STUDENT DISCOURSE IN A NATURAL SCIENCE CLASSROOM: *A CASE STUDY OF HIGH SCHOOL TEACHING IN SWAZILAND*

by

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submitted in accordance with the requirements

for the degree of

Master of Education with specialisation in Natural Science Education

at the

University of South Africa

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July 2012

DECLARATION

Student number: 3346-631-9

I declare that this dissertation, **"Student Discourse in a Natural Science Classroom: *A Case Study of High School Teaching in Swaziland*"**, represents my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

------------------------------------ NOVEMBER 2012

VF Sitsebe (Mr.)

Acknowledgements

The successful completion of this dissertation of limited scope would have been impossible without the support and assistance of the following dedicated and wonderful people:

- Firstly, I would like to thank God for His strength and wisdom which enabled me to persevere even when things seemed impossible, became stressful and difficult.

- I also wish to thank my supervisor, Professor LC Jita, for his support, advice and encouragement throughout the course of this study. I am grateful for his willingness to help in reviewing drafts of each chapter of this dissertation and also for developing me academically.

- I am also highly appreciative of the help from Mrs Van der Watt of the College of Human Sciences, University of South Africa. You truly have been a source of hope and strength to me.

- I am also greatly indebted to the Headteacher, Mathematics/Science teachers and students of the school at which the research was carried out, for without their cooperation this study would not have been possible.

- Finally, I would like to express my sincere appreciation and gratitude to my family for their patience and understanding throughout the course of this study.

- Lastly, once more, all honour, glory, might and majesty be to God!

Summary of the Study

Title:

"Student Discourse in a Natural Science Classroom: *A Case Study of High School Teaching in Swaziland"*

The aim of the study was to investigate classroom discourse among high school natural science students in Swaziland.

The research problem was:

Can student interactions tell us something about the negotiation of understanding during natural science teaching?

A qualitative approach was used, specifically, the observational case study style. The population comprised three Form 4 students and their natural science teacher, purposely selected. Data was collected using the non-participant observation and the standardised open-ended interview methods.

The collected data was analysed using the discourse analysis approach. The analysed data indicated that prevailing discourse patterns were teacher and student talk, as well as written work.

A conclusion was that student classroom discourse in the natural sciences should be encouraged among all students for improved understanding and meaning making.

Key terms: Student classroom discourse; natural sciences; everyday science talk; classroom science talk; observational case study; non-participant observation; standardised open-ended interviews.

Students Informed Consent and Assent Form

My name is Vusi Sitsebe, and I am conducting a research study for a Masters degree in Education at the University of South Africa (UNISA). My research topic is: ***Student discourse in a natural science classroom: A case study of high school teaching in Swaziland.*** The study seeks to understand how and why students talk during the science lessons in Swaziland. I also want to understand what the students talk about and how it is important to them during the lessons. To understand this, I shall observe five science lessons, and observe how students (and their teacher) talk about science during these lessons. Three students shall then be selected for further interviews about their talk during the lessons. The science teacher will also be interviewed about student talk in general during the science lessons.

You have been selected to be part of this study. I wish to observe and document your interactions and talk during the science lessons. I shall bring a voice recorder to help me capture the voices of all the participants during the lessons. After each lesson, I wish to interview all participants, for not more than 30 minutes, about their talk during the class. You, the participants will have access to the transcripts and will be allowed to give your comments and will be allowed to give your comments on these. The study is fully financed by the researcher.

Your identity, as a participant in this study, will remain confidential and no names of schools or participants shall be used in any reports about this study. Only myself and my supervisor at UNISA shall have access to the transcripts and notes for this study. You are free to participate or to withdraw your participation at any time during the study. You may choose not to answer some of the questions during the interviews should you wish.

The study is very important to understand how Swazi students talk about science in their classrooms. It will help to improve the teaching and learning of science in the country. Your participation is therefore important to me. If you have any questions, comments, and/or suggestions, please feel free to contact me at Ntfonjeni High School, where I work or call me at 24371186. My supervisor at UNISA is Prof LC Jita and he can also be reached at +27 (12) 429-4840.

By signing this form, you the student, agree to participate in the study and give permission to the researcher to use the information in the dissertation and other publications, as well as at conferences.

Signed:__________________________ __________________________

Participant Researcher

Date:____________________________ __________________________

I, the parent/guardian of the above-mentioned student, understand the contents of the study as described by Mr. VF Sitsebe in this letter. I also consent to my child's participation in the research project.

Signed:___________________________Date:____________________________

TABLE OF CONTENTS

CHAPTER ONE

OVERVIEW OF THE STUDY

CHAPTER TWO

LITERATURE REVIEW

CHAPTER THREE

RESEARCH METHODOLOGY AND STUDY DESIGN

CHAPTER FOUR

FINDINGS OF THE STUDY

CHAPTER FIVE

DISCUSSION, LIMITATIONS OF THE STUDY, ASPECTS OF FUTURE RESEARCH, RECOMMENDATIONS AND CONCLUSION

STUDENT DISCOURSE IN A NATURAL SCIENCE CLASSROOM: a case study of high school teaching in Swaziland.

CHAPTER ONE

Introduction, Background and Statement of the Problem

1.1 Introduction

Swaziland students usually do not talk much in class. This is especially so in formal natural sciences classes. This could be partly because of the authoritative teaching approach some teachers use at school (Hodson 1992). Swazi culture, in general, tends to discourage student talk in class unless directed by an adult. Vibrant student talk during natural science lessons may also be curtailed by adolescence, lack of content mastery and the use of English (a foreign language) in teaching natural science. However, for learning to occur students need to interact with each other, the teacher and the content. Many science activities require students to talk together during natural sciences lessons. If student discussion is significant for learning, then it is valuable for researchers to understand how students talk to each other during the natural sciences lessons. To understand specifically why they talk, to whom, about what and what exactly they say researchers need to understand the conditions prevailing when students do so. How do students themselves think about such conversation, about natural sciences, natural sciences teachers and teaching, talking about natural sciences in class and out of class?

To answer some of the questions above, I have undertaken a small-scale research project on student discourse in a natural science classroom. Such a research project is relevant since the Ministry of Education and Training (MoET) in Swaziland has introduced a learner-centred and context-based approach to the teaching of science at school. The approach engages pupils in textual and experiential enquiry; and is considered discourse enabling. It encourages pupils to read, write and discuss; as well as investigate natural phenomena scientifically. Moje et al (2001) define discourse as a way of knowing, doing, talking, reading and writing. It is what a student draws on to talk about, write about and represent knowledge (Gomez 2007).

For this study I adapted both definitions as I was interested in studying the discourse natural science students and teachers draw on during natural science lessons and the meaning they give to such communication. Since several discourses can be operational at the same time during any one natural science lesson, I concentrated on disciplinary (content area), classroom (instructional and interactional) and everyday (social) discourses. So, student discourse in a natural science classroom refers to the ways in which the students try to make meaning of science concepts and activities, as well as the funds of prior knowledge (either everyday or academic) they draw from as they interact with the natural science teacher and the science content.

Student discourse in a natural science classroom involves reading, writing and communicating science (Osborne 2002). By natural science classroom, I refer to a room where a science subject such chemistry, physics, and/or biology is taught or learnt. Student discourse in a natural science classroom was chosen to use as the lens for focusing at the movement between everyday knowledge and acquired classroom science knowledge. Students learn science in complex environments and also bring with them multiple ways of understanding and talking. Teachers also draw from multiple discourses to frame, explain and describe concepts and phenomena (Gomez 2007). They even use information from other disciplines in addition to everyday ways of explaining the world. They teach each science discipline according to the norms that distinguish it from other science disciplines. To successfully teach each discipline teachers need to use the appropriate science discourse resources and formations (ibid. 43). The resources are the vocabulary used in communicating ways of understanding a phenomenon, while the formations are ways of behaving, talking or gesturing in the different learning areas. Gestures are an important and integral part of science discourse as they link hands-on activities with science discourse (Roth & Welzel 2001).

In this study, I observed patterns of student discourse in a natural science classroom so as to gain understanding of how students engage with the subject in general. This research on student interaction in a natural science classroom is, of course, not the first one as Von Aufschnaiter et al (2008) state that research on student discourse had already started in the 1990s. Other researchers have in the past studied science discourse observing a specific aspect, such as classroom discussion, as a tool to enhance formative assessment and practice in science (Anderson, Zuiker, Taasoobshirazi & Hickey 2007); the potential co-construction of student identity and scientific literacy (Brown, Reveles & Kelly 2005);word understanding in physics (Farrell & Ventura 1998); the analytic and theoretical discussion of student discourse during a science fair presentation (Gomez 2007), and many others. This study is different, however, in that it is about how students talk and engage with each other, with their teacher and with the subject matter during natural sciences within the specific cultural context of Swaziland. It was also critical for me to understand what the content and context of these conversations are in the science classrooms of Swaziland. Studying discourse in a natural science classroom has enabled me to propose informed intervention strategies that encourage students to talk more and engage during natural sciences lessons in schools. Student talk during natural sciences lessons is crucial as it provides an interactive medium for exploring and knowing the world scientifically (Anderson et al 2007). It forms a basis for learning and is integral to meaning making.

1.2 Motivation for the research

The interest to study communicative interactions in a natural science class arose from a number of factors that affect the teaching and learning process in science in my school and most other high schools in Swaziland. These are factors like the persistent shortage of properly qualified teachers in science, and the general understanding that high school science is difficult. In my school our science laboratories (3) are well equipped, but the pass percentage of students in the sciences is not as high as we expect it to be. One then begins to wonder about the contributing factors. Could it be the teachers' qualifications? The fact that many teachers of science in Swaziland are diploma holders (qualified to teach science at the junior level) instead of degree holders may be an issue. However, there have been many cases where such diploma holders have produced very good results with students. This observation concurs with that of Goldhaber and Brewer (2000) wherein they concluded that there was no strong evidence that teacher certification in mathematics and science was systematically related to student achievement. Pondering further, could it be the kinds of interactions and communication that occur during natural sciences lessons? In other words, it is essential to get inside these natural sciences classrooms and understand what is happening and how students are engaging with each other, the teacher and with the subject matter. It is some of these concerns that triggered my interest to study the way high school students read, write and communicate during natural sciences lessons. A study on classroom discourse will be beneficial to the Ministry of Education and Training, and to other high school teachers in Swaziland and elsewhere, by revealing in some detail how students make meaning of the science content.

1.3 Research problem, aims and objectives of the research

The key research problem for this study was to understand how high school students communicated with the teacher, with each other and with the subject matter during natural science teaching. The aim of the research was to investigate how high school students communicated during the teaching and learning process in Swaziland schools. I wished to study student discourse specifically in a natural science classroom, as a way of understanding further those student interactions with science in the context of Swaziland. The main objective was to bring vibrant learning within the natural science classroom.

1.3.1 Statement of the problem

It had been my observation, as a natural science teacher, that over the years many students in my school did not achieve an acceptable level of success (credit pass) in the sciences. That would happen despite the three well-equipped science laboratories at the school. Students often complained that the natural sciences were too difficult for them to cope with. Was it that those students were unsuccessful at the sciences because they did not engage in vibrant talk during science lessons? Much of my reading on this topic suggested that students need to be active participants in lessons for them to gain understanding and thus success. The observation of students communicating reticently – in most Swaziland classrooms during natural sciences lessons – gave rise to the idea of proposing a study on the topic. I seriously needed to get into a natural science classroom and observe student engagement with the subject content and with the natural sciences teacher. The study grew out of the desire to suggest informed intervention strategies that encourage students to actively participate in natural sciences classrooms in Swaziland and elsewhere. The problem for the research could thus be stated as: Can student discourse tell us something about the negotiation of meaning and understanding during natural sciences teaching?

The research problem revolved around the conversations that occurred during natural science learning at high school. The research questions arising from the problem were:

(a) What characterises student discourse in a natural science classroom in some schools in Swaziland?

In this question I wished to breakdown student discourses within the natural science classroom in Swaziland. I wished to know in more specific terms who talked during class-time, to whom and about what. What was the content and nature (for instance, responses to teachers' open ended questions, students' questions to each other and so on) of those conversations?

(b) What is the meaning and role of such student discourse within the context of the natural science classroom?

In this question I wished to understand what students thought of the classroom discourse and its relevance for their learning of the subject matter. I was interested in exploring what the teachers thought of student discourse in their classrooms, and their own (and students') role in creating and sustaining such classroom discourse in the natural sciences.

(c) How can the observed student discourses and meanings be understood and explained?

1.3.2 Aims and objectives of the research

The aims of the research were to:

- create a scheme that described the various kinds of student discourse in the natural sciences classrooms of Swaziland;
- describe the content of such student discourse;
- understand how students and teachers in Swaziland schools interacted with each other through discourse;
- understand the meaning of such discourse to those participating in such discourse;

- venture an account of why the discourse was the way it was and what were the implications for the teaching and learning of natural sciences in Swaziland and elsewhere; and
- suggest informed intervention strategies that would encourage student discussion in the natural sciences classrooms.

The objectives of the research were to:

- observe classroom discourse in several natural science lessons in a Swazi classroom;
- conduct interviews with the teacher and learners about classroom discourse;
- review relevant literature on classroom discourse in natural sciences;
- document teacher's and learners' experiences of classroom discourse in Swaziland.

1.4 Contribution of the research

This research contributes to existing knowledge on student conversation during natural science lessons by specifically researching how Swazi students talk and engage with each other during natural sciences lessons. It will help anyone who may wish to teach natural sciences at high school in Swaziland gain understanding of what to expect from the students. Swazi students (and others elsewhere) on reading this research may get to understand the problems of restrained classroom talk and improve their spoken interactions during natural sciences lessons. The Ministry of Education and Training may also organise workshops to suggest teaching strategies and methods teachers may use to encourage student talk during natural sciences lessons. The research was aimed at expanding the theoretical foundation of education, as well as education practice. This study reveals how Swazi students make meaning of the natural sciences content. From a deeper knowledge of student discourse, natural sciences teachers may then be able to produce teaching strategies and methods that are better able to match the students' learning styles and encourage students' spoken participation in class.

