten months of the year. Children are no longer trained in their father's skills and crafts, and many extra burdens are placed on the people left behind. Women have to raise children, as well as fetching water, ploughing, planting and harvesting the crops and feeding the family.

(*SCOM*: Semester 1, 2011: 37-38)

APPENDIX 16

Format of a scientific report

Write up your findings as a scientific report in the following format:

TITLE: The title says what your report is about. It should be brief (aim for ten words or less) and describe the main point of the experiment or investigation. However, a title which is too broad such as "Pulse measurement" is not descriptive enough. An example of a title would be: "Studies on the incidence of skin cancer in South Africa". If you can, begin your title using a keyword rather than an article like 'The' or 'A' etc.

ABSTRACT: The abstract should summarise your aim/objective; it should briefly introduce your topic, mention your method of doing the investigation; it should also briefly mention your results and the implications of your results. Abstract should be a single paragraph.

INTRODUCTION: One to one and a half pages. This section should give some background information about the topic. It explains the objectives or purpose of the experiment and prepares the reader for what to expect. It tells the reader what other researchers have found in the past. By including this section, you place yourself and your experiment in the context of the previous research. However, the information used from other literature must be cited as in-text references. This shows politeness to other researchers and to your reader, because you are not claiming that the information in the theory section is your original ideas. You are also making what you say stronger, because it comes from a published authority, and is not something that you made up yourself.

HYPOTHESIS: One sentence. The hypothesis must be in the form of a statement that can be tested.

MATERIALS & METHODS: One or two paragraphs. Describe the materials (if any) you used and steps you did to complete your investigation. This is your procedure. Be sufficiently detailed that anyone could read this section and duplicate your experiment. It may be helpful to provide a figure or diagram of your experimental setup, if needed. Write the entire method section using past tense and passive voice. You should discuss any uncertainty and precautions you used in the experiment.

RESULTS: Your data from the experiment must be noted in a table and/or should be expressed in the form of graphs or diagrams, whichever is appropriate. You must choose what will make your results easy to understand and meaningful.

DISCUSSION: This is the section where you interpret the data. Explain the data using information from your introduction. Do not merely repeat the results in words. You must interpret the results that you have obtained based on the information from your introduction. You must also answer questions such as how your data compares with what you expected based on information from other literature. Remember to incorporate in-text references. How do your results differ? Try to explain the differences from what you expected. This is also where you would discuss any mistakes you might have made while conducting the investigation. You may wish to describe ways the study might have been improved.

CONCLUSION: One very short paragraph. Summarise the findings. Did you accept or reject the hypothesis you stated earlier and why?

REFERENCES: You should list all the in-text references used in the 'introduction' and 'discussion' section here as per the format discussed in 'referencing and citation' earlier.

30

(*SCOM*, Semester 2, 2011: 30)

APPENDIX 17

The following is a brief explanation of compiling the Results and Discussion Sections of the Scientific Report

Prins, R. (1994). *Doing Science: Question, Observe, Conclude*. Kentucky: Western Kentucky University Press.

The Results and Discussion Sections of the Scientific Report

Results

In the Results section, you relate significant findings in an organized, readable form. Present numerical data in tables and/or graphs. Show relationships between and among factors in figures. Tables and figures are numbered separately e.g. Table 1, Table 2, Figure 1, Figure 2. All tables and figures must have titles describing their content. Label the axes of graphs and specify the units used on each axis. The Results section basically consists of significant quantitative data. Do not make judgments, draw conclusions, explain, or cite literature here. Keep the Results precise.

Discussion

After you have conveyed to the reader your significant results, you *now* need to **explain** their meaning in relation to the question asked. You also need to relate your discussion to the literature/theory. This is the purpose of the Discussion section. In this section you interpret the results, explain their significance, compare with other studies, and explain any weaknesses of the experimental methods or design. This is the most important section of your paper, and it is generally allotted high marks. It is also the most difficult section to write. Except when citing authors directly, write in present tense and avoid excessive repetition of results**.**

Some specific suggestions on how to "build" the Discussion may include an outline with the following components. These are only suggestions, but ultimately the Discussion must show clarity of understanding of the Results in relation to concepts and or other studies you may have read about.

1. Answer the question.
2. Write about the specific data which led you to your conclusions.
3. Write about the predictions you made before you started the experiment. Do your results confirm your predictions or not? Do the data support or refute the hypothesis? If so, what are your conclusions? If not, do you have an alternative hypothesis or can you suggest a follow-up project?
4. Link the data with the literature/theory.
5. Comment on how your results conform to findings of other researchers whose work you may have read/researched.
6. Identify weaknesses you discovered in your experimental design. You need to tell the reader how these imperfections may have affected your results. It is important for you to understand (and acknowledge in your report) how these limitations affect the validity of your conclusions.
7. Write about problems that arose during the experiment. Unforeseen difficulties with the procedure may have affected the data and should be addressed in the Discussion.

(*SCOM*, Semester 2, 2010: 88-90)

APPENDIX 18

REPORT ON EXPERIMENT 1

Name.. Group...............
Bench Number..................
Demonstrator... Date..................

Results

Table1..

Before Purification	Mass of sample tube + crude alum	
	Mass of empty tube	
	Mass of crude alum	
After Purification	Mass of sample tube + crystals	
	Mass of empty sample tube	
	Mass of pure alum crystals	

Calculations

Calculation of % yield = $\frac{\text{Mass of.............................}}{\text{Mass of.............................}}$ x 100

= $\frac{\text{.......................}}{\text{........................}}$ X 100

= ....

Discussion

....
....
....
....
....
....
....
....
....
....

Conclusion

(*Foundation Chemistry:* Semester 2, 2010: 4-5)

LABORATORY REPORT 1: EXPERIMENT 9.1

Write up a laboratory report of Experiment 9.1. Use the spaces and graphing grid provided below. Refer to your notes (Section 3) on how to write a laboratory report.

Aim:

Apparatus:

Method:

Results:

Table 1:

Slope of Graph calculations:

Discussion:

Conclusion:

(*Foundation Physics:* Semester 1, 2011: 8-10)

APPENDIX 19

A REPORT ON ELECTROMAGNETISM

TITLE

An experiment showing the relationship between the strength of an electromagnet and current or number of coils in the electromagnet.

ABSTRACT

Conducting an electromagnet by wrapping the iron nail with an insulated wire in order for a current to flow, determined the relationship between the number of coils and the number of pins picked up by a magnetized iron core. Electromagnets acts as ordinary magnets to picks up the number pins, but what was different between these two, is that the electromagnet can be switched off and on. The results obtained showed the direct proportionality between the number of coils and the number of pins picked. The distance was controlled so it had no much effect.

NOT DIRECT.