1.5 Chapter demarcation

Chapter 1: Introduction

In chapter one I cover an introduction to the investigation. The introduction states what the research is all about and why it was undertaken. The researcher is convinced that the study is topical and valuable along with the benefits stated. The aims and research questions for the investigation are stated. Important concepts covered in the research are explained in this chapter.

Chapter 2: Literature review

This chapter is only for the review of relevant literature. It begins with an overview of how the literature is structured. The literature reviewed includes what has already been done on the subject and to what extent and success. Sources of the literature on classroom discourse in the natural sciences are cited. Chapter 2, then, provides a background for the study.

Chapter 3: Research method and design

In the third chapter the researcher explains the research method and design. The study is qualitative and the style of research is a case study. The chapter also contains the sampling method (purposive sampling) and the data collection strategies.

Chapter 4: Research results, data analysis and discussion

> Discussed under this section on results are the data. Chapter 4 presents the results of the study, analyses them using the discourse analysis approach. They are then discussed.

Chapter 5: Conclusions, limitations of the study, and recommendations

> Conclusions are drawn from the analysed data. The limitations of the study specify its scope and confinements. Recommendations are made with regard to similar future research.

1.6 Summary

This chapter discusses the background information about the study. It also includes the motivation for the study, as well as the problem statement. The aims and objectives of the research are also stated here. The contribution of the study to the body of research is also given, together with concept clarification. Three research questions arising from the problem statement are also stated in this chapter. The chapter closes by giving a demarcation of every chapter.

CHAPTER TWO

Literature Review

2.1 Overview of the literature reviewed

In this section I begin by briefly discussing the development of social skills of students in the course of natural sciences lessons. A subsection on student discourses follows whereby emphasis is given to student discourse in a natural science classroom. A subsection on language, identity and science then follows. In this subsection language problems encountered by high school Swazi students during natural sciences lessons are discussed. The identity students have to acquire during natural sciences lessons is also discussed, with an emphasis on scientific identity. The last subsection covers the conceptual framework for the study. The conceptual framework is divided into three parts, namely, social constructivism; classroom discourse; resources and formations.

2.2 Literature reviewed

Classroom science involves many social activities that demand certain social skills from students. Teachers then have the task of developing some of these social skills in their students. These social skills may be part of student discourse in a natural science classroom. A literature review on the development of social skills in students through natural sciences follows.

2.2.1 Social skills development in natural sciences lessons

Social skills acquisition is essential to every student for effective communication in the natural science classroom. The skills help in social interactions during learning (Andersone 2004). In natural sciences we are taught to understand ourselves, other organisms we live and interact with, as well as our environment and the whole universe. Social skills acquisition is essential for self-assessment and personal development of students so that they may understand and live in harmony with their environment. Communication is part of classroom discourse and embraces relationships among students and between them and their teacher, and as well as their environment (which may be their classroom or their natural science laboratory). Social skills include mutual communication, skills to work and co-operate in a team, a creative attitude towards work and striving for quality (ibid.).

While working in groups social skills assist natural science students cope with discourse patterns such as argumentation, discussion and explanation. Collaborative learning also aids natural science students develop these discourse patterns and master them. They are mechanisms which enable natural science students to construct meaning during collaborative group work. According to studies cited by Green (2007), giving and / or receiving explanations enhances learning. Engaging in such interactions benefits the learner/explainer in several ways such as: detecting and repairing gaps in their own knowledge; detection of discrepancies between everyday knowledge and scientific knowledge; the explainer may be encouraged to use simpler and more familiar words, as well as generate and link examples to prior knowledge; and lastly, discussion exposes the students to new ideas which they may assimilate to extend their understanding or develop new knowledge. In a natural science lesson an explanation of the behaviour of radioactive substances may turn into a heated debate when discussing, for instance, sites for dumping harmful waste.

Debating is the backbone of science and natural science students have to develop the social skills of engaging in controlled argument. They have to learn, in addition to defending and declaring their stand, challenging other's positions. When natural science learners engage in debate their conceptual understanding is enhanced. Such arguments are good for science and the critical evaluation of whatever discovery or invention is being debated. Students need to know the subject content for effective argument as well as the context in which argument is permitted and encouraged. Controlled argumentation is a good interactional social skill for natural science students because: it enables them to make their ideas explicit; encourages learners to search for new knowledge and ways of convincing others; and allows learners to make fine conceptual distinctions in the subject domain. Such arguments were some of the discourse patterns I looked for during the data collection stage of this research. Green (2007) describes four types of argument statements:

a) Claims - assertions or conclusions whose merits are to be established.
b) Grounds - facts that are appealed to in support of the claim.
c) Warrants - reasons justifying the connection between particular data and the knowledge claim.
d) Backings - basic assumptions that provide the justification for particular warrants.

Social skills help students learn to appreciate group results and their group mates' individual success, even though teenagers tend to appropriate individual performance as a means of expressing adulthood and self-independence (Andersone 2004). By team/group work is meant the contribution by each student towards the achievement of a common result, not a situation where students work as a group/team and have their individual tasks. Examples of teaching strategies that utilise social interactions are peer tutoring, co-operative learning and peer collaboration (Lumpe & Staver 1995). Peer tutoring is a situation where a more experienced peer academically assists a less experienced peer. In co-operative learning students are assigned to groups in which they work to reach a common goal. The third teaching strategy (peer collaboration) involves peers working together to solve problems they may not have been able to solve alone, and is good for teaching highly cognitive concepts. These teaching strategies enable learners to develop social skills and also act as motivational tools for learners through sharing ideas, seeking a consensus and remaining open to new insights. They also help learners achieve good results as they have been found to enhance physical science concept development (ibid. 74). Students also learn to consider other members' points of view, to give commands and to conform to them, as well as to be responsible for others in the group. In a co-operative group members who are academically handicapped are not ignored by their peers but are helped to achieve better than when they work individually. This is because in co-operative conditions students perceive greater peer academic support, less competition, and greater disagreement and conflict than in individualistic conditions (Johnson et al 1985). Academic controversy increases motivation and achievement among students through constructive arguments and explanations when they attempt to validate opposing hypotheses.

Students can acquire social skills from natural science books as well as through conversations and discussions with other people for better social interaction in the natural science classroom. This is all enables acquiring and understanding scientific knowledge. The social skills are important to prevent possible conflicts and disturbances between a teacher and student in a natural science class when they have to deal with different social concepts, possible prejudices and procedures and attitudes that may need to be stressed, lessened or changed. A natural science class with good social interactions will tend to encourage better learning, loyalty, co-operation and common values, which all lead to knowledge acquisition and the discovery and development of talents among students. In fact for any society to be successful, including the natural sciences society, it is important for it to uplift its social capital (loyalty, co-operation and common values) and intellectual capital (knowledge and talents). Natural sciences teachers are thus encouraged to use group and project work alongside other forms of teaching to increase the development of social skills in their students (Lumpe & Staver 1995). A project-based syllabus develops social skills in students by engaging them in textual and experiential inquiry. The approach provides both students and teachers with opportunities to investigate, read, write and talk about questions of interest to them (Moje et al 2001). The students then develop the culture of learning natural sciences through social and cultural interactions in the natural science classroom. Thus a project-based syllabus is good for natural sciences teachers to adopt since it engages all students in science learning.

2.2.2 Student discourse in a natural science classroom

Discourse is about conversation or speech events occurring within a particular socio-cultural setting (Gee, Michaels & O'Connor 1992). In the present context, the socio-cultural setting is the natural science classroom in a high school. Gee (1996) defines discourse as some connected pieces of language which, put together, make sense to some community of people. The community of people, in this case, is the teacher and students in the natural science classroom. In the natural sciences the learners are taught appropriate ways of talking about the knowledge in that subject or domain studied (Gomez 2007). When discourse is in the form of text it will include other things such as actions, objects in the environment, gestures, glances, attitudes, thoughts and values which add meaning to the text. Gestures are considered by Roth and Welzel (2001) as representations for something else; and are precursors to language rather than being an additional feature that accompanies language. So, in a natural science classroom students should be taught what to do or how to talk, read, write, interact or even appear to think, as science is a social activity. This is true even for someone engaging in a monologue since they have an imagined audience they are dialoguing with which influences their thoughts by how it behaves, sits, looks and responds during the monologue. In a natural science class the monologue may be when a student quietly reads a science textbook or writes a text.

Since students usually come from different socio-cultural settings they bring diverse and complex ways of behaving and interacting into the natural science classroom. Therefore, the way students interact in one science lesson may not necessarily predict how they interact in future natural science lessons. The way they may participate in one natural science lesson may either be in conflict with, or reinforce, other ways of behaving, talking and valuing that they have already adopted or shall adopt in other lessons. Moje et al (2001) note the importance of these diverse and complex ways of behaving, talking and valuing and call them every day or social discourses. Every day or social discourses are very necessary in the natural science lesson since they influence the ways in which natural science students take up classroom discourse. Science learning requires students to blend their everyday or social discourses with their classroom or science discourses. This is not that easy though for the novice natural science learners since the discourse of science relies heavily on themes and concepts that are not immediately reachable for them (ibid.). They need to blend their reading, writing and oral language practices with prediction, observation, analysis, summarisation and presentation in order for them to become members of the scientific discourse community. In the natural science classroom students are expected to apply previously learned basic language, literacy and technology skills to interpret, comprehend and apply scientific knowledge.

In the natural science classroom the teacher is considered by the students as a more capable peer with whom meaning is constructed through shared discourse (Rollnick 2000). The teacher mediates scientific thinking within the Zone of Proximal Development (ZPD) using scientific language to the students who are learning to talk, read and write science. The ZPD is the gap between what a pupil can do unaided by the teacher, and what the pupil can do when assisted by the teacher or a more capable peer (McCown, Driscoll & Roop 1996:44). It supports the theory of assisted learning in which meaning is developed through shared discourse between the teacher and the learner. The ZPD is necessary for this study since it emphasises social interaction for facilitating cognitive development of a pupil. It also enables teachers to determine what experiences will best assist the development of their pupils. In a natural science classroom, therefore, the teacher's role is to assist the students to reach what Vygotsky calls the ZPD through the use of scientific discourse. As students use science discourses they have to take into account its appropriateness, feasibility and correctness in a given context.

The issue of language is not just about a set of grammatical structures, but a communication system in which the meaning carried by the language in a particular situation or context is associated with its function in that context. For natural science students to communicate effectively they need to have more experience and familiarity with the scientific discourse. Students need not only the linguistic competence for effective communication but also familiarity with the classroom or laboratory and the activities taking place within it. They have to understand the concepts, procedures and social dynamics of the laboratory. This means that if they are in a biology lesson and are learning about the respiratory system they have to use appropriate biological terms and concepts. Similarly, in a chemistry lesson they can talk, for instance, about the vapour of a certain substance that damages the air passages when inhaled. Pursuing this idea, in the latter example for a biology lesson, students would be expected to call the respiratory parts by their biological terms. In short the language of science teaches students to call a spade a spade, not just a tool for digging in the garden. This is at times against Swazi culture where a child is not expected to bluntly call some things by their exact names, but instead use some more formal words (usually these are descriptive words) that people in authority or elders can easily accept. What is regretful though is that at times science education does not recognise the requirements of traditional society (Bajracharya 1997).

The natural science teacher is faced with the task of using discourse enabling activities and methods when teaching the subject content. These should be activities that encourage learners to interact with each other, with the subject content and with their natural science teacher. Some of these are project-based approaches that give the students opportunities to investigate, talk, read and write about questions of interest to them (Moje 2001). Project-based approaches allow students to interact with the world and with other people. Lumpe and Staver (1995) document, that school-age children use their experiences with the world and other people to develop conceptions. Hence it is valuable for teachers to employ collaborative teaching methods to familiarise the students with classroom science discourse and thus learning. Lumpe and Staver (1995) quote Mayer defining learning as “changes in the learner’s knowledge, where such changes are due to challenges”. This is not meant to say learning begins at school for children. Children learn as they develop by interacting informally with the natural world and with other people; but they develop everyday knowledge, not the formal knowledge they acquire from schooling (ibid.).

Finally it is the duty of the natural science teacher to engage the students in activities that promote social interaction in the classroom or laboratory so that the students may develop scientific discourse. Peer interaction, using collaboration, is one way of improving student discourse through social cognitive conflict. Activities that promote verbal interaction in the natural science classroom or laboratory also promote the giving and receiving of help which results in learning. In this study I shall be looking for such student classroom discourse as verbal interaction if they occur and what meaning they have for the students. Verbal interaction is significant for concept development during the natural science lesson.

To improve verbal interaction in the classroom during natural sciences classes, the natural sciences teachers may need to engage the students in narratives. The narratives students tell during natural sciences classes reveal their beliefs and misconceptions about natural and artificial phenomena (Bajracharya 1997). Students' cultural stories can be used by the natural sciences teacher to bridge between students' home lives and culture, and the modern world of science and technology. The students may also tell their stories using other valuable ways such as poetry, drawings, and student exhibitions. The problem with misconceptions is that they tend to restrict students' reasoning during science learning, though Hamza and Wickman (2008) have found that in some contexts misconceptions do not significantly interfere with learning natural sciences. Narratives are also beneficial for natural sciences learning because they engage the students in vigorous interaction which can lead to scientific inquiry. For this reason (for instance, narratives engaging students in vigorous classroom interactions) the use of narratives in the natural sciences classroom to promote scientific discourse will be one of the themes to observe during this study. Narratives provide a "road map" to the natural science students which permits a remember-from-words comprehension of the concepts (Knox 1997). They act as building blocks for memory and human cognition; provided they resonate with the students' experiences. During a natural science lesson students may be asked to write a story (Rockow 2008) incorporating in it facts about the topic in question, or they may be told the story by the natural sciences teacher (Bajracharya 1997). The teacher's story could be the personal story of a certain scientist whose concept is about to be introduced. At other times the natural science teacher may ask the students to narrate their own stories to the whole class. Some of the stories told by students have mythical explanations for some of the topics covered in natural sciences lessons. The natural sciences teacher should then introduce the scientific explanations by using the mythical explanations as a base, since the students hold on to their non-scientific explanations. During discussions of the students' stories the teacher gets a chance of discovering the many social beliefs the students bring with them into the natural sciences class. Some of the beliefs may result in heated debates among the students. The natural sciences teacher may then have an opportunity to convert those debates into scientific inquiry. The natural sciences teacher should know how to handle controversial issues since some of the students may tell stories that include controversial issues.

Controversial issues are important in a natural science class since they stimulate student interest in science (Van Rooy 1994). They can lead to heated group or whole class discussion. Controversial issues have the potential of linking previous controversial issues to current controversial issue, thus giving natural science students the opportunity to challenge contemporary concepts and belief systems. However, the natural science teacher should encourage care and honesty among students as they handle controversial issues during classroom discourse. At the same time the teacher needs to encourage rational reasoning as the students formulate their views on such issues. The values of care and honesty are also positive in that they can foster empathy in natural science students for those directly concerned when such issues are debated or played out in the form of drama. When controversial issues are handled in groups the main advantage is that almost all the students get actively involved. They develop classroom discourse interaction patterns such as communication and listening skills. The use of controversial issues by natural science teachers and *handling them well* makes natural science students appreciate science and view it as a dynamic and exciting field of study to pursue further.

Controversial issues also increase students' conceptual understanding if the teacher facilitates the arguments (Von Aufschnaiter et al 2008). They learn science in the process of argumentation because they need to develop valid arguments. Scientists habitually engage in debate with the aim of developing and also improving scientific knowledge (ibid. 102). Likewise, by engaging in classroom debate natural science students develop and improve scientific knowledge. In the classroom disputes facilitate student-to-student and student-to-teacher discourse. Disagreements arising out of controversial issues may also help the natural sciences teacher elicit students' prior knowledge about the disputed the concept. This is possible since for students to engage in effective debate they need to have knowledge of the subject content in addition to the ability to rationally argue (Green 2007). Narratives therefore are constructive in the natural science classroom since they motivate students to feel the natural science curriculum is relevant to their lives by bringing together their different ideas, interests and experiences (Stears & Malcolm 2005). Narratives motivate students and give them immediate access to the science topic because the natural sciences teacher makes the subject matter more comprehensible by using dialogue between the characters in the story (Isabelle 2007).

As the natural science teacher makes subject matter more accessible the students develop the social skill of listening. Listening develops critical qualities in the students, such as imagination, activation of prior experiences, knowledge and imagery (ibid, 16), which will enable them to cope with abstract content in the sciences. Narratives aid memory and are used a lot in oral culture. A natural science teacher can make it easier for students to grasp/remember a certain concept by narrating to them how a certain concept was discovered and mentioning the name of the scientist(s) involved. An example may be that of how Archimedes discovered the volume of an irregularly-shaped object. It is an engaging story that once told students never forget, especially the “eureka” bit. No wonder we never forget the cultural stories we are told as we grow up.

Storytelling is a powerful form of communication. In Swazi culture young children are expected to share the main hut (kagogo) with their grandparents where they tell them a lot of interesting and informative stories, though some may be frightening at times. Some of the stories are in the form of parables whose meanings become clearer when these children grow up and meet these things in real life. Hence if you introduce a concept to a typical Swazi child using storytelling then that concept becomes deeply rooted and remains in that child’s memory. A concept introduced in the storytelling approach to Swazi students becomes comprehensible and memorable. Stories told for teaching purposes interest students because they are usually based on a problem to be solved, a conflict to be resolved or the prospect “What if…” (Stears & Malcolm 2005). Motivating the students’ interest in the concept being taught helps the students develop positive expectations for subsequent natural science concepts. Storytelling thus improves students’ socio-emotional functioning, academic competence and content retention (Stein & Hussong 2007). Stories also develop students’ positive school experiences, high levels of attachment and good experiences with their natural science teacher. Storytelling is one form of verbal interaction I will observe during data collection in the natural science classroom or laboratory.

The storyline approach interests all the students in a group because it caters for all the different learning modalities. The four main modalities are: visual-spatial, auditory, kinaesthetic and symbolic abstract. These learning modalities are preferences among the sensory modes favoured for learning purposes (Samples 1994). Students with visual-spatial preferences tend to rely on sight for accessing information and experience. They prefer learning content that includes images and requires spatial reasoning such as solid and plane geometry in mathematics, anatomy and geology. They like presenting conceptual understanding in pictures and diagrams. Those students whose preference is auditory learning are usually good at listening and carrying out written work. They focus on hearing and paying attention to patterns of sound. They display musical reasoning and even tap out rhythms that express the task at hand. Kinaesthetic students prefer learning that involves touching, movement and full body participation. Such students benefit from being allowed to gesture, mime or even dance the ideas being expressed. The last mode is symbolic abstract and does not involve the senses but the left cortex of the brain. Students who prefer this mode enjoy school work which involves reading, writing, oral reports and expressing their knowledge mathematically. These students like using symbol codes for representing information and experience.

The storyline approach can cater for all the four different learning modalities when implemented using the launch, explore and summarise (LES) instructional mode (Isabelle 2007). In the "launch" phase the teacher activates and elicits students' prior knowledge about the concept to be investigated by either probing questions or displaying models or providing visual display. This phase caters for all four different learning modalities provided the questions are not only oral but also written down. The teacher then conducts a brief discussion with the students before moving to the "explore" phase. During the "explore" phase the teacher may give a student a copy of a story with the history of the concept. The copy would help the visual learners and those who prefer symbolic codes. The teacher then reads the students the story. Reading would obviously benefit the auditory learners. While reading the teacher may also use an overhead projector to display a diagram/drawing of the model depicting the experiment. The drawing helps create a visual context for the story, as well as provide students with a helpful visual impression of the historical event. This helps them to compare the model in front of them with the real object shown by the drawing. The teacher then discusses with the students what is factual and what is not. The discussions help those kinaesthetic learners as they may even demonstrate some of the scenes during the discussion; benefiting even the other students with the other learning modalities.

The teacher may then move on to the last phase, the "summarisation" stage. At this stage the teacher makes a connection between the stimulus provided during the "launch" phase with the ideas stated in the story. This will help students formulate scientific ideas from the content of the story. Students preferring symbolic abstraction modality then benefit a lot. The teacher may even cite real-world experiences with the same science principle as in the story. This will enable students develop a deeper understanding of the concept at hand. Finally, the teacher may ask the students to write down what they have learned in a few sentences, or ask them to draw a picture conveying their understanding. This last activity may benefit mostly those students whose preferences are symbolic abstraction and involve visual-spatial modalities. An extended activity the teacher may ask the students to do would be to make an artefact out of what they have learned. This extended activity might go down very well mostly with learners with visual-spatial and kinaesthetic modalities. The science and computer laboratories, woodwork and metal workshops would be the appropriate places for them to design and make their artefacts. The other students with the other learning modalities may be excited by the hands-on exercise, with the result that the whole group will be motivated by the practical activity (Hattingh, Aldous & Rogan 2007).

The storyline approach also caters for all four learning styles as stated by Samples (1994). These are ways in which students prefer processing information and experience. The first group are those students who prefer learning about topics that matter to them personally. This group prefers learning in small group conversation using quiet reflection. The second group consists of traditional learners. These prefer objective content, are thoughtful, respect content as authoritative, think quietly and reason about the significance of content. The third group is made up of students who are like those in the second group, but differ in that they take action. They like applying the content they have learned in a practical and useful way. The science laboratory is their rightful place. The fourth group consists of students who are subjective and take action through their beliefs. They enjoy taking risks and going beyond the usual.

2.2.3 Language, identity and science

In the learning of natural sciences in my school the issue of language is a serious one as in most schools in Swaziland. In addition to the language of science students are expected to understand and use when communicating in the natural sciences they also have to learn the subject in the medium of English, which is not their first language. All of them have siSwati as their mother tongue or first language, and learn English as a second language (ESL). For the students in my school learning natural sciences through a second language is often one of many problems they have to grapple with. Such issues as poverty and lack of resources are other complicating factors adding to their difficulties in crossing cultural borders from Swazi to science. The issue of culture comes in as most of the natural sciences textbooks we use at the senior level originate from western countries and are thus written within a western cultural framework. Though early natural sciences educators supported the idea that culture and language are two separate concepts between which students can manoeuvre with ease depending on their culture and preparedness (Rollnick 2000), contemporary research has shifted to support the view that culture encompasses language. Stears and Malcolm (2005) describe culture as a lens through which people view and understand the world. Therefore, culture has direct influence on students' understanding of science. The students thus join a new culture in a natural science classroom and have to learn the language of science in order to develop scientific literacy (Brown, Reveles & Kelly 2005). They also have to learn new ways of conducting themselves such as the use of their body parts to express and convey certain information to one another or even to their natural science teacher.

Concerning the issue of culture, children are never to use certain gestures with their elders according to Swazi culture. These may be gestures like pointing a finger at an elderly person who may, for instance, be your natural science teacher. Because of such a custom the Swazi child are hesitant to point *directly* at objects or drawings during a natural science lesson, yet this is imperative in the sciences. When labelling biology drawings the pointer *must* touch the part being named. The Swazi child may then find himself/herself starting the pointer some distance from the part whose label is to be written. This is from the everyday life of Swazis where certain objects or places like mountains are never pointed at using the index finger but using a fist or one's head. As a child you are told your index finger will bend permanently or it will be cut off. The main purpose though for such traditions is to instil fear and thus respect in the children for such objects and places. In the case of mountains it could be those where members of the royal family are laid to rest. So, a natural science teacher for Swazi students should be somebody who is aware of their culture to help them with deeply rooted customs that may be in conflict with behaviour expected from a natural science student in the natural science classroom.

The effect of the issue of culture in African societies is so powerful that it tends at times to inhibit effective learning (Jegede, Fraser & Okebukola 1994). The natural science teacher should, therefore, be somebody ready to utilise the students' cultural variables to their benefit and recognise their socio-cultural backgrounds which might impede fruitful learning of scientific concepts since learning is influenced by what students already know. It is the duty of the school, therefore, to generate rich scientific cultures in the classroom for students to see the need to communicate in scientific discourse (Wallace 2004).

Gestures are some of the student interactions I shall observe during data collection as they are claimed to be precursors to language development (Roth & Welzel 2001). They shall be mentioned in the data analysis and interpretation stages. Scientists and engineers require visual representations to point to or reference with their hands to make themselves understood. The same applies to the natural science students when working in the natural science laboratory; they may use gestures to explain their experiment results, science projects or to express their misunderstandings. Gestures are part of cognition among school-aged individuals and play an important part in the development of scientific discourse. They also speed up student talk when the student explains a concept using diagrams (ibid. 106). In this way the student develops a high conceptual discourse. Gestures enable students to construct complex explanations through a succession of actions. Gestures have iconic, deictic and metaphoric functions (ibid. 105). The function is deictic when it involves pointing to an entity using the index finger. It is iconic when its topology is isomorphic with its content. Iconic gestures also have a deictic function. Generally, students and teachers use gestures when attempting to produce descriptions and explanations.

High school natural science Swazi students are thus doubly challenged since they have to first understand the culture (western) within which the text books are written before proceeding to learn the scientific language (science discourse). This is a big problem to them even though those whose culture is western also have the challenge of having to learn the culture of science. As Rollnick (2000) asserts, in all cultures there is a gap between the culture of science and that of society. According to this claim that language is the expression of culture, every natural science student then needs to be an active participant in the social practice of science – such as student discourse in a natural science classroom. Allowing students to use vernacular language during natural science language has been found by some scholars to promote scientific literacy (Wallace 2004). Such scholars even claim that not only scientific discourses develop but also non-scientific discourses such as moral stories develop. In fact they claim that vernacular language should be the starting point for scientific language use. Nonetheless, this does not cancel out the issue that for science learners to make sense of scientific discourse they need to have many opportunities for doing science and talking about science with both advanced and inexperienced users of the scientific language. Learners need to develop the desire to use the scientific language, so that they may find themselves integrating the scientific language into their own forms of communication.

Natural science teachers should allow code switching (switching between two languages in which the speaker has some measure of competence) among their students, to a certain extent though. Rollnick (2000) gives three cases that can call for code switching:

- when a word describing a scientific concept is needed or the English form is more compact than the vernacular form;

- when quoting; and
- to repeat the explanation of something explained in English.

The natural science teacher may code-switch in order to explain a difficult concept or to alert learners that a key term is about to be introduced for the first time. At times code switching helps when preparing to record information in writing. Home language can also help surface alternative conceptions.

Language is the means to construct interactions in the natural sciences classroom and is therefore central to scientific literacy. It mediates interaction and knowledge acquisition. The natural science teacher has to help natural science students focus on and learn the language of science, and how to use scientific reasoning patterns (Miller 2004). Hence students have to acquire a scientific identity which will carry implications of how they perceive the teacher and one another during lessons (Brown et al 2005). Their success or failure in natural sciences will pivot around how they are allowed to position themselves with respect to natural science content, natural sciences practices and other natural sciences students and teachers. Identity is dynamic and can change from context to context, from moment to moment, and can be ambiguous or unstable. It is constructed through social interactions in the natural sciences classroom and that is why the language of science is considered an active resource for scientific identity construction. A natural science student may thus associate himself/herself with the other natural science students by using the language of natural science.