INTRODUCTION

The purpose of this report is to elaborate about three factors affecting the strength of the electromagnetism. Electromagnetism is an object that acts like an magnet, but its magnetic force is created and controlled by electricity (Kurtus, (2005). Electromagnets are very useful than ordinary magnets. The powerful electromagnets are often used to lift heavy metals in scrap yards. The powerless electromagnets are often used in radios, telephones, TV; electrical doors, doorbells, computers etc (Magnetic Attraction, (2005). The most interesting fact about electromagnetism is that they can be switched off and on. Electromagnets were conducted by wrapping the iron core with an insulated wore, and connecting the ends of the wire into the battery.

THEORY

Magnetism is the ability of certain materials to repel or to attract other materials. Magnetic material work naturally, but some electrical magnets which can be turned off and on can be conducted, and such electrical magnets are named electromagnets (Magnetic Attraction, (2005). When

2

electromagnets are conducted, they can be useful in attracting some certain materials like pins, coins money etc. When they have tuned off the power of the nail stops being magnetized. Electromagnets are more useful than ordinary magnets. They can be stronger by using a bigger length of the wire than a nail and by winding more electrical wire around them (Magnetic Attraction, (2005).

HYPOTHESIS

When an iron core is being wrapped around by an insulated wire the strength of magnetic field increases. WEAK HYPOTHESIS.

APPARATUS

- An iron nail
- Pins
- A 9v battery
- An insulated copper wire

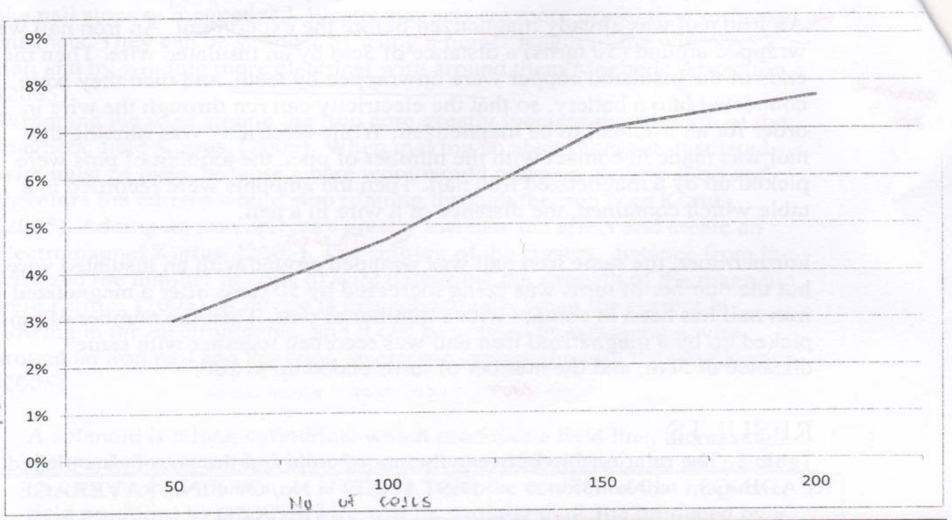


Figure 1 Relationship between no. of coils and the average of picks

DISCUSSION

In 50 turns the iron nail picked up 3 pins, in 100 turns the iron nail picked up about 4.7 pins and in 200 turns the iron nail picked about 7.7 pins, the reason why the number of pins picked increases as the number of turns increases may be that the number of coils of wire and the distance from the wire is directly proportional to the strength of the magnetic field. This means if the number of coils of wire is doubled or if the distance from the wire is doubled, then the strength of the magnetic field will also be doubled. And a reason for wrapping the wire in a coil concentration to increase the magnetic field is because of the addictive effect of each turn of the wire.

Additionally, the other reason why the iron nail keep on picking more and more pins after each increasing turn and even after the electromagnetic has been switched off and again switched on, this may be because the iron nail was already magnetized and also the iron nail has been permanently magnetized. 5

CONCLUSION

NO.

In concluding the number of pins is directly proportional to the number of coils. And the results shows that a wrapped iron core by wire increases the strength of the magnetic field.

REFERENCE LIST

1. Atherton, M.A, T, Duncan, D.G Mackean, (1983). Electromagnets. Science for Today and Tomorrow. John Murray, London.
2. Griffith, W.T. (2004). The Physics of Everyday Phenomena. New York: McGraw Hill p283-285
3. Kurtus, R. (2005). Electromagnetism. *http:www.school-for-champions.com/science/electromagnetism.htm.* Revised 3rd April 2005.
4. Magnetic Attraction (2005). *YOU MAGAZINE,* 27TH January 2005.

ABO

A sample of a scientific report on 'Electromagnetism' submitted by Nokulunga for *SCOM*

APPENDIX 20A

ESSAY

METHODS OF SOLID WASTE DISPOSAL

Essay Topic:

"You have been employed by the municipality of your city or town of residence to study and report on the methods of solid waste disposal. Write an essay in about 500 to 600 words making well-supported recommendations concerning which method(s) should be used by your municipality."

How is an essay structured?

A well structured essay is expected to be organised into three parts: introduction, body and conclusion.

Introduction:

- General statement or orientation to topic.
- Brief summary of the main topics/arguments/points made in the essay.

Body:

- Should be divided into paragraphs.
- Each paragraph should have a topic sentence and 2-3 supporting sentences. The supporting sentences support, expand or explain the point made in the topic sentence.

The function of the essay's **body** is to fully develop the argument outlined in the introduction. Each paragraph within the body of the essay elaborates on one major point in the development of the overall argument (although some points may consist of a number of sub-points, each of which will need a paragraph). The main point in each paragraph needs to be clearly stated in the form of a topic sentence, which is then supported with evidence.

Conclusion:

- Restatement or summary of the main points made in the body paragraphs and a final comment (if appropriate).

Scientific American December 1988 Volume 259 Number 6 pages18-24

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(*SCOM*, Semester 2, 2010: 49)

APPENDIX 20B

Please check the following aspects of your essay:

Introduction

1. Does it explain important concepts such as *high population density*, *what you include in the idea of violence*, and *primates*?
2. Does it indicate whether your essay will agree or disagree that high population density does or does not lead to violence?

Main essay

3. Is your essay written in your own sentences, or have you copied sentences from the readings?
4. Does your essay contain **evidence** for what you say?
5. Is your essay organised logically? Is everything on a particular subtopic dealt with together or do you jump around from topic to topic and talk about a particular subtopic in different parts of the essay?

Conclusion

6. Do you include a conclusion that summarises the important points you have made?

e.g. In conclusion, the most important proof that high population density leads to violence is …

e.g. In summary, it is clear that high population density does not lead to violence because…

Referencing

7. Do you include **in-text** references?

e.g. According to Friedman (1975), human beings are…

e.g. Like human beings, monkeys and other primates control their behaviour in order to avoid conflict (de Waal, Aureli and Judge, 2000).