The language used by students identifies them, for example, as scientific, literate or competent. The development of identity in a person is a step by step process during which the individual struggles to perceive him/herself in a similar fashion as those around him/her (Brown et al 2005). Identity development is a lifelong struggle during which physical, emotional and psychosocial conflicts are resolved so that the individual can experience their world in a more adjusted and fulfilling manner. Brown et al (2005) note discourses as ways of being certain kinds of people and they say every communication carries meaning which contains a message based on personal, political and discursive identity.

Students use identity as a recourse for communicating their position, as well as a tool for classroom interaction. In the natural science classroom students display their scientific identity through conversations and the development of new conceptual knowledge. They have to use scientific discourse willingly. When a science student uses scientific discourse in the natural science classroom, the natural sciences teacher may identify that student as a well-informed natural science student. Such discursive identity usually signals the standing and status of the student in the classroom (Brown et al 2005).

A student develops natural science literacy through classroom conversations. These conversations may be between the natural science student and the other students or between the student and the natural science teacher. The natural science teacher plays a significant role in the development of science literacy in a student by either affirming or restating a student's response. Students challenge each other by extending each other's understanding. The natural science teacher may also provide students with opportunities to understand natural science by prompting and validating their responses as they build one another's responses. The teacher's praises and prompts are very essential in encouraging students to contribute including knowledge the teacher may not think they have. Both the teacher and the students construct new natural science understanding during such dialogues in the natural science classroom. During such dialogues the students, together with the natural science teacher, should use relevant technical terms for them to understand each other. This is important for the students who are still learning or are to learn natural science as there is a close affiliation between language, identity and science learning.

The importance of discussion in a natural science classroom calls for greater emphasis on the use of appropriate scientific vocabulary (Wellington 2006). Students are also encouraged to practise active and critical reading of natural science text. They have to write summaries of what they understand from their textbooks, as well as make drawings and graphs to assist in natural science knowledge construction. Critical reading may be accompanied by arguing how ideas are supported by evidence – which may be experiments in a natural science classroom (Osborne 2002). However, students need to take care of the ambiguity of some terms in a natural science text, which may be in the same subject but in different contexts (the same word may carry different meanings in different contexts). The natural science teacher is expected to assist natural science students learn better by teaching with enthusiasm, using many teaching strategies (Akerson 2001), as well as employing interdisciplinary instruction. The natural science student is expected to use English language for purposeful communication of scientific ideas through reading, writing, speaking and listening. English language learning is beneficial since it develops oral language skills in students through shared experience; and this is necessary experience for reporting scientific investigations in the classroom as well as arguing one's point of view or findings because scientific knowledge changes with new investigations and evidence. The natural science teacher may also monitor the development of student ideas from misconceptions toward a better understanding of scientific concepts through their written work and talk.

A considerable problem bilingual students face during natural science learning is that they have to cope with two language systems in addition to the language of science. The students from my school have the task of comparing and contrasting siSwati and English in a semantic, cultural and social sense in their interactions during a natural science lesson. This challenge makes it difficult for students to cope when thinking and learning content, as science discourse requires students to use language (Jappinen 2005). However, Kearsey (1999) argues that using two languages gives the student a wider experience of using new languages. This is more of an advantage especially where the student uses both languages extensively at home and in the wider community. The main problem with students from local Swaziland schools though is that they use only siSwati extensively outside of their classroom. The only chance they get to use English extensively is at school or when writing school work.

Another disadvantage faced by bilinguals is interference between the two languages because understanding in one language interferes with understanding in the other. This is true even between the scientific language and everyday English. Students often have problems with understanding the vocabulary used in everyday English especially when used in a scientific context. This study, therefore, seeks to explore how students in the selected sample deal with this potential problem of interference between siSwati and English and the scientific language and everyday English in their discourse. The issue of interference between everyday English and the scientific language is a common one because of public exposure to technical terminology. This, in a way, is an advantage since to be an informed citizen these days one should have an understanding of the concepts and processes of science (Miller 2004).

2.3 Conceptual framework

This subsection summarises the themes to be used for data collection and interpretation. It is divided into three parts:

i) Social constructivism – covers the main theory on which the research is based;
ii) Classroom discourse – covers what is the main focus of the research;
iii) Resources and formations – covers some aspects of language.

The research is based on a framework of learner-centred education, consistent with the aims of the Swaziland General Certificate of Secondary Education syllabuses (Ministry of Education and Training 2009).

2.3.1 Social constructivism

Social constructivism emerged from the new sociology of science known as the Edinburgh School which explained scientific theories in terms of the "social circumstances of science and the social arrangements of the practice of science, and interpersonal dynamics in laboratories" (Matthews 1993). Social constructivism is an appropriate learning theory for this study as it stresses pupil engagement in learning through dialogue, conversation and argument in a social setting (ibid. 359). Fosnot (1993) places the responsibility of establishing a community of learners who engage in questioning, proving and debating scientific inquiries on the science teacher. The main focus for this research is the study of patterns of classroom discourse among natural science students; with special attention paid to student talk during natural science learning activities. Student talk benefits the student since it is one of the main ways by which the natural science teacher will get to know if the student has developed the appropriate knowledge and understanding according to the quote from an unknown source, "Boy, open thy mouth, that I may see thee". This theory of social constructivism describes knowledge acquisition (epistemology) and child development well. Child development proceeds interactively from the social to the individual; so does learning which occurs within the context of social interactions (Stears & Malcolm 2005). In the natural science classroom learning leads to acquisition of formal/academic knowledge. The base for the formal knowledge is laid by the learner's day-to-day social interactions of culture and everyday life. The learner's everyday knowledge, on which formal knowledge builds, includes cultural knowledge, practical knowledge, community knowledge, theoretical knowledge, experiential knowledge and spiritual knowledge (ibid.). In the natural science classroom the learner just experiences the formal activities as new ways of thinking, different from their everyday social activities. Thus they require some effort to link these and negotiate any conflicts which may occur.

Social constructivists portray learning as “a form of cultural apprenticeship” in which “aspirant members of a culture learn from their tutors” and “novices are introduced to a community of knowledge through discourse in the context of relevant task” (Osborne 1996). The aspirant members or novices are the natural science students while the tutors are natural science teachers, and the community of knowledge and relevant tasks are the natural science subject and its learning activities respectively. Clearly, from the above statements one may conclude that for meaningful learning to occur in the natural science classroom discourse plays a central role. Osborne (1996) suggests that learning science is just learning to speak the scientific language. Constructivists lay stress on understanding as the main goal of science instruction (Matthews 1993) during the teaching and learning process, instead of rote learning where learners just memorise almost everything without necessarily understanding it.

According to constructivists, knowledge is personally and socially constructed. Scientific ideas and theories result from the interaction of individuals with phenomena who then communicate them. Since communication is central to knowledge acquisition and understanding in the natural science classroom (and I observed student and teacher talk during the study), I find social constructivism an appropriate theory for this research.

2.3.2 Resources and formations

According to the sociosemiotic theory of language, language has two semiotic functions: resource and formation (Gomez 2007). The words used in communicating social and cultural ways of understanding phenomena are the semiotic resources, while semiotic formations are the particular ways of talking, gesturing and behaving. These two functions of language are central in this study since discourse in the natural science classroom involves the use of everyday language as well as scientific language. Students, and their natural science teacher, have to know, understand and use the appropriate vocabulary for that particular science discipline as they exchange information. They also have to behave themselves according to the particular format for presenting a science report of an experiment. These two semiotic functions of language were some of the things I observed during the research.

Without the proper scientific vocabulary students find themselves like visitors in natural sciences lessons since they may fear answering questions posed by the teacher; and this often limits them in classroom discussions. However, the natural science teacher has to encourage the students to use not only the scientific vocabulary, but also everyday language, and assist them by restating their contributions using the scientific language. As the natural science teacher does this the students are helped to move along, what Stromdahl in Gomez (2007) calls, a conceptual locality, from proximal (life/world) understanding and concepts to distal (more abstract) levels of discourse. The natural science teacher has to make the natural science students aware that during classroom conversations and dialogue they are moving along this continuum. However, the natural science teacher should be careful not to introduce too many scientific words too rapidly as this tends to make science seem difficult and remote to students (Miller 2004). In the event of the teacher introducing too many scientific words rapidly the students will only be able to read them without understanding their meanings Understanding the words and making them part of classroom conversation widens students' comprehension and deepens their insight.

2.3.3 Classroom discourse

According to Von Aufschnaiter et al (2008), research focusing on classroom discourse during the teaching and learning of science only emerged in the 1990s. This study too has as its main focus the conversations or speech that occurs in the natural science classroom. Anderson et al (2007) claim that influential people in education also prioritise talking science over reading and writing science. Vygotsky is one such person who advocates the principle that meaning making during learning comes through shared discourse between the learner and a more capable peer (Rollnick 2000) or the teacher. The more capable peer or teacher assists the novice/less capable learner in learning to talk science. Socio-cultural views of classroom discourse place social interaction in the centre of meaning making and learning (Anderson et al 2007). During learning students are expected to talk in ways that are appropriate to the discipline studied (Gomez 2007). When learning physical science they are expected to talk differently than in life sciences. This is with reference to the semiotic resources and formations they use.

The chatter students engage in during natural sciences lessons include everyday language, yet they are expected to use mostly the scientific language. Students are said to use everyday discourse when they use colloquial, non-scientific, yet descriptive ways when talking about phenomena (ibid.42). It is the duty of the science teacher to help the students engage with the scientific language, and also to translate the scientific discourses into everyday conversation. By so doing the science teacher helps the students move from the proximal end of the continuum of conceptual understanding to the distal end. The proximal end is marked by the use of life/world vocabulary and explanations whereas the distal end is marked by the use of more abstract discourse.

Green (2007) identifies two types of interactions that occur in natural sciences classrooms: monological and dialogical interactions. Monological interactions are “one-way” kind of reasoning while dialogical interactions involve multiple and contrasting kinds of reasoning. Examples of monological interactions are discussions and explanation and of dialogical interactions, argumentation interactions. Disputes are one kind of constructive interaction that natural sciences teachers should teach and encourage since they increase students’ conceptual understanding (Von Aufschnaiter et al 2008). They have elements such as data, claims, warrants, backings, qualifiers and rebuttals. Such debate facilitates student-student and student-teacher classroom discourse. Monological interactions usually lead to dialogical interactions, such as, a story being narrated by a natural science teacher to natural science students (monological interactions) resulting in a debate or argument in the classroom (dialogical interaction). An argument is a dialogue between two or more people holding opposing views (Green 2007).

The two kinds of interactions (monological and dialogical) mentioned above are both substantive and multi-voiced. An interaction is described as substantive provided it is based on disciplinary knowledge and multi-voiced when it involves two or more participants. Both of these terms apply to interactions occurring in a natural science lesson. The interactions are substantive because they are always about the subject content. I observed student-student and student-teacher interactions all of which were multi-voiced. Observing those interactions was not complicated for me (the researcher) as there were no serious cultural, social or linguistic differences among the students, or the teacher. All the students and their natural science teacher had SiSwati as their mother language and the same culture. The natural science teacher, therefore, did not have trouble modifying classroom instruction so as to accommodate cultural, social and linguistic differences among the natural science students. But the natural science teacher’s instructional strategies had to vary to cater for the students’ different learning styles and modalities.

The natural science classroom discourse should encourage students on when and how to embrace, not reject, classroom science talk. It should encourage science students to progress from everyday science discussion to extended scientific discourse (Gomez 2007). This enables them to communicate their science understanding using a science vocabulary. Their communicative competence improves so long as they practise the scientific language extensively (Rollnick 2000) during natural science lessons.

2.3.4 Summary

Chapter two began by giving an overview of the literature reviewed. The review was given under three subheadings, namely, social skills development in natural sciences lessons; student discourse in a natural science classroom; and language, identity and science. After discussing some of the pertinent literature relating to this study, then proposed a conceptual framework to guide the study. The conceptual framework is divided into three subheadings which are social constructivism; classroom discourse and resources and formations. Integrating literature on these three subheadings, I was able to identify the key concepts and approaches to use for data collection and analysis.

CHAPTER THREE

Research Methodology and Study Design

3.1 Introduction

McMillan (2004) defines research as a disciplined inquiry of gathering, interpreting and reporting information using acceptable principles to verify that a knowledge claim is reasonable. In education research is applied to educational problems and questions. Janes (1999) defines research as a way of trying to answer a question about the nature of things in an organised, recognised and replicable way. The results of the research should also be acceptable to the intended audience. For this research I accepted the latter definition (that by Janes) since with this study I have answered a question about the nature of things in my school; not tried to verify a knowledge claim. The definition by McMillan & Schumacher (1997), that research is a systematic process of collecting and logically analysing data for a specific purpose is also suitable for this study.

In the present study a problem was identified by the researcher in the field of education, which was that of poor performance in the sciences by students in Form 5 (exit point in school education system in Swaziland) external examinations. Questions arose in the researcher's mind as to what could be the causes of the problem. This research was then embarked on to find answers to the questions. These answers would finally be the solutions to the perceived educational problem. The approaches the researcher used during the research in a bid to gather data are known as *research methods***.** These are the techniques for finding answers to the research questions (Cohen, Manion & Morrison 2002).

McMillan & Schumacher (1997) define research methods as those systematic and purposeful procedures the researcher employs during data collection and analysis in a bid to yield information on the research question(s).

By research design is meant a blue print of the research project (Mouton & Marais 1990). It is the arrangement of conditions for the collection and analysis of data beforehand. The research design aims at maximising the validity of the research findings through careful planning and structuring of the research project (ibid. 33). It involves rational decision-making by the researcher. For this study the researcher opted for approaches which maximise the validity of the findings by selecting and using the best-fit-for-purpose methods and making rational decisions at every stage of the project, bearing in mind that the design of a qualitative research evolves during the study.

3.2 The qualitative research design

Since this research was meant to find answers to questions by observing student interactions during natural science lessons, the qualitative approach was used in preference to the quantitative one. The qualitative approach was chosen since by using it one is able to study how individuals make meaning of reality through social interactions, and not by means of observed or recorded numerical data as is the case with the quantitative approach (McMillan 2004). In this study natural science students were observed on how they made meaning of classroom discourse during natural science lessons. I did not have to disturb the natural setting of the natural science class so I was able to observe the student classroom discourse occurring naturally without my intrusion. It had to be so since qualitative researchers believe behaviour is best understood when it occurs without external constraints and control; also the situational context is important in understanding behaviour. The qualitative approach was suitable for this study because meaning making during classroom discourse is constructed socially, and the researcher’s role is to observe patterns of classroom discourse during natural science lessons. The mode of data collection was also less structured and more interactive.

For full understanding of the entity studied qualitative researchers prefer close or direct interaction with the source(s) of information; hence the use of qualitative methods in this research. I spent about eight hours observing natural science students during natural science lessons and after lessons interviewing them to get first hand information. A qualitative approach enables the researcher to give a detailed account of what has been observed in the very form in which it occurred naturally, not just a summary in the form of numbers. Nothing is taken for granted; the intention is to give rich descriptions of what has been observed so that the complexity of human behaviour is reflected accurately. For this study I noted even the gestures students made during the lessons and the researcher-student interviews.

This research is, therefore, qualitative in that it explores traits of individuals and settings that cannot easily be described numerically (Charles 1995). In this case the traits are interactions of students in a natural science classroom. The information for this research was collected by observing, describing and recording the interactions that occur in a natural science classroom. The main data collected was verbal.

3.3 The case study design

3.3.1 Why a case study?

The broad approach that suited this educational research was the interpretive and subjective paradigm (Cohen, Manion & Morrison 2002). This approach emphasises the interpretive and subjective dimensions. With it one understands and interprets the world in terms of human activity. For this study the researcher wished to know and understand the student classroom discourse during natural science lessons, with the purpose of interpreting those classroom discourse patterns in order to find answers to the research questions. The researcher needed to study the dynamic, complex and unfolding student interactions in the real life context of the natural science lessons; hence the use of the case study approach which recognises the uniqueness and dynamic nature of contexts, as well as in-depth investigation of human interactions in a unique instance. A case study allows rigorous data collection, using several methods (triangulation), and allows a situation to speak for itself rather than be largely interpreted by the researcher. Quality and intensity are hallmarks of the case study approach rather than quantity. Out of the four specific qualitative approaches (ethnographic study, case study, phenomenological study and grounded theory) cited by McMillan (2004) the one found suitable for this research was the case study**.** McMillan (2004) defines a case study as an in-depth investigation of one entity or experience which is carefully defined and characterised by time and place. It is a specific instance that illustrates a more general principle (Cohen, Manion & Morrison 2002). In the present study the specific entity studied was a final year high school natural science class (at Tfolani high school) in the eastern part of Swaziland. The general principle studied was student classroom discourses during natural science lessons. The case study approach was chosen since it enables one to investigate and report the dynamic and unfolding interactions of events and human relationships. In this research I studied how high school natural science students interacted with each other, with the teacher and with the natural science content through discourse. The interactions consisted mostly of student talk during natural science classes. A case study was also an appropriate approach since I, as the researcher, had little or no control over the student interactions. Mine was just to observe the students interact and interview them on why they talked, how they talked, to whom and about what, what they thought about such talk, about science, science teachers and science teaching.

3.3.2 The observational case study

The type of case study for this research was, therefore, the observational case study**.** Using this method the researcher gathered data by just observing the participants investigating a particular aspect (McMillan 2004). The researcher observed patterns of student classroom discourse during natural science lessons. The patterns of classroom discourse observed were student interactions during natural science lessons.

The kind of observation chosen for the case study was non-participant observation (Cohen, Manion & Morrison 2002). In this kind of observation the researcher (observer) does not take part in the group activities he/she is investigating and does not assume group membership. The non-participant observation method of data collection enables the researcher to use equipment for audio- or video-recording the classroom discourses. Non-participant observation studies are usually suitable for artificial environments such as the natural science laboratory, and the researcher is not expected to explain his presence as he does not partake in the group activities. I did not participate in the natural science lessons, but just sat somewhere in the room and observed the lesson in progress. Observation and interviewing of participants during data collection has effects which may end up lowering the reliability of the collected data if not controlled. These are effects due to: the researcher; the participants; the measuring instrument; and the context (Mouton & Marais 1990).

3.3.3 Validity, reliability and reactivity

Since the data had to be collected directly from people the tendency was for them to react to the research in one way or the other**.** They could supply inaccurate information because of apathy or wilfulness. The participants could even modify the information or their behaviour with the intention of impressing or misinforming the researcher. Human beings are thus regarded as highly reactive sources of data compared to products of human beings such as behaviour and characteristics. Reactivity was the most serious threat to validity of the findings of this research as human behaviour was the source of data. To minimise the threat of reactivity to the validity of this study the researcher observed and interviewed the students over a period of about one month in order to be able to discard the data clouded with high or unfavourable reactivity. That was the best option since in a case study like this one the researcher has very little or no control over the participants during lesson observation. It was only during the interviews that the researcher had control over the interviewees but to a limited degree. The observation effects mentioned above which lower the reliability of research findings are nothing but the consequences of nuisance variables.

Researcher effects are categorised into two groups: those associated with researcher characteristics and those associated with researcher orientations. Researcher characteristics are attributes like gender, nationality, age, educational level and socio-economic status. These attributes had little negative effect on the validity of the data as I (the researcher) am a Swazi national and a mathematics/science teacher in the school, and the class from which the participants were selected was a group I was teaching. These characteristics are known as organismic variables and are broadly categorised into the affiliation of the researcher, the image the researcher has with the participants, and the distance between the researcher and the participants. By affiliation of the researcher is meant the organisations with which the researcher is associated. If it is a highly influential organisation then the participants are highly motivated to participate in the research; however if it is an unknown organisation or one which causes suspicion then the participants may react negatively. Affiliation impacted positively in this study as the researcher was a member of influential organisations such as Yonge Nawe Club and the Science Club.

The participants may consider the researcher as a stranger, an outsider or an intruder. In this research the participants did not consider me (the researcher) as a stranger or outsider as I was a teacher in the school. They did not even consider me as an intruder as I sought their consent to conduct the research with them. I made appointments with them and their natural science teacher for whenever I would come to observe them in class. Language, culture and the socio-political situation of the researcher and the participants were the same; hence the participants (natural science students) did not reveal any negative perceptions about the researcher.

The distance between the researcher and the participants may also have some impact on the research findings. The distance could be as a result of gender, race, urban-rural differences, or even styles of dress. To reduce gender effects there were two girls and a boy in the group of participants to be observed and interviewed. It has been found that girls tend to be reticent when interviewed by female researchers (Mouton & Marais 1990), therefore, as a male researcher it did not matter whether I had two or one of them in the group for fairness of gender and reduced bias. Race did not have a part to play as we were all black people in my school except for five students. My status was still that of a teacher to the research participants (3), though during our interactions I brought them a bit closer. Urban-rural effects were not a problem as the school was a rural one and I was a resident in one of the surrounding villages of the school from which the students also came. My dress code was always formal at school on school days. So, my familiar dress code did not have much effect on the students during the observation and interview stages.

The other category of researcher effects is that of researcher orientations**.** By researcher orientations is meant the attitudes, prejudices, opinions, beliefs, preferences, tendencies, and values of the researcher (Mouton & Marais 1990). Both observations and interviews are influenced by these researcher orientations to a certain extent. Van Fraassen (1980) supports this idea by stating that our observation language is thoroughly theory-infected. Van Fraassen argues that the way we talk is guided by the pictures provided by previously accepted theories. This means we observe objects, phenomena or actions according to preconceptions. That is why it is vital to know what to look for. For example, through a light microscope one may tend to concentrate on trapped bubbles of air instead of a few amoeba cells, if not guided by a more capable peer or prior knowledge. It is, therefore, essential to make the right observations in order to make the correct inferences (Padilla & Pyle 1996).

The problem with the above orientations is that they may result in bias. The researcher may have specific expectations from the respondents' answers, due to his/her beliefs and perceptions. These expectations may make the researcher partial when further probing, classifying of responses, and such like. In this study I avoided bias-producing cognitive factors, such as my beliefs and perceptions, as I observed and interviewed the natural science students. I also did away with the expectation that the interviewees would give the same answers to the same questions in future. I avoided assuming or predicting the students' responses. That was why I asked them mostly open-ended rather than leading questions. I was also cautious about role expectations as they usually lead to rigid stereotypes. Role expectations are the tendencies of interviewers to believe that certain attitudes or behaviours occur in certain individuals and thus expect certain sorts of answers from those individuals. I cleared my mind of any prejudice about any of my student interviewees or their natural science teacher. During the interviews I also avoided reinforcement and feedback as those might have influenced subsequent responses. I avoided saying, "Good" or nodding or giving any form of approval to some of the responses.

Participant effects*:* as in the case of the researcher effects, participant effects are also characterised as those that result from the characteristics that are inherent in the participants and those that are the result of participant orientations. Under participant characteristics I looked out for memory decay, the omniscience syndrome and finally interview saturation. As I collected the data from the natural science students I remembered that human beings have natural memory decay.

Memory decay is usually related to: the period between the occurrence of events; the regularity of the event; the significance of the event; and lastly accessibility to the regular interviews. I emphasised the significance of the study so that the students could take the interviews seriously. The frequency and regularity of the interviews ensured that data related to the interviews was at the students' finger tips. I also had to be conscious about the omniscience syndrome so that I could eliminate responses that were not authentic. The omniscience syndrome is a situation where an interviewee believes he/she is capable of answering any question. With the last characteristic, interview saturation, I did not have a problem since my school is located in a rural area and the students there were very rarely interviewed. What they were used to were questionnaires, not interviews. So, the natural science students did not refuse or show reluctance because of over-saturation.

Under participant orientations there were three main effects to be considered: role selection, level of motivation of participant, and lastly, response patterns. Role selection is about the new role the participant perceives to take up in the research setting. The participants may ask themselves about the kinds of people they should be as they answer the questions or do research activities. Then it was essential for me (the researcher) to clarify and emphasise the significance of the participants in the research. Though that reduced the "do not know" responses, it, at the same time, might have resulted in the measurement of more imaginary attitudes and opinions. I did not over-emphasise the significance of their participation in the research. The research topic was attractive enough to motivate the participants. The questions for the interview were such that they did not threaten the interviewees, but raised their interest in engaging in the study. The questions asked did not relate to private issues. Therefore, I made the interviewing experience meaningful, rewarding and enjoyable to all parties involved. The third effect under participant orientations (response patterns) did not show up in the present study as the interview questions did not involve scaled items, fixed-alternative items, statements, ranking response, but were mostly open-ended questions. Open-ended questions minimise the social desirability tendency whereby participants give answers that make them appear well-adjusted, unprejudiced, rational, open-minded and democratic. The interviewees were asked to be frank with their answers.

Measuring instrument effects: the measuring instrument for the study was the interview. Some of the effects have already been discussed. The interview effects included question sequence effects; open question effects; do not know effects; interview length effects; question sensitivity effects; leading question effects and fictitious attitude effects. The questions were asked in a specified sequence as laid out in the interview guide, that is, standardised open-ended interviews (Cohen, Manion & Morrison 2002). Asking the participants the same questions in the same sequence increased the comparability of their responses and reduced interviewer effects and bias. The questions were based mostly on what had transpired during the progress of the lesson. This is especially so if open-ended questions are asked. Because of the many advantages of open-ended questions almost all the questions for the interview were open-ended so that I could get a truer assessment of what the students believed and to establish co-operation and rapport. The interviews with the pupils were made as short as possible (not more than 30 minutes) to minimise loss of interest among them. I avoided asking sensitive as well as leading questions.

Context effects for this study were considered in two dimensions: spatio-temporal factors and then the research settings within which the interviews were conducted. With the spatio-temporal factors I had to be sensitive to the time, cultural and political factors. I had to mind the time for conducting the interviews. The time was neither too short (to get detailed data) nor too long such that the students would start losing interest. That was why I conducted the interviews for about one month during the second term of 2011. During that school term there was less academic and social pressure on pupils. During that period we had, as a country, no national cultural events. Coming to political factors, nothing much was occurring during the second term of 2011 in Swaziland since even the next parliamentary elections would be held in 2013. We only had the Elections and Boundaries Commission moving from constituency to constituency conducting civic education in preparation for the 2013 elections. One would say we were enjoying apparent political stability in the country. The research setting for the interviews did not impact negatively on the data as it was the very science laboratories the pupils were used to where the interviews were conducted. Hence I did not expect them to have problems with the new roles they might think they had to assume during the interviews.

3.3.4 Purposeful sampling

Before and after each lesson I interviewed three intentionally selected students from the natural science class. The subject teacher for the natural science group helped me with the selection of the most successful student in the subject, the one who was average and the one with the poorest performance. Those were the three students whose interactions during natural science lessons I observed and interviewed. The students were selected that way with the hope that all the different abilities were represented since the main purpose of conducting the research was triggered by the poor performance of natural science students in Form 5 despite the availability of three well-equipped laboratories.