8. Do you include references at the **end** of the essay?

(*SCOM*, Semester 2, 2009: 52)

APPENDIX 21

Observation of SCOM Lesson (Student Group A) Date: 28 July 2011
Topic: Tuberculosis: Reading and Discussion of Text 1 (SCOM, Semester 2, 2011: 17)

Sudeer (AL): Good afternoon. I hope you have read the article that I asked you to. Right, who is brave enough to start talking about the topic? As I told you the other day, Tuberculosis - or TB is not an uncommon disease. I am sure most of us know someone who has it … or had it… or might get it. *(Students nod in agreement)* Ok, I am waiting for someone to start talking about the reading. Any takers? Volunteers?
Siya: It is an infectious disease caused by bacteria. The bacteria is called Mycobacterium. And it affects the lungs.
Sudeer: Good. Now, look at that word 'Mycobacterium' in the reading. Can you see how it is written, I mean typed. *(A student answers that it is italics).* That's correct, now scientific names .. of species or diseases and such have to be typed in italics. Please note that. As I always say, make notes along the margin of these little things … it. And notice too that the word tuberculosis after 'Mycobacterium'is also in italics but starts with a small letter 't'. *(Writes 'Mycobacterium tuberculosis and 'infectious on the chalkboard).* We'll kind of add to this list as we go along.
Sudeer: Okay, who would like to read the first two paragraphs? *(A student volunteers to read aloud)* Okay, let's talk about what these paragraphs are saying. Mr Ngubane, would you like to start.
Mr Ngubane: Ja, sir, it's about this disease, tuberculosis. It tells us the about the man – Robert Koch, and he is the one … he discovered it. And for treatment, we can take antibiotics.
Sudeer: Yes, correct. That was what was in the first paragraph, how about the 2nd now. Nokuthula, would you like to tell us what it says?
Nokuthula: The bacteria causes an infection. And you need drug therapy.
Sudeer: Yes, right. *(Let me give you a few minutes to read the next two paragraphs on your own and then we'll talk about it).*
Sudeer: Okay, now I don't want you to read it out to me. I just want some points about that heading at the top, 'How does a person get TB?' And, as you give me the points, I will write them on the board. *(Answers given from random students. Sudeer draws up a list of words on the board).*
Sudeer discusses the meanings and pronunciation of the following words and phrases: infected sputum; transmitted; minute particles; related bacteria; pasteurized /unpasteurized.
Sudeer: Since you have read at home, let's discuss the next part of the topic on page 18. What happens when the TB bacteria enters the lung?
Student 1: Reads the first few lines from the text.
Sudeer: Ok, but I thought you would tell me rather than read. But never mind, if you look at that paragraph that she just read, I need for you to tell me what you think is important
Student 2: can cause lung infection.
Sudeer: Yes, now what you should do is highlight or circle or underline the words 'inhaled TB bacteria'; 'lung'; and then highlight also lung infection. Now, what I'm showing you are some reading skills – after reading that first part, just by looking at those words you highlighted, you will know what happens to the body. The bacteria is inhaled – that means it goes into the lungs and you get a lung infection. What I have just shown you is how to read, understand, and make some notes in the reading passage.

APPENDIX 22

Cephalopods 3B

The cephalopods are a class of the phylum Mollusca which have adopted a swimming way of life. They include the squids, cuttlefish, octopuses and nautiluses, all of which have beak-like mouths and well-developed heads with a crown of appendages around the mouth. These appendages usually bear suckers or hooks.

Cephalopods are the most highly evolved of the molluscs and are thought to be the most sophisticated of all invertebrates. They are masters of bouyancy control, have highly evolved brain and sense organs, and are capable of learning. As a class, cephalopods play a key role in the food webs of most marine ecosystems since they fill niches as both predator and prey. They cover an enormous size range, from the tiniest squid that measure just a few centimetres, to the deep sea squids which may reach a total length of 18 m or more if their tentacles are included.

Some 185 species of cephalopods have been recorded in southern African waters: 106 squids, 42 cuttlefish and 37 octopuses. True nautiluses do not occur in southern African waters, but the paper nautilus, *Argonauta argo*, a relative of the octopus, is common here. The delicate, paper-like shells of these animals frequently wash up on our shores and are highly sought after by collectors.

Anyone who has ever used SCUBA apparatus will know that buoyancy control is one of the finer aspects of underwater diving; until you've mastered it, your movements in the water column are clumsy and uncomfortable. Interestingly, cephalopods have developed buoyancy control to a fine art. A close examination of a cuttlefish, for instance, will reveal that these animals can control their own density by regulating the amount of gas in the chambers of their inner shell.

Cephalopods swim mainly by jet propulsion. Their strong, muscular mantles dilate and suck in water and then contract suddenly to squirt it out. Valves control the exit of the water so that it jets out of the siphon; the siphon can be pointed in any direction to control the way in which the animal moves.

The free-swimming squids and cuttlefish are active, fast-moving hunters that feed mainly on fish or swimming prawns. They have one pair of extremely long, sucker-studded tentacles, which they use to capture their prey. Their four pairs of arms are used for holding their prey while they devour it. Octopuses, on the other hand, have eight arms and hide in holes on the seabed, emerging only to capture passing snails, fish and especially crustaceans such as crabs and rock lobsters. All cephalopods use their powerful beaks to shred their prey. Some species inject toxins from their poison glands into their prey in order to subdue it.

Many cephalopods use their ink glands as a defence against predators. When being pursued they will squirt out a black

MODE OF LIFE

Organism	Phylum	Movement	Type of Food	Feeding Habits	Protection	Mode of Life
1. Sea anemone						
2. Chiton						
3. Sea urchin	Echinodermata	Five pairs of tube feet operated by water pressure, spines are moveable	Graze on algae and kelp	5 powerful jaws scrape off and chew algae	Hard test covers body, Pedicellaria and spines (sometimes poisonous); Radial symmetry ensures protection from all sides	Sedentary; Heterotrophic; Herbivorous; Cryptic
4. Mussel						

(*Foundation Biology*, Readings, Semester 2, 2011: 37)

APPENDIX 23

Chapter 2: WORD PROBLEMS

When you have completed and understood this section, you will be able to do the following question.

An earthquake emits a primary wave and a secondary wave. Near the surface of the earth the primary wave travels at about 8 km per second, and the secondary wave at about 4.8 km per second. From the time difference between the two waves arriving at a given measuring machine, it is possible to estimate the distance to the quake. Suppose a machine measured a time difference of 16 seconds between the arrival of the two waves. How long did each wave travel, and how far was the earthquake from the machine?
(Speed, Time, Distance relationships, Translating English into Maths, Simultaneous Equations)

Problem solving strategies :

1. **Read and understand the question**
It is obvious that we cannot expect to solve a problem successfully if we haven't read it carefully and if we have not understood it. It is like going on a journey without knowing where or in which direction you have to go. It is very important to understand what information is given and what is required.
2. **Draw a diagram**
A picture, a figure, a diagram or a graph is helpful in the solution of many problems. The very act of drawing a figure helps to concentrate on the information given, and to notice relationships. It is very useful to have all the information in one place. In many cases a picture is worth a thousand words. It is very rare that we would solve a problem in geometry without drawing a figure to show given lengths, angles, shapes, etc. But a figure is often useful in other areas as well.
3. **Look for a pattern**
Patterns are very important in Mathematics, so important, that Mathematics was once described as the study of patterns.
4. **Algebraic method**
It is often useful to introduce notations. This translates the problem into symbols and can have an effect of simplifying the solution. Some students find that by substituting variables for unknown quantities it translates into an algebraic problem and hence use an algebraic method to solve the problem.
5. **Multiple choice questions**
Sometimes you can decide on the answer without solving the problem and you can eliminate some of the possible answers. One of the answers may be too high or too low to be a sensible answer to the problem .In a problem where the correct answer is obviously an odd number you can eliminate even among the given possible answers. Sometimes it is quicker to substitute the answers. You may be able to find other reasons why some of the answers can be excluded as possibilities.
6. **Verify your answer**
If possible check or justify your answer. Is your answer a sensible one or is it realistic?

Steps in Method:

- ✓ Read the question. Get a picture of what it is about.
- ✓ What are you asked to find?
- ✓ Give these things letters. Say **exactly** what the letters represent.
- ✓ Translate information into equations.

(*Foundation Mathematics*, Semester 1, 2011: 14)

APPENDIX 24

☞ Task 3

Answer the following questions:

1. Are the two sister chromatids that are connected by a centromere identical to one another or do they contain different alleles? Explain **(2)**
2. As noted above, these structures are called replicated chromosomes (or simply just chromosomes). Replicated chromosomes are quite different from unreplicated chromosomes seen earlier. Compare replicated chromosomes to unreplicated ones by filling in the blanks below:

    a. the amount of DNA in the replicated chromosome is_______times the amount of DNA in an unreplicated chromosomes
    b. the number of copies of each gene in a replicated chromosome is______times the amount of copies in an unreplicated chromosome
    c. each replicated chromosome contains ________(insert number) complete copies of genetic information
    d. The copies of genetic information in each chromosome are___________________(identical, homologous, or complementary)? **(4)**

Explain in your own words why there is so much concern about the depletion of ozone from the atmosphere in recent years.

____

____

____

Explain in your own words why respiration made organisms more efficient.

____

____

(*Foundation Biology*: Semester 1, 2011: 89; 91)

APPENDIX 25

Foundation Chemistry (CHEM099/199) Test 1
Duration: 1 hour Total Marks: 30 Date: 18th August 2011

QUESTION 1 [9 marks]
The solubility of most solids increases with a rise in temperature and decreases as the solution cools. Answer the questions below based on the crude alum experiment.

What is meant by the phrase "solubility of a substance"? (1)
The maximum amount of a substance that can dissolve in a given amount of solution at a specified temperature and pressure ✓
Use discretion as did not do Chap 7 last semester.

What scientific name is given to each filtration process represented by Figures A and B? (2)
Figure A: Gravity filtration (Filtration under gravity) ✓
Figure B: Vacuum filtration (Filtration with suction) ✓

Why is the filtration process represented by Figure B preferred to that of Figure A? (1)
When filtering tiny solid particles that can otherwise go through a filter paper with large pores (which is mostly used in
gravity filtration)
OR to increase the rate at which filtration is achieved OR for the obtained crystals to be as dry as possible ✓

Explain why you used an open flame and not a steam bath, to evaporate the filtrate when you did this practical. (1)
The solvent used is non-volatile OR solvent cannot catch fire while evaporating ✓

While carrying out this experiment in the laboratory, splattering may occur resulting in low percentage yield:
(i) what is meant by splattering? (1)
Jumping out of liquid droplets from a container while boiling ✓
(ii) why does splattering occur? (1)
Excessive amount of heat supplied ✓

i. With the aid of calculations, explain how you will prepare this stock solution in the laboratory. (4)

Moles of NaOH in the stock solution = molar concentration of solution x volume✓½
= 2.683 mol dm^{-3} x 3.7500 dm^3 ✓½
= 10.06 moles of NaOH ✓½

Molar mass of NaOH = M of Na + M of O + M of H
= 22.990 + 15.999 + 1.0079
=39.997 g mol^{-1} ✓½

Mass of NaOH containing these moles = Mm of NaOH x moles of NaOH
= 39.997 g mol^{-1} x 10.06 moles
= 402.4 g ✓½

Measure out 402.4 g of solid NaOH using a weighing machine ✓½
Transfer the mass through a funnel into a volumetric flasks containing small amount of distilled water and dissolve it. ✓½
Add distilled water up to the mark and mix well. ✓½

APPENDIX 26

1. Explain the meaning of the statement "TB is evolving faster than therapies" in the context of the article.

2. Use examples to explain 2 ways in which TB can harm economies.

3. Why does the TB bacterium thrive in the lungs?

4. State why individuals with HIV are susceptible to TB.

5. Give 2 reasons why TB is difficult to eradicate.

6. TB is an infectious disease which can lead to severe illness and possible death.

   Explain 3 precautions a TB patient should take to keep the disease under control.

7. Choose **one** of the measures mentioned in Par. 3 and explain how it can be implemented in South Africa.

8. Give **two reasons** which indicate that the New York City TB control programme was effective.

9. List *one* factor that contributes to the rise of the drug resistant TB.

10. How does the delay of laboratory-reports impact on the treatment of TB?

11. Explain, *in your own words*, 2 plans of action that can be taken to prevent the spread of TB in hospital wards.

12. Summarize the article in 100 words.

(*SCOM*, Semester 2, 2011: 25)

APPENDIX 27A

Question 1

The maize that we eat in South Africa (*Zea mays*) is believed to have evolved from a wild Mexican grass called *Zea mexicana*. Recently, a close relative of *Zea mexicana, Zea diploperennis* was discovered in the mountains of Mexico. *Zea diploperennis* is highly resistant to (can withstand) attack by pathogens (disease causing organisms). This plant can also grow in infertile (poor) soil.

Research botanists and geneticists have found the resistant genes in *Zea diploperennis* and implanted them into *Zea mays.* As **a starting point** to establish the suitability of this genetically modified crop for cultivation the following experiment was done.

Experiments were conducted to compare the survival of *Zea mays* with the resistant gene and normal *Zea mays* without this gene. One hundred maize seedlings (5 sets of 20 seedlings) with the resistant gene were infected with a pathogen and allowed to grow for 3 months in a green house. The plants were grown in 3L plastic pots filled with sterilized potting soil at 26^{o}C and 50% humidity. Each seedling was given 100ml of distilled water every second day. The pathogens interfere with the movement of water, resulting in the death of the maize plant. The survival of these 100 infected seedlings was recorded (**Table 1**).

The experiment was repeated with 100 normal maize plants that did not have the resistant gene. These plants were infected with the same pathogenic organism. These plants were grown under shade cloth (which keeps out direct sunlight) as the green house was too small to fit all the pots.