3.3.5 The interview method

Interviews are used for data collection since they are a means by which the participants (interviewer – myself and interviewees – the natural science students and the natural science teacher) interchange views on a topic of interest, discuss their interpretations of the world, and express how they regard situations from their point of view (Cohen, Manion & Morrison 2002). For this research the interviews enabled me to sample natural science students' opinions on how they regarded their talk and gestures as well as their natural science teacher's talk and gestures during natural science lessons. Interviews also allow greater depth of data collection compared with the other methods as the researcher could video-record the lesson observations and interviews, and also have a high response rate since the interviewees become actively involved and thus motivated. The type of interview employed in this research was then the standardised-open-ended interview**.** This type was relevant to this research since the questions asked were the same for all the three students; and that made the data collection complete for all the students. The standardised open-ended interview has the advantage of making organising of data, as well as analysing, simple. The interview method is chosen since it involves gathering of data through direct verbal interaction between individuals, unlike a questionnaire (even if it can be self-administered). Some of the students' work (notebooks, homework, exam scripts and test books) were collected for data. From the students' work I looked for the kind of vocabulary used, whether everyday or scientific or both, and the participants' understanding along a continuum of knowing.

A standardised open-ended interview needs careful planning. Cohen et al (2002) cite seven stages, as set out by Kvale (1996) that can be used to plan an interview. These are: thematising, designing, interviewing, transcribing, analysing, verifying and reporting.

3.3.5.1 Thematising

Thematising involves giving the purpose of the investigation and the reasons why the interview approach has been chosen. This stage also gives an outline of the theoretical basis as well as the broad aims of the study. The broad aims are then reduced to research objectives. This research was based on a framework of learner-centred education. The approach gives the students full responsibility of their education. The teacher facilitates the teaching/learning process and is no longer feared by the students and viewed as a figure of authority. Knowledge is believed to be socially constructed as the students interact with each other, with the teacher and with the subject content. Social constructivism is the guiding theory for this study as it emphasises learner engagement in dialogue, conversation and argument during learning. The vocabulary used during the interactions, the meanings the students gave to those words and the understanding they had of classroom discourse were the focus of this study. Natural science students were observed for the use of both everyday language and the science language during natural science lessons.

With the present study the purpose was to investigate discourse interactions among natural science students, between students and the natural science teacher, and, finally between the natural science students and the natural science content. Therefore three intentionally selected science students from a natural science group during a natural science lesson were observed, and then interviewed individually after each observed lesson on why they talked, how they talked, to whom and about what? From the research problem it was possible to come up with three broad aims for the study. They were:

- to investigate the nature of student discourse in a natural science classroom in some schools in Swaziland
- to investigate the meaning and role of such student discourse within the context of the natural science classroom
- to explain the observed student classroom discourses and meanings.

These broad aims made it possible to know who talked during natural science class time, to whom and about what. I got to know even the content and nature of conversations during natural science lessons. For the researcher to succeed in doing that he/she really needs to get the information from the primary source; thus the interview approach was the ideal one for a study of this nature. The interview approach also made it feasible to understand what students thought of classroom discourse in relation to learning the subject matter.

Both interviews and observations employed as means of data collection to improve the reliability of the data and thus the validity of the data collection instruments. Triangulation was useful in that the variety of methods used for data collection complemented each other, and as such corrected each other's shortcomings (Mouton & Marais 1990). Taking, for instance, the direct observations (a more reactive method), the natural science students' work (documentary sources – less reactive method), and the interviews (highly reactive method), the researcher was able to blend the advantages of those three methods of data collection and come up with a more valid research design.

The specific objectives for the research that yielded answers to the research problem were to:

- describe the kinds of student classroom discourse in the natural sciences in Swaziland;
- describe the content of such student classroom discourse;
- understand how students and teachers in Swaziland schools interact with each other through discourse;
- understand the meaning of such discourse to those participating in such discourse;
- give an account of why the discourse is the way it is and what the implications are for the teaching and learning of natural science in Swaziland and elsewhere; and lastly
- to suggest informed intervention strategies that encourage student talk in the natural science classrooms.

3.3.5.2 The interview schedule

The second stage, designing, involves the preparation of the interview schedule. Included in the schedule are the items to be used in the interview; whether they will be fixed-alternative items, open-ended items or the scale (Cohen, Manion & Morrison 2002). For this study only open-ended items were used since they have a number of advantages: they are flexible; they allow the interviewer to probe; they enable the interviewer to test the limits of the respondents' knowledge; they encourage co-operation; and they allow the interviewer to make a precise assessment of what the respondent believes. The interview questions for the schedule were based on the research objectives. It was the research objectives which were incorporated into the questions included in the interview schedule. For this study a number of key issues were raised in a conversational style. The issues revolved around student discourse in a natural science classroom. An example of an open-ended question that the interviewees were asked was: Do you find it useful or beneficial for students to talk during natural science lessons? Can you explain your reply? The focus was on probing why and how students talked during the natural sciences lessons. I sought to understand the meanings they associated with such discourse patterns and preferred indirect questions to direct ones since indirect questions made the purpose of the questions less obvious. Thus the indirect approach was likely to produce frank and open responses. Most of the questions were general and non-specific so that the interviewees were led to give the desired information with less alarm; unlike specific questions which cause respondents to be cautious or guarded and give less-than-honest answers. An example of a general, indirect and non-specific question would be:

Do natural science textbooks assist students in understanding scientific concepts?

An example of a direct and specific question may be:

> Is the recommended Physics textbook assisting you in understanding current electricity better? Please explain to me as the researcher, how the textbook help you understand better?

Ways of responding to questions vary according to the kinds of questions asked. According to Cohen et al (2002), there are seven response modes: the unstructured response; fill-in response; tabular response; scaled response; ranking response; checklist response; and the categorical response. Since most of the items in the interview were indirect questions, they required unstructured responses.

Unstructured responses gave the respondents freedom to give their answer as fully as they chose rather than being constrained by the nature of the question. An example of an unstructured response may be:

> Why have you chosen the natural sciences stream?

The other response modes were not used in this study.

3.3.5.3 Interviewing

The third stage of an interview is interviewing. At this stage the interviewer sets up and conducts the interview after designing it. The interview must be conducted carefully and sensitively. The interviewer needs to be an expert in interaction and communication by providing an atmosphere which will enable the interviewee to feel secure and talk freely. For this study the interviews were conducted in a secluded place like the laboratory, during school hours, when there were no lessons in progress. The interviewer also needs to consider the ethics of research. These ethics include informed consent, guarantee of confidentiality, beneficence, anonymity and non-maleficence. Informed consent arises from the participants' right to freedom and self-determination; where self-determination encompassed the participants' responsibility should anything go wrong in the research, and the participants' right to refuse to take part or to withdraw once the research had begun. It was, therefore, about the subject's decision whether to participate in the research or not after being informed of the facts that were likely to influence his/her decision. Consent was sought from the natural science teacher concerned, from the students themselves, as well as from the students' parents as most of them were minors. To all the parties involved I explained the purpose of the study and invited questions. Thereafter permission was sought to proceed with the investigation.

Beneficence is about that the investigation will benefit the participants. The results of this study enabled the researcher to suggest informed strategies that encourage more student talk during natural science classes. The study was expected to help the participants and future natural science students appreciate and understand natural science better through classroom talk and interaction. Non-malificence was about ensuring the subject that the interview or its results would be harmless.

Anonymity refers to the information provided by the interviewees: that it should not reveal their identity to either the researcher or any other person. But since for this study I conducted face-to-face interviews there was no way the interviewees could expect anonymity from me (the researcher). I could only guarantee them confidentiality. The best I could do to ensure their confidentiality was to ask them to use an alias of their own creation. Another way was to prevent duplication of records and passwords, so as to control access to data.

It was necessary to ensure that the questions for the interviews were not threatening to the interviewees by exposing their ignorance. Threatening questions would end up limiting the reliability of the data as the interviewees might end up giving less honest responses. The reliability of data was enhanced by conducting the interviews in a field which was the researcher's specialty – the natural sciences. The interview questions asked had to be clear to the interviewees and were only those meant to elicit the kinds of data sought, that is, they were based on the research questions. For fruitful interviews the researcher also had to be a good listener and mind non-verbal communication as those aspects contribute to the interpersonal, interactional, communicative and emotional aspects of an interview. Appropriate verbal and non-verbal feedback was given to the interviewees during the progress of the interview. Suitable silences were kept so as to give the interviewee enough time to think and to answer the interview questions.

Coming to directiveness, the interview situation guided the researcher on how directive to be during each interview, lest the interviewees would become bored. They were motivated by avoiding the use of academic language, but instead it was translated it into their everyday and colloquial language. That also helped make them feel comfortable about the language used and thus the researcher got to know what terms they use amongst themselves about the matter at hand. Each interview began with the less demanding "what" questions and ended with the more demanding "how" and "why" questions, so as to put the interviewees at ease. The interview questions were brief and to the point.

Aspects which were avoided, which could become problems during the interview, included among others:

- interruptions from outside such as knocks on the door and telephone calls;
- stage fright in interviewees;
- awkward or embarrassing questions;
- jumping from one topic to another, instead of a smooth transition;
- giving opinions or advice, instead of listening actively; and
- handling sensitive matters.

The interviews were recorded using a voice recorder about which the interviewees were informed. A video recorder could have been used as it yields more accurate data (it captures even gestures) but the problem was that analysis of that kind of data could have been too demanding for a study of this level (dissertation of limited scope - Masters). Voice recording constrained the interviewees less than video recording.

3.3.5.4 Transcribing

The fourth stage of the interview is transcribing the recorded data into written work. For this study the researcher was required to selectively transform the audio-recorded data into writing, though the words in a transcript are decontexualised as they are no more as solid as they were in the social setting of the interview. To ensure that as much non-verbal communication as feasible was transcribed, the researcher captured the different kinds of data audio-recorded during the interviews so that as full a context as possible of the discourse was displayed on paper (Gee, Michaels & O'Connor 1992). I also had to decide what was necessary and appropriate to capture in terms of texture of the talk, quality of voice, pronunciation, rhythm and intonation. Decisions were guided by the scope of the study; not forgetting the potential of data loss, distortion and reduction of complexity. A decision on the organisation of words on the pages and the layout of dialogue also needed to be made. The central aim was to make the transcripts as representative of the original interviews as possible.

3.3.5.5 Analysing

The fifth stage of an interview is analysing**.** At this stage of interviewing the collected data is coded and then interpreted. Coding is the ascription of a category label to a piece of data, with the category label decided in advance or in response to the data that have been collected. For this study there were two segments of discourse to be analysed. Each segment of discourse was the unit of analysis. One segment of discourse was the open-ended teacher-student interchange and student-student interchange; and the other was the students' written natural science work. Each segment was analysed with respect to vocabulary and students' understanding along a "continuum of knowing".

The vocabulary/phrases within each segment were coded according to whether the terms used represented classroom science talk or everyday science talk. By classroom science talk vocabulary is meant a wide range of science terms; from procedural terms such as observe and enquire to those that are closely aligned with science as a discipline like experiment and hypothesis testing. Included under classroom science talk was domain-specific vocabulary such as osmosis and root pressure. Student classroom science talk was coded according to where their explanations fell along a continuum of conceptual locality. Definitions and descriptions of natural science phenomena that were acceptable in natural science fell at the more distal point of locality of the continuum. Vocabulary was coded as everyday science talk when: (a) casual terms were used to describe natural science phenomena, experiences and observations; (b) objects, their data or procedure were referred to without having first established their existence in context (for example, it, this); and (c) students used informal talk or vocabulary to describe natural science phenomena or to describe observations that had no science meanings.

The collected data was analysed using the discourse analysis approach. This approach was used with success by Kimberley Gomez (2007). In this approach the data was analysed with respect to how the vocabulary (semiotic resources), formations (how the students said the semiotic resources), descriptions and explanations helped students gain understanding of the natural science concepts under investigation. The two segments of discourse were each coded according to whether the content was descriptive (that is, gave characteristics or listed processes without relating them to other processes or materials); relational (that is, connected description to function or to cause-effect); or explanatory (that is, gave the relationship between the description, function or cause-effect and the phenomenon). Student discourse was also coded with respect to whether their explanations were good; misconceptions; or confused, mixed up and difficult to follow. Explanations were considered good if the students used appropriate/acceptable terms and concepts in their classroom or everyday science. A misconception was the incorrect use of terms and concepts to describe a phenomenon. It could also be the incorrect or incomplete description of a phenomenon. Students' discourse was also characterised as located at a more proximal or distal conceptual point of discussion about scientific phenomena.

The natural science teacher's talk during the recorded lessons was analysed too. The analysis was based on whether the teacher used classroom or everyday science semiotic resources and formations to question, respond to, clarify, or even extend student's talk contributions during lessons. The natural science teacher's discourse was also characterised with respect to whether it was toward a more proximal or distal point of conceptual locality during interactions with the students.

3.3.5.6 Verifying

Verifying is the next stage of an interview and covers issues of reliability and validity of the data from the interview. Since the main cause of invalidity was bias (Cohen, Manion & Morrison 2002), I avoided being biased at all stages of the interview (except where that was inevitable). The main sources of bias can be categorised into characteristics of the interviewer (I) and respondent (students), and the content of the questions. A reasonable degree of reliability was maintained since the interviews were structured by means of an interview guide. The format and sequence of words and questions were the same for each interviewee (the natural science students). As the interview questions were open-ended they allowed important but unanticipated issues to come up during the interview. Leading questions were avoided to minimise bias in the interviews. A leading question is one which makes assumptions about interviewees or one which puts words into interviewee's mouths. The audio-recorded responses of the interviewees increased transcript reliability.

All the stages of the interview –, thematising, designing, interviewing, transcribing, analysing, validating and reporting – have to show some degree of validity. For this research the validity of the seven stages was catered for in the following ways:

Stage 1: Thematising

The theoretical framework was sound and the research questions linked well with the theory underpinning the research (social constructivism). All the research questions were answerable provided the natural science teacher adopted teaching methods which embraced social constructivism.