(Extracted from *Foundation Biology* Test, Semester 2, 2011, August)

APPENDIX 27B

3.3 Consider the widgeon grass, the clam and the blue crab. Briefly explain **<u>how</u>** and **<u>why</u>** the amount of **biomass and energy** available for these organisms differs. **(6)**

Widgeon grass is a producer and has the most biomass and the most energy available since it gets its energy directly from the sun which it converts into biomass. ✓Not all of the sun's energy is converted to biomass since some of this energy is not available for photosynthesis and some is lost as heat while the producer performs its life functions. **✓The primary consumer (clam) can only access energy by consuming the flesh (biomass) of the producer and therefore has less energy available than that was available to the producer. Furthermore, not all the biomass of the producer is digested and thus some of the energy is not available for the clam✓. Since the clam will use some of its energy gained from the grass for life functions, only the left over energy may be converted to biomass and be made available to the secondary consumer, the crab. ✓Some parts of the clam biomass will not be digested by the crab, thus energy available for the crab will decrease✓. Further losses of energy will occur during the crab's life processes leaving a smaller amount for conversion to biomass and thus the amount of biomass also decreases as we move up the trophic levels✓**

(Extracted from memo of *Foundation Biology*, Semester 2, 2011, October)

APPENDIX 28

Let the 40% solution = x

Let the 70% solution = y

$$40\% x + 70\% y = 49\%$$

$$0.4x + 0.7y = 0.49(100\text{mL})$$

$$0.4x + 0.7y = 49 \quad - (1)$$

$$x + y = 100 \quad - (2)$$

Substitute (2) in (1)

$$0.4x + 0.7(100 - x) = 49$$

$$0.4x + 70 - 0.7 = 49$$

$$21 = 0.3x$$

$$x = 70\text{mL}$$

Substitute x in (2) to solve for y:

$$x + y = 100$$

$$70 + y = 100$$

$$y = 30\text{mL}$$

$\therefore$ 70mL of solution x and 30mL of solution y are required.

APPENDIX 29

3.4 A chemist has two concentrations of Hydrochloric acid , a 40% solution and a 70% solution. How much of each should she mix to obtain a 100 millilitres of a 49% solution? (3)

$\cancel{2(40x)} + \cancel{70x}$

$40x + 70y = 49\%$

$x + y = 100$

$y = 100 - x$

$40x + 70(100 - x) = 49$

$40x + 700 - 70x = 49$

$-30x = 49 - 700$

$\frac{-30x}{-30} = \frac{-651}{-30}$

$x = 21{,}7\%$

21,7 % Should be mixed to get 49% Solution.

1

APPENDIX 30

3.2 Solve for x and y

$3x-2y=-9$ - - - ①

$2x+6y=5$ - - - ② (3)

$\frac{\cancel{3}x}{\cancel{3}} = \frac{-9}{3} + \frac{2y}{3}$

$x = -3 + \frac{2}{3}y$ - - - ③

Subst ③ into ②

$2(-3+\frac{2}{3}y)+6y=5$

$-6+\frac{4}{3}y+6y=5$

$\frac{22}{3}y=5+6$

$\frac{22}{3}y = 11$

$y=\frac{3}{2}$

$x=-3+\frac{2}{3}(\frac{3}{2})$

$=-3+1$

$x=-2$

$\underline{3}$

APPENDIX 31

1. The sum of three consecutive natural numbers is 63. Find the largest of these numbers.

2. The length of a rectangle is twice its breadth, while the perimeter measures 6m.Find the length and breath of the rectangle.

3. A boy hikes 41 km. in 9 hours. For the first part of the hike he walks 4 km/hr. and walks 5 km/hr for the rest of the hike. How long did he walk at 4 km/hr and how long at 5 km/hr.?

4. Joseph is 6years older than his sister Amanda .In 3 years, he will be twice her age. What are their present ages?

5. Tickets to a circus cost R2 and R3 each. If 250 tickets were sold and R550was collected, determine how many R2 tickets and how many R3 tickets were sold.

6. A number consists of two digits and is such that when the number is divided by the units digit the answer is 3. If the digits are reversed the new number exceeds the original number by 36.what is the original number?

7. Peter and Paul start cycling towards each other along a straight road. They are initially 20 km apart. Peter cycles at 15 km /hr and Paul at 20 km/hr. How far will Peter have cycled when they meet?

8. Two tanks are being filled with water. Tank A contains 100 litres when the valve is opened and water is allowed in at the rate of 20 l/min. Tank B is empty when the valve is opened (simultaneously with that of tank A) and water flows in at 45 l/min. Determine how long will it take for the two tanks to contain equal volumes of water?

9. A 2 litre bottle of cooldrink cost R9 , while a 1.25 litre bottle cost R5. What is the % savings by purchasing the cheaper product?

10. If a teacher gives three exercise books to each pupil in his class then he has 44 left. But if he gives each pupil four exercise books then he has 3 left. How many exercise books did the teacher have?

11. The population of a country is 20 million. 60% of the population is 25 years of age or younger. The number of people in that country over 25 years of age is?

12. In 1995 Mrs. Mahlangu is 45 years old and her son is 17. In which year will Mrs . Mahlangu 's age be double hers son age ?

13. A café owner started selling a new line of ice cream. After a short period of time he calculated that the average number of these ice creams he sold per day was 33 exactly. The next day, Friday, he sold 40 ice creams which increased his average to 34. How many ice creams must he sell on Saturday to increase his average to 35?

15.1 A bug starts at one vertex and crawls along the edges of a unit cube. It never crawls along the same edge more than once. The longest journey the bug can make consists of?

(*Foundation Mathematics*, Semester 1, 2011: 24)

APPENDIX 32

Observation of Foundation Biology Lesson (Student Group A)

Date: 17 August 2011

Topic: *Scientific Method for Laboratory Practical: Yeast metabolism*

Lisha (DS): Hi students, today we are going to do an experiment with yeast.

Lisha: Okay, we have been talking about the ... er scientific method so far. You need To know the scientific method to do this experiment with yeast today. Right, can anyone recall what we said about the scientific method?

Wiseman*: We must ask questions.

Lisha: Yes, but what is it we ask questions on?

Fortunate: What we can observe.

Lisha: Absolutely, what we can 'observe' or 'see'. Now why are these questions needed? (*Pause)* Come on, tell me.

Sibo: For getting the hypothesis.

Lisha: Of course! Now, can anyone explain what is an hypothesis?

Students: An educated guess.

Lisha: Correct and ... such enthusiasm, good! Now students, we test our hypothesis through experimenting. What else is essential in experimenting? Try, Siya*?

Siya: The variables.

Lisha: Most definitely. Now, variables are changing factors. We already read about the dependent and independent variables, right?

Lisha: Ok, now let's look at this background information. Patrick*, can you read this paragraph for us? *(Patrick reads)*

> One of the characteristics of living organisms is that they all show metabolic activity. You may have not realized it, but the yeast that you use to make bread rise (or to brew beer) is a type of living organism. These organisms are unicellular fungi, and are heterotrophic. When you mix a little yeast with some sugar, the yeast feeds off the sugar. As digestion (metabolism) proceeds, carbon dioxide gas and ethanol are released as by-products. The bubbles of carbon dioxide make the bread rise (and ethanol make s beer alcoholic). Like all metabolic processes, yeast metabolism is controlled and aided by enzymes. These enzymes are proteins, which have become inactive at low temperatures and denatured (destroyed) at high temperatures".

Lisha: Okay, unicellular refers to having one cell; unlike multicellular – more than one, like mushrooms. Now, what is the meaning of "heterotrophic"? *(Class is silent, Lisha urges them to attempt an answer.)*

Vuyo*: an organism that cannot make its own food.

Lisha: Very good. Now that describes yeast. You can see that it says there that the 'yeast feeds off the sugar'. And what is this?

Students: Digestion.

Lisha: An important word I need you to look at for this experiment is 'denatured', in This case it means destroyed – see, it's in brackets - not change in nature.

Observation of Foundation Biology Lesson (Student Group B)

Date: 10 May 2011
Topic: *Laboratory Practical: Mode of Life*

Lisha's brief on the practical
Lisha: Well, as you can see the marine specimens are on the work benches and you will go around and look at each – now, mode of life is information about their feeding, habitat, movement and so forth.
Lisha: For example, what do we have here?
Siya*: Octopus
Lisha: Correct. What phylum does it belong to?
A few students: Mollusca
Lisha: Yes. Mollusca. Now, you know that octopi – that's more than one, right, belong to ... what? .... Cephalopods.
Lisha: Let's talk about the anemone *(explains how this word is pronounced)* – it feeds on small ...
Lungani: fish *(pronounced as 'feesh')*
Lisha: Ja, and the sea urchin?
Lungani: algae
Lisha: Good. Algae *(writes word on board)* Algae *(explains how to pronounce the word)* and ... what else
Students *(unison):* kelp
Lisha: When we talk about mode of life, we will obviously use terms such as predator, omnivore, ... what else?
Nonsikelelo: heterotrophic
Lisha: Excellent. Somebody remembers that word from our lesson the other day.Ok, Nonsi, what does it mean
Nonsikelelo: an organism that can't make its own food
Lisha: Good, now, these are what you need to think about as you examine these specimens.

* Students' names have been changed.

APPENDIX 33

Organic	chemical compounds that contain carbon molecules (and usually hydrogen and oxygen), molecules found in biological material are organic.
Ossicle	small unit of echinoderm endoskeleton made out of chalky material
Parasite	organism living on or in, and feeding off, another organism, much larger than itself
Pelagic	found in the open ocean (not on the surface or at the bottom)
Pentamerous	having five parts
Phytoplankton	unicellular algae (protist), major producer in marine environment
Polyp	body form with tentacles facing upwards (like sea anemone)
Population	group of interbreeding individuals of the same species
Predator	organism that actively hunts and kills live prey
Prokaryote	unicellular organism that does not have true nucleus or membrane bound organelles (bacteria)
Protist	organism (could be unicellular or multicellular alga or protozoan) that belongs to the Kingdom Protista
Protozoan	unicellular animal like organism belonging to the Kingdom Protista
Radially symmetrical	body plan where the body parts are arranged symmetrically around a central axis (body can be divided in any direction to give two equal parts that are mirror images of each other).
Saprotroph	decomposer/ an organism that feeds on dead material and causes it to decay (by secreting enzymes onto material and absorbing digested nutrients) e.g. fungi and bacteria.
Scavenger	animal that feeds on dead organisms (they do not hunt and kill prey).
Sedentary	capable of moving slowly
Sedimentary cycle	the recycling of nutrients through slow geological processes (weathering and erosion etc).
Sedimentary rock	rock formed by many layers of sediments compacting one on top of the other
Sessile	firmly attached to surface/ not mobile
Species	type of organism; groups of similar individuals that can interbreed.
Specimen	a particular example of something (a particular organism or part thereof).
Sustainable	able to continue indefinitely
Taxon-	classification category
Terrestrial	lives/found on land (opposite of aquatic)
Tertiary consumer	consumer that feeds on carnivores
Tissue differentiation	different types of tissues which have distinctly different structures and which perform different functions.
Vegetarian	person who only eats vegetables, grain, nuts and fruit (and eggs and dairy products, although some may not eat these either).
Ventral	lower part of the body
Viable	capable of living
Visceral	refers to interior of body (organs in the main body cavity)
Vitamin	organic compound that is needed for growth and metabolism

(*Foundation Biology*: Semester 1: 2011: 5)

APPENDIX 34

3. The evolution of autotrophic organisms

As the numbers of heterotrophic bacteria increased, competition for food i.e. for free organic molecules also increased. Under pressure of this competition, organisms that could access new energy sources had a better chance of survival.

Experimental evidence shows that the part of a chlorophyll molecule which traps light energy is easily assembled from formaldehyde – a compound which was freely available to early prokaryotic cells. About 3.2 billion years ago, these light-trapping pigments and other metabolic machinery began to evolve in some anaerobic Eubacteria.

By 2.5 billion years ago, the full photosynthetic pathway was well established. These cells could make their own energy-rich molecules out of simple non-organic materials, releasing oxygen as a by-product. The first **photosynthetic, autotrophic** organisms had evolved.

Sunlight, an unlimited source of energy, had been tapped. For nearly two billion years, photosynthetic descendents of these cells dominated the living world.

Consequences of the evolution of photosynthesis

$CO_2 + H_2O$ + radiant energy → $C_6H_{12}O_6$ and O_2

The evolution of photosynthesis had far reaching effects, moulding the course of evolution and shaping the future of life on the planet.

Firstly, with the arrival of autotrophs, **the flow of energy** in the biosphere took on a modern, familiar form: radiant energy is channelled through the photosynthetic autotrophs to all other forms of life.

Secondly, oxygen is released as a by-product of photosynthesis. Over millions of years, the amount of **oxygen gas (O_2) in the atmosphere steadily increased**. This had three very significant effects:

Draw a simple diagram to summarise the ideas on the origins of the eukaryotes by endosymbiosis and enfolding of the cell membrane.

a. Some of these oxygen molecules were **converted into ozone (O_3)**. Ozone is responsible for filtering the destructive ultra-violet rays out of sunlight. This protected organisms from ultra-violet rays so that they could survive in the surface layers of water and on the land.

b. An increase in free oxygen resulted in the evolution of **new metabolic pathways** which enhanced the efficiency of organisms. Until now, all bacteria had relied on anaerobic metabolism to produce useable energy from food molecules. This is not a very efficient process, and produces only limited amounts of energy. With the availability of free oxygen, **respiration** evolved in some organisms. This allowed them to oxidise food molecules to release significantly larger amounts of useable energy in the form of ATP. By producing a more efficient metabolism, the process of respiration opened the door for the evolution of larger and more complex life forms.

c. An oxygen-rich atmosphere **stopped any further spontaneous origin** of organic molecules or living cells.