Stage 2: Designing

All the different aspects of the research design were adequately considered. The aspects included the research methodology (case study approach under qualitative research, with non-participant observation and the informal conversational interview methods employed); operationalisation (translating the research aims into research questions to which answers had to be generated from the data); sampling (purposive) and research ethics (mainly those that involved interpersonal interaction, such as informed consent, confidentiality and the consequences of interviews).

Stage 3: Interviewing

The data collected during the research was trustworthy since several methods were employed (triangulation). The methods for data collection were observations, interviews and documents. Triangulation improved the reliability of the data and thus the validity of the data collection methods for the research.

Stage 4: Transcribing

Though I did not video-record the lessons and interviews but instead audio-recorded those, most of the essential oral data was carefully translated into the written form. Even gestures were transcribed using connotations within brackets. In that way the essential information was not lost and the interpretations and conclusions drawn from the transcripts were valid.

Stage 5: Analysing

The method of data analysis, namely, discourse analysis, was suitable for the data and had been used successfully in similar studies in the past by other researchers. The coding system too was suitable for the qualitative data, thus interpretations of the data were valid.

Stage 6: Validating

Ensuring validity at all the stages of the interview, the observations and all the methods of data collection improved the validity of the whole study. It was the use of appropriate methods of data collection which ensured reliability of the data and thus validity of the whole research.

Stage 7: Reporting

The validity of the report of the study was approved by me, my supervisor (Prof. LC Jita), members of the M & D Committee and finally members of the general public. The report was in the form of a dissertation of limited scope.

3.3.5.7 Reporting

The final stage of the interview was reporting the results of the research. The report is a dissertation of limited scope. Because the research was qualitative the report bore word-based accounts. The report begins with an introduction. In the introduction are contained the theme of the study; the aim and objectives. An outline of the methodology follows. The methodology includes an outline of the design of the interview, the interview, the transcripts and finally an outline of how the data were analysed. The report also includes the results of the interviews. Discussed under results are, the data analysis, the interpretation of the data, as well as data verification. The report closes with a discussion of the interview data.

3.4 Demarcation of the field of study

The subjects for this qualitative research were high school natural sciences students. The study was undertaken from May 2011 to September 2011 in the eastern part of Swaziland. It was conducted at a high school where the researcher was currently teaching.

3.5 Summary

Chapter three opens with an introduction into the chapter. Then the qualitative research design is described. The case study design is then explained with extensive discussion of the sampling approach, the data collection methods and the instruments. The chapter concludes by engaging in a discussion on the validity, reliability and ethics of the study and also provide a clear demarcation of the field study.

CHAPTER FOUR

Findings of the Study

4.1 Introduction

In this chapter the findings are presented in the form of a case study of the teaching of natural sciences in one Swaziland high school, Tfolani Secondary School. This case study report begins with the contextual description of the school, where the academic environment is described with respect to how it influences student discourse in a natural science classroom. Data for the case study was obtained through interviews with teachers, observation of natural science lessons and analyses of classroom documents (including students' books) in order to identify evidence of student discourse in the natural science classroom. With this case study report, the researcher seeks to answer the following research questions:

(a) What characterises student discourse in the natural sciences classroom in some schools in Swaziland? In this question, I was interested in getting a detailed breakdown of student discourses within the natural science classroom in Swaziland. I wanted to understand in more specific terms who talked during class-time, to whom and about what specifically. What was the content and nature of those conversations?

(b) What is the meaning and role of such student discourse within the context of the natural science classroom? In this question I wished to understand what students thought of the classroom discourse and its significance for their learning of the subject matter. I try to explore what the teachers think of student discourse in their classrooms, and their own (and students') role in creating and sustaining such classroom discourse in the natural sciences.

(c) How can the observed student discourses and meanings be understood and explained?

The purpose of this study is to explore student interactions during natural sciences and thus suggest informed interaction strategies that will encourage student talk in natural science classrooms in Swaziland and elsewhere. Classroom observations, interviews and documentary evidence collected from students were used as sources of data for the case study.

4.2 The Tfolani high school case study

For the purpose of exploring student discourse in a natural science classroom, I focused the study on one classroom and conducted individual interviews with the respective natural science teacher. The selection of the classroom was based on its level (senior class) and on the Biology teacher (Mr Sameline) who agreed to participate in this research project. I also followed three natural science students, observed eight natural science lessons and collected student homework, test and examination scripts. The small number of lessons and students observed was to cater for depth as a qualitative case study is characterised by a few participants and in-depth analysis. The different sources of information helped in understanding student discourse in the natural sciences classroom. My premise in approaching the data collection was that science discourse includes reading, writing and all forms of communication within the science classroom.

Mr. Sameline (pseudonym) is the mathematics and science teacher in the Mathematics/Science Department at the school. The department has eleven mathematics/science teachers and three science laboratories. Mr. Sameline has been with the school for almost seven years since completing his Secondary Teachers Diploma (STD) in mathematics and sciences. Although Mr. Sameline was trained to handle science and mathematics at the junior level (Forms 1 to 3 or years 8 to 10 of schooling), he has been asked to handle the senior level

(Forms 4 and 5 or years 11 to 12 of schooling) as well. This is due to the shortage of science degree holders throughout Swaziland. Of the eleven mathematics and science teachers at the school, only two are properly qualified to teach at the senior level. Of the remaining eight, three are science degree holders but without an education qualification, two are degree holders in agriculture also without an education qualification, three are diploma holders and one is qualified at the certificate level. Mr. Sameline has been teaching these subjects for the past three years.

The school itself is a relatively big school in a rural community with about 850 students and 42 teachers. The school has one head-teacher and two deputy head-teachers. It is about 27km from the nearest small town, Siteki. English is the medium of instruction in the school, although most of the communication among and between the students is in SiSwati, their mother tongue and national language. The students do all the subjects offered in the school (core subjects) which are compulsory. The subject Biology is allocated seven periods (two doubles and three singles) of 40 minutes each, in a six-day cycle. The school opted for a six-day cycle instead of the government-recommended five-day cycle in order to accommodate all the subjects it offers in the timetable with enough periods.

4.3 The teaching and learning of natural sciences at Tfolani

I conducted classroom observations with a view to understanding how students interacted with their natural science teacher, with each other and with the natural science content during lessons. Eight Biology lessons were observed and five of those were selected for inclusion in this study as they were representative of all eight lessons. The natural science teacher (Mr. Sameline) and the three selected students (all in Form 4H) were interviewed before and after each lesson observation. The instrument used for data collection is included in Appendix X, including the pre- and post-observation interview questions. The instrument was adapted from Foreman (2008). Following is an analysis of the three ordinary (content based) Biology (Biology is taken as a natural science at school level in Swaziland) lessons and two Biology practical lessons, to illustrate specifically the discourse patterns within these lesson types.

4.3.1 Food tests: reducing sugars and fats (Practical lesson)

In our pre-observation interview, Mr. Sameline revealed that he had planned a practical lesson for the next biology class on food tests (reducing sugars and fats). When asked about which scientific concepts he thought some of the students would struggle the most with, he identified the observation of the series of colour changes during the test for reducing sugars as being potentially problematic for some of the boys in his class. He reasoned that the difficulty in colour observation for many of the boys was because of their assumed colour blindness. When asked how he would make up for this problem of colour blindness among the boys in his class, he proposed a mix of the boys with girls in each group. Indeed, as an example, during the practical lesson there was a disagreement among the three students I was observing about the colour changes.

4.3.1.1 Argumentative student discourse

Below is a five-minute transcript of the lesson to illustrate the student discourse and disagreement during the practical lesson (pseudonyms used for students):

Turn	Transcript
1	Vincent: Pour an equal amount (of water and the food solution). Thank you it's okay.
2	Sarah: Pour it (the equal amounts of water and food solution).
3	Sharon: Don't chachatel (don't shake).
4	Sarah: It won't change. (laughter)

5 Vincent: This thing will change. You will see miracles guys.

6 Sharon: It changed to yellow.

7 Vincent: It will change don't worry.

8 Sharon: It's changing slowly.

9 Vincent: If it wasn't equal amounts it won't change. Is it yellow or orange?

10 Sarah & Sharon: It starts from the top.

11 Vincent: No! Just observe. Just bean observer. Is this yellow? Not yellow.

12 Sarah & Sharon: It's orange.

13 Vincent: Not orange.

14 Sarah & Sharon: It's orange.

15 Vincent: We've finished the Benedict's solution. It will be a light blue colour. You write what you see since this is an experiment.

16 Sarah: We will say from blue to what?

17 Vincent: To this colour. Write this colour. If you're not sure write from blue to the colour I saw.

From the above transcript, Vincent could not agree with Sarah and Sharon in as far as the final colour of the solution during the test for reducing sugars using Benedict's solution in the food that was tested. An argument broke out during the final colour observation. The girls agreed between themselves that the final colour was orange, yet Vincent couldn't agree with them on both colours they were suggesting, that is, yellow and orange. Such arguments are beneficial since they enable learners to think at a higher level during classroom discourse. This was a classic example of the teacher's prediction and preparation prior to the lesson where he thought that the boys would likely struggle with observing the colours and colour changes.

Such minor disagreements among students are not misplaced within the science classroom. They often challenge students to read even more so that they are better able to substantiate what they say to their peers. In the foregoing instance as well, the argument was constructive since it did not bring about any personal differences between Vincent and the two girls. Vincent accepted the girls' observations that the colour changed from light blue (colour of Benedict's solution) to green, to yellow, and finally to orange. This is evident in the following transcript when Vincent answered Mr. Sameline about the final colour change:

Turn	Transcript
1	Teacher: What about the reducing sugar? What did you observe? What are your observations? Yes!
2	Vincent: The colour changed to orange.
3	Teacher: The colour changed to orange. Were there any series of colour changes?
4	Class: Yes.
5	Teacher: Can you list the colour changes you saw? Nhh! Yes. Green, yellow, orange, finally orange.
6	Class: Yes.
7	Teacher: You say that orange or brick-red. Brick-red. It's a colour that is close to orange. Angitsi? (Isn't it?)
8	Class: Yes.
9	Teacher: Brick-red or orange. Somewhere there! So, when you see these colours it means it's a positive test for reducing sugar. Because you don't have the time now, please try to copy these questions and try to answer them at home. At home. Okay! Thank you. But before you go try to clean the equipments. We need them clean.

Mr. Sameline's idea of mixing the sexes in the different groups, after his prediction of the problem of colour blindness among the boys, worked out well. Also, Vincent seems to have learnt something meaningful from the conversation and disagreement with the girls (objective 4 accomplished).

Below is another example of how student discourse was orchestrated through the practical lessons and how students seemed to be learning through this kind of discourse with each other. Another argument started when they did not agree on how to dissolve the food to be tested for fats in ethanol. Sharon (one of the students who tends to struggle with Biology) suggested that they had to dissolve the food in the ethanol by shaking, and Sarah (who is one of the best students the in Biology class) argued that the food had already been dissolved and thus there was no need for shaking. Sarah was supported by Vincent (who can be characterised as an average student in this Biology class) who agreed that they did not have to shake the mixture, although he did not give reasons for his idea. The short transcript below illustrates the argument:

> Sharon: You dissolve the food in ethanol.
>
> Sarah: The food is already dissolved. It is cooking in there (giggling and pointing). Why? Why are you crying? I think it is done in a clean test tube.
>
> Vincent: Yes! The clean test tube will be having water.
>
> Sharon: What is this?
>
> Vincent: It is the ethanol.
>
> Sarah: Here is the food. It is cooking (cooking oil). It is dissolved.
>
> Sharon: How many cubes?
>
> Sarah: It is enough.
>
> Sharon: You don't shake?
>
> Sarah: This one (pointing at the bottle of ethanol) is it not water? (Giggling)
>
> Vincent: Put the solution into hot water.
>
> Teacher: Not everything which is clear is water. Do you get me?
>
> Students: Yes!
>
> Vincent: You don't shake. Pour it.

While the mixed gender groups helped in shaping the discourse patterns as we have seen with colour issues, there was also another valuable consideration by the teacher in forming these groups with the Biology class. The mixed ability groupings were designed to enable the more capable students to help their less capable peers during the learning process (that could improve their natural science results). In this specific example, though, things seemed to have worked out the other way round; where the more capable students (Sarah & Vincent) misled the group such that it ended up getting unexpected results and therefore had to start afresh. Even after getting the unexpected results they did not try Sharon's suggestion but wanted to ask from the teacher where exactly they went wrong. So, mixing students of different abilities at times does not work out for the good of every student considering how Sharon's suggestion was ignored by her more capable peers and not even acknowledged after their teacher said they had to dissolve the food by shaking. The students were to blame in this practical since the procedure for testing the food materials for reducing sugar and fats had been written in tabular form on the chalkboard. Their carelessness is evident in the above transcript where Vincent said they had to put the solution into hot water; something done when testing for reducing sugar not fats. In studying student discourse patterns within the science classroom, it is clear from these examples that group work can both enhance student discourse with possibilities for improved learning, something envisaged by the aims of the study. However, on the other hand, as in the case of Sharon, group work can sometimes stifle student discourse with possibilities for reduced learning, if not properly monitored.

4.3.1.2 Teacher role in classroom discourse

It is interesting to follow the role of the teacher during these practical discussions. For one, Mr. Sameline was responsible for setting up the scene by outlining what needed to be done during the practical lesson. Another positive aspect arising from this practical lesson was that Mr. Sameline often came in to refine the students' answers by giving them the "expected answers" such as the colour brick-red (a biological terminology) as an improvement to orange (which is an everyday vocabulary). Mr. Sameline therefore helped the students move along the continuum of knowing from the proximal point to the distal point of locality. A similar instance was when Mr. Sameline gave the students the term white emulsion to replace milky white colour (see the following transcript).

Teacher: So, for the fats what did you observe? Raise up your hand and talk to the class. Nhh! What are your observations in the test for fats? Your results? You observed nothing? Nhh! Raise up your hand! Yes Thwala!

Thwala: We observed a milky white colour.

Teacher: He observed a milky white colour. Angitsi? So, what name can you give to that colour that you saw? Nhh? You observed – we call it a white emulsion. This is a colour that is milky. Is a milky colour. Did we all observe it?

Class: Yes!

4.3.1.3 Student experimentation

Practical lessons are also good for students since they help develop their manipulative skills as the lesson usually involve hands-on activities. The students get to know and use the laboratory apparatus more and better. They even go further and experiment with what has not been specified in the procedure; thus fulfilling the fourth objective of the study. This gives them answers to certain questions and gives them a chance for discovery; though they may find themselves risking their health or even lives. Below is a transcript revealing the students' mischief, where they wanted to find out what the result would be if they used cold instead of hot water for the experiment.

Vincent: If you put it in cold water it will change again?

Sarah: It can.

Vincent: It can. Let's try it.

Sharon: It is true.

Vincent: You see it cannot change.

Sarah: Let us not do it because we've not talked to the teacher.

Vincent: Try it with cold water if you want to pay for it.

Sarah: We have to wash this.

Here the students hid away from Mr. Sameline what they were doing since they were afraid of being punished for it. However, their exploration yielded positive results which they needed to interpret and could have been beneficial for the whole class to discover that temperature is a factor affecting the rate of reaction.

4.3.1.4 Discourse sharing

The group that had the students I was observing was the last one to finish the food tests. Part of the explanation for their slow pace may be attributed to weak background knowledge and their refusal to ask from other groups. Their disagreements leading to debates also delayed them such that the whole class had to wait for them before a class discussion of the results could be conducted by the teacher. Vincent was the one who was strongly against getting help from the other groups. With him everything had to be asked of the teacher.

This practical lesson was dominated by student talk; which was a positive aspect. The teacher dominated only the introductory and conclusion stages of the lesson, both of which accounted for about twenty per cent of the lesson time. Such lessons give students opportunities to learn from each other, share information and materials, secretly experiment with certain concepts, explore new ideas, develop practical and intellectual skills, lay a concrete base for more abstract concepts for future learning, as well as develop confidence and love for the subject, thereby meeting all the objectives of the research. A practical lesson also caters for all the students with their different learning styles. A practical lesson makes students feel they own the lesson by making them responsible for the results and ensuring the practical is done within the lesson time.

Though a practical lesson encourages student discourse unfortunately for this lesson the students never asked their teacher a direct question pertaining to the practical, or gave a well thought out answer to their teacher. The most frequent answer they gave their teacher was, “Yes” in a chorus. That was only after asking them his most frequent question “Are we together?” or “Angitsi?” But the students are not fully to blame as their natural science teacher never asked them a question needing an elaborate answer during the practical. In fact in the pre-observation interview I conducted with Mr. Sameline he described the students as reluctant to talk.

Extract 1

Vincent: Yes, the clean test tube will be having water.
Sharon: What is this?
Vincent: It is the ethanol
Sarah: Here is the food. It’s cooking, it is dissolved.
Sharon: How many cubes?
Sarah: It is enough
Sharon: You don’t shake?
Sarah: This one is it not water? (Giggling)
Vincent: Put the solution into hot water.
Teacher: Not everything which is clear is water. Do you get me?
Students: Yes!

Extract 2

Sharon: Even if you can shake.
Vincent: We started by shaking. That’s where we had it wrong.
Sharon: No shake here.
Sarah: We shake the solution and then pour it.
Sharon: There is no written shake here.
Vincent: But they say dissolve the food in ethanol.
Sarah: Which means we need to shake so that we can. When you dissolve it you need to shake.
Teacher: The procedure there says you have to dissolve, which means you have to stir or shake. How do you dissolve sugar?
Sarah, Sharon & Vincent: We shake it.
Vincent: You shake Sir.
Teacher: You simply put the sugar there and stir the thing.
Sarah & Sharon: You stir.

Vincent: Wow! Let’s start afresh guys.

From the two instances one is left with the view that Mr. Sameline has the task of teaching his students to ask him questions or to immediately seek help when in doubt during a lesson. That will help them move with the teacher and not be left behind. In both instances one wonders what would happen had the teacher decided to ignore the students and leave them arguing. It would appear that orchestrating student discourse in this classroom instance is a complex process that is full of contradictions. On the one hand, the students seem to be reluctant to seek the teacher’s intervention in certain instances and would rather argue among themselves. An interesting point to ponder therefore in trying to understand student discourse is the teacher’s role in shaping the discourse.

The practical lesson allowed the students multiple opportunities to freely use other forms of communication such as gestures and facial expressions. Raising the tone of the voice was also used by the teacher, and the students as well, when emphasising a point. The natural science teacher would, at times, also repeat what he would have said as a way of emphasising his point.

Another good thing about a practical lesson is that it allows students to share ideas and thereby promote student discourse about science. This was more so in cases where the students took their discourse across groups by comparing their experiment with those of other groups. Unfortunately for this group it did not compare its results with those of other groups and it had to seek correction from the teacher since it had missed the procedure somewhere along the line. Below is a short transcript of their argument about sharing of information:

Sharon: Let’s compare our work with others.
Vincent: Don’t compare our work with theirs!
Sarah: Let’s go and get a written report.
Sharon: We mustn’t transfer guys.
Vincent: Don’t look at somebody’s work!

Sarah: Let's continue to do the reducing sugar.

From this transcript one can tell the characters involved in the decision-making about whether or not to share with others. The girls (Sharon & Sarah) favour the idea of seeking help from other students. Vincent on the other hand refuses to get help from other students. Vincent, instead, preferred getting help from their teacher rather than from their peers, as shown by the transcript below:

Vincent: Where do you put the glucose? Here is the hot water.

Teacher: Make a solution of the sugar. Have you done that?

Vincent: We are waiting to do it.

Teacher: Where is the sugar solution?

Vincent: She's coming with it. We started afresh sir. We did not shake.

It was after making a solution of the food by dissolving it in water through shaking that they realised the results. A practical lesson, therefore, teaches learners the worth of following the procedure as indicated and avoiding taking short cuts or being negligent. Of significance in this transcript is also how the students' discourse tends to be shaped by the teacher's interventions. The students tend to seek these interventions to feel more secure and assured during their own discourse about science in the classroom. To return to the issue of following procedures, Mr. Sameline stated the idea of following the procedure and being observant right from the beginning of the lesson while introducing the practical to the students. Here is how he stated this:

Teacher: This is where you're going to get hot water in there. Get some beakers from your tables and collect the hot water and put in the test tube with Benedict's solution and the solution of the food. If there is any question that you have you can see me as I'll be moving here checking your observations and procedures. Any problem? So, once you're through with the table you can start. Fats are here. You can come I'll give the fats and glucose powder and then you go and conduct the experiment. Okay! It's up to you which one you start with, but what is important is to follow the procedure. You follow the procedures and have to observe what is happening. The students who needed to comprehend the scientific term "solution" as they were expected to make a solution of the sugar before adding Benedict's solution; which is exactly what the teacher emphasised to the group. When summarising the lesson Mr. Sameline emphasised that students are expected to raise their hands before answering a question. That was one of the rules he gave the class from the beginning of the school year; but they would answer seated. The group seemed to have serious problems with following procedure. Even when they had to test their food for the presence of fats they made another blunder. They realised the blunder after getting negative results. It seems they needed Mr. Sameline or a more capable peer to help observe them as they performed every step of the procedure. Again they did not shake the food with ethanol as a means of dissolving the food. Here is their conversation after comparing their results with other group's results and realising something had gone wrong.

Sharon: What happened to ours? May be we had a lot of water. They put the ethanol in a lot of water.

Sarah: It's ethanol. It's written. Maybe we did not shake. But look the colour is like this one.

Sharon: Even if you can shake.

Vincent: We started by shaking. That's where we had it wrong.

Sharon: No shake here.

Sarah: We shake the solution and then pour it.

Sharon: There is no written shake here.

Vincent: But they say dissolve the food in ethanol.

Sarah: Which means we need to shake so that we can. When you dissolve it you need to shake.

Looking at the first term of the transcript above Sharon uses a description which indicates her vocabulary to be at the proximal end of the continuum of conceptual understanding. She says the ethanol was put in a lot of water instead of using the term dilute. Mr. Sameline also made a mistake when trying to correct the group. He did not ask them which substance they were testing for and at what stage they were. He assumed they were testing for reducing sugars yet they were doing a test for fats. The students also did not correct him, as is revealed in the following short transcript:

Teacher: The procedure there says you have to dissolve, which means you have to stir or shake. How do you dissolve sugar?

Sarah, Sharon & Vincent: We shake it.

Vincent: You shake Sir.

Teacher: You simply put the sugar there and stir the thing.

4.3.1.5 Language effects on discourse

The teacher in the last line (of the above transcript) is also making a mistake of using the word “thing” as students tend not to be specific and call items things instead of calling them by their names. An example is the following transcript where Sharon and Vincent use “thing” instead of the proper names of what they are talking about:

Vincent: We’ve to make it equal amount. Don’t shake your body!

Sharon: Here is the thing.

Vincent: Never ever without washing this equipment.

Sarah: It first comes up and then the colour changes to cloudy colour and the fats come on top.

Sharon: It seems like there is some bubbles.

Others: Yes!

Vincent: This thing is separating itself.

Sarah: Let’s write. It’s okay.

Sarah, Sharon & Vincent: Colour changes to cloudy and the fats come on top.

Sarah: Cloudy white or whitish.

Vincent: The white thing. Is it not the ethanol?

The last “thing” used by Vincent in the transcript could better be replaced by substance. Vincent is also using a wrong word (white) to describe the appearance of ethanol, instead of clear. But this may be due to interference from the mother language SiSwati where the same word is used for clear and white. Another bad language practice for a science classroom by Vincent is not calling apparatus by proper names, whereas a practical lesson is good for them in that they talk about and handle the apparatus as they do the practical. Vincent called a test tube a glass. Mr. Sameline made a vocabulary mistake almost similar to Vincent’s during his introductory remarks of the practical lesson. He used the word boil instead of heat when referring to the procedure for testing food for reducing sugars. He should have said you then heat the solution in a hot water bath instead of saying “you boil the solution in a hot water bath”.

4.3.2 Testing a leaf for starch

In a pre-observation interview with Mr. Sameline he said in the next Biology lesson he would be teaching the students about the procedure to be followed when preparing a leaf for a starch test. This lesson was dominated by teacher talk, as opposed to the first lesson on food tests. Teacher talk accounts for more than 90 per cent of lesson time and was done in most cases while writing notes on the chalkboard for the students to copy into their notebooks. During note taking the only talk one hears from the group is the teacher’s. The laboratory becomes so quiet that when passing by with the door closed one may think there is no lesson in progress. The teacher talk dominating the lesson is in accordance with what all the three student interviewees said during the pre-observation interviews, that it is their teacher who talks a lot during lesson time.

When interviewed about talk during lesson time the Biology teacher, Mr. Sameline, also said the students do not talk much and it is only those he gives permission to talk that do so. According to him, during a formal lesson everyone who says something should let the whole class know what they are talking about.

Another reason the teacher gave for students being reserved during lesson time was being afraid of giving a wrong answer in the presence of their colleagues. So, in general he described his Swazi students as shy. That the students are reluctant to talk is evident in the present lesson since not even one question was asked by the students of Mr. Sameline (something to be taken care of by objective 2). The only time they talked was when answering questions from Mr. Sameline; and even then they were brief. When interviewed just before the Biology lesson Vincent said it is important for students to talk during lesson time and he talks during lesson time when allowed by the teacher to do so. But the lesson observation session came out with a different story – the boy did not talk at all during class time. When interviewed about it after the lesson his reason for being quiet during the lesson was that he found the concept difficult and was left behind. So, while quiet during the lesson he said he was trying to think about the concept so that he would catch up with the teacher. Then, if it is the case that students remain quiet mostly because they are left behind, then it is no wonder that they tend to find the sciences difficult as a subject. Instead of stopping the teacher for clarification where they have difficulty they prefer to keep it to themselves to sort it out on their own after class. Getting help from other students during lesson time becomes difficult in Mr. Sameline's lessons as he does not allow for private talk (something defeating the fourth objective). Vincent claimed he secretly tried to get help from colleagues during the lesson. The questions he would ask them now and again during a lesson, "Are we together?" and, "Angitsi?" had just become habitual interjections to the students. These interjections no longer held meaning or significance for them. Their usual answer to the questions, "Yes", which they sing out as a class is also taken by the students as a habitual response. Even when they have been left behind they just follow everyone and say, "Yes". When interviewed, also before the lesson, Sharon understood the requirement for silence by the teacher when she argued that students should not be allowed to talk during a lesson as that disturbs the teacher and the other students as well. This means that Sharon is against the idea of quietly seeking concept clarification from friends while the teacher is busy teaching.

The main concern here is, if a student fails to understand in class and hopes to understand later, how does that student perform the practical successfully in the next biology lesson without having had time to seek help after the formal lesson? Then what happened during the previous Biology practical lesson where Sarah, Sharon and Vincent messed up the test for fats is highly likely to happen even when they have to test a leaf for starch. Should the students keep piling up the concepts they do not understand? If so then how will they pass a test on those concepts or even an examination (internal or external)?

The Biology teacher's questions are such that the students answer by giving a word or a short sentence, which is not good for encouraging substantive student discourse in the classroom. When a test or examination question requires them to describe, explain or even apply their knowledge of the concept the students are often faced with serious difficulties. The Biology teacher ends up not asking such questions