Explain in your own words why there is so much concern about the depletion of ozone from the atmosphere in recent years.

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Explain in your own words why respiration made organisms more efficient.

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4. The evolution of eukaryotic cells

Before the atmosphere became aerobic (with free O_2), the only cells that existed were **prokaryotic**. Prokaryotic fossils can be found in sediments well over 3 billion years old, whereas the earliest known eukaryotic fossils date back only 1.5 billion years ago.

Eukaryotic cells are larger and more structurally complex than prokaryotic cells. Their metabolic activities are compartmentalised, which means that different reactions are separated from one another in specialized **membrane-bound organelle**s. They have a **true nucleus**, which means that their genetic material is separated from the activities of the cytoplasm by a membranous nuclear envelope. This high degree of organisation means that eukaryotic cells can be relatively large and complex, while still being very efficient. Four of the six kingdoms of life comprise organisms made of eukaryotic cells. The efficiency and

(*Foundation Biology*, Semester 1, 2011: 7, 83-84)

APPENDIX 35

An investigation into the effect of smoking on lung capacity

Abstract
The lung capacity of male students was investigated to determine whether short-term smoking has any effect on the elasticity of the lungs. The vital capacity of subjects was determined by measuring the tidal volume, inspiratory reserve volume and the expiratory reserve volume of their lungs. It was found that smokers had a lung capacity on average 872 ml less than that of the non-smokers. This difference indicates that evidence of lung deterioration can be detected after 2-3 years of smoking.

Introduction
The long-term effects of cigarette smoking on the body are many and varied. For example, it is known that smoking reduces the ability of blood to carry oxygen, increases blood pressure, increases the risk of heart attack and cancer and suppresses the immune system.

Smoking also affects the lungs by building up tars within the lung membranes. When cells begin to digest the tars, they may also digest the cell membranes themselves. This often results in emphysema, a disease characterised by the breakdown of the walls of the alveoli and a loss of elasticity in the lung tissue (Helms *et al*., 1998). The result is a loss of lung capacity which means that people with advanced emphysema struggle to inhale and exhale properly.

However lungs deteriorate very slowly and a reduction in lung capacity is noticeable long before people become ill with full emphysema. If one could show short-term smokers that they already have a reduced lung capacity, this might help them to drop the habit before it becomes life-threatening. This investigation was therefore done to determine whether smoking has an affect on the lung capacity of first-year students who have been regular smokers for less than 4 years. The null hypothesis was that there would be no difference in the lung capacities of smokers and non-smokers.

Materials and Methods
Four smokers and four non-smokers in the 2007 Foundation Biology class were identified. They were all males between the ages of 17 and 20 years; between 165cm and 180cm in height; and in good general health. The smokers had all been smoking regularly for 2-3 years.

During one afternoon practical session, these students were asked to exhale into a lung capacity meter (serial number 700245; manufactured by Bazer)

Centre for Science Access
Foundation Biology

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Title: ROOT GROWTH AS A FUNCTION OF MOISTURE

Abstract

The purpose of this investigation is to determine whether the amount of moisture available to seeds affected the rate of seedling growth as measured by root length. Zea mays seeds were subjected to three different moisture levels and their roots were measured after one week. Seeds given 7.5 ml and 15 ml of water appeared to grow faster than those given 3 ml of water, but there was very little difference between seeds given 7.5 ml and 15 ml of water. There may be an optimum level or range of moisture for seed growth.

Introduction

Research findings indicate that pea seeds germinate and grow at a faster rate (measured as root length) when provided weekly with 15ml of water as opposed to 5 ml of water (Smith, 1897). My hypothesis, constructed from previous observations and information, is that other cultivated seeds germinate and grow faster when moisture is provided in greater quantities. Corn, chosen as a representative cultivated crop will be used to test this hypothesis. Root growth is considered a reliable indicator of seedling growth. I predict that corn seedlings given more water will have longer roots. The results of this study should contribute to our knowledge about corn and its requirements for growth.

Materials and methods

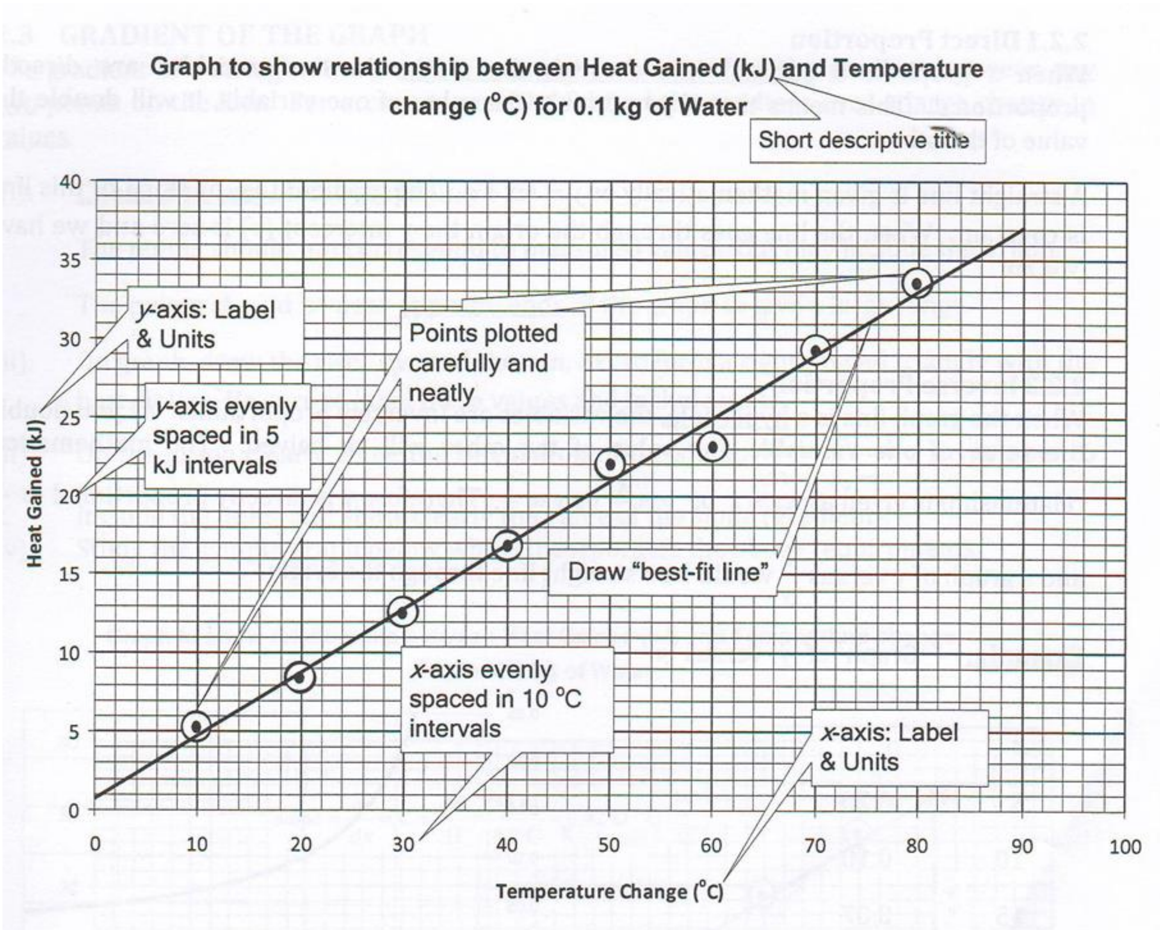
Choose corn seeds randomly and treat them with three different moisture levels in Petri dishes containing absorbent filter paper. Three groups of eight corn seeds each received total quantities of 3 ml, 7.5 ml or 15 ml of water, measured using a graduated measuring cylinder, over a period of one week. The Petri dishes were covered and placed in the same growth chamber so that all conditions other than moisture level were identical for the three groups of seeds. We grew all the seeds at 32°C. All seeds were watered at the same time. After one week, the length of the longest root of each seedling was measured using a metric ruler. Group means were calculated.

Results

The mean root lengths for the three groups of seedlings grown at different moisture levels are shown in Table 1. The mean root length of seedlings provided with 15 ml of water was greater than the mean for those given 3 ml of water. Similarly the mean root length of seedlings that received 7.5 ml of water was greater than the mean for those that

(*Foundation Biology*, Semester 2, 2011: 47)

APPENDIX 36



(*Foundation Physics*, Semester 1, 2011: 9)

APPENDIX 37

Poster: Assessment Grid

	Content (50%)	Visual aspects & organisation (20%)	Language (15%)	Referencing & use of sources (15%)
≥ 75 %	Title is descriptive, innovative, accurate and specific. Sustainability and recycling are clearly defined in scientific terms; accurate, specific, detailed. Shows clear understanding of nutrient recycling in nature Shows how humans can learn to recycle from nature Discusses an example of recycling in context of human environment Relates processes above to conservation ethic / sustainable living, i.e. good integration of theory and practice Evidence of integrated independent research beyond the bare minimum requirements set out in topic (i.e. more than 4 references, and those independently sourced of high standard)	Material logically organised into sections. Information presented in a way which flows. Appropriate and visible font sizes chosen. Illustrations, diagrams, pictures appropriately linked to text. Balance between pictures and text. No excessive "white space".	Expression is very good. Almost no grammatical or spelling errors. Full sentences. Poster is written in a voice attempting to be objective rather than subjective.	All citations are correct. Reference list is correct. Paraphrasing and quotations clearly differentiated and correct.
70- 74 %	Descriptive title both accurate and specific. Sustainability and recycling are defined in scientific terms; accurate, specific, detailed. Shows clear understanding of nutrient recycling in nature Shows how humans can learn to recycle from nature Outlines an example of recycling in human context Relates processes above to conservation ethic / sustainable living i.e. some integration of theory and practice Evidence of independent research beyond the bare minimum requirements set out in topic (i.e. more than 4 references, and those independently sourced relevant to topic	Material organised into sections. Information presented in a way which flows. Appropriate and visible font sizes chosen. Illustrations, diagrams, pictures appropriately linked to text. Balance between pictures and text. No excessive "white space".	Expression is good. Few grammatical or spelling errors. Full sentences. Poster is mostly written in a voice attempting to be objective rather than subjective.	Most citations are correct. Reference list is correct. Paraphrasing correctly done.
60-69 %	Descriptive title which attempts to be accurate and specific. Sustainability and recycling are clearly defined in scientific terms.	Material mostly organised into labeled sections. Information mostly flows logically.	Some grammatical or spelling errors. Predominantly full sentences.	Most citations where expected and are correct. References in list and the format are

	Shows understanding of nutrient recycling in nature Shows how humans can learn to recycle from nature Refers to example(s) of recycling in human context Functional link between processes above to conservation ethic / sustainable living i.e. little integration of theory and practice Evidence of independent research requirements set out in topic i.e. at least 4 references	Appropriate and visible font sizes chosen though some lapses may occur. Illustrations, diagrams, pictures appropriately not always clearly linked to text. Balance between pictures and text could be improved. May be some "white space".	Poster grapples with writing in a voice attempting to be objective, but minor slips into subjective.	largely correct; minor errors. Minor instances where a phrase echoes original.
50-59 %	Title has some or all keywords but not specific (often vague) Clear attempts to define sustainability and recycling but lacks accuracy, specificity and detail. Gestures at understanding of nutrient recycling in nature Some reference to how humans can recycle Gestures at example of recycling in human context Inadequately relates processes above to conservation ethic / sustainable living i.e. almost no integration of theory and practice Bare minimum of independent research done i.e. 4 references but scant references to independent sources	Material not always set out in labeled sections. Information sometimes does not flow logically. Appropriate and visible font sizes chosen though several lapses may occur. Illustrations, diagrams, pictures appropriately not clearly linked to text. Little balance between pictures and text. May be some "white space".	May be a lot of grammatical or spelling errors and some incomplete sentences Marked by significant lapses out of objective description into subjective reportage. Shifts between tenses.	Reference list and the format may be wrong. Citations may be incorrect in placement or format. May be instances where wording is close to original (in marks at the lower 50s)
40-49 %	No title / Incorrect title. Sustainability and recycling are not defined in scientific terms. Cannot distinguish between / conflates human and natural recycling. Focuses on human recycling or natural recycling without reference to the other or without any link whatsoever. No relation to conservation ethic; no outline of the reason for sustainability or recycling. i.e. no integration of theory and practice No independent research; no evidence of using a print source not in the manual.	Material not organised into labeled sections. Information flow illogical. Inappropriate and font sizes chosen. Illustrations, diagrams, pictures appropriately unrelated to text. No balance between pictures and text. Excessive "white space".	Grammar / spelling may interfere with meaning. Incomplete sentences. May fail to use passive past in Method. Extensive use of subjective reportage rather than objective description and analysis; no full grasp of scientific academic writing register.	Reference list but its wrong or very few references. Citations may be incorrect or very few. Many instances where wording is too close to original
<40 %	No title No understanding of recycling or sustainability. Significant information has been omitted. Irrelevant information. No understanding of conservation ethic. Link between examples and discussion unclear or tenuous.	Almost all the Info in wrong sections. Muddled and illogical.	Grammar / spelling may interfere with meaning. Incomplete sentences. Almost no attempt at objectivity in the writing.	No citations No reference list No distinction between the student's voice and the voices of other writers: muddled about citation and referencing but attempts clearly notable.
0 %	Extensive plagiarism: Sentences have been copied directly from other texts. No attempt t come to terms with the content of the report or the science which informs the field work.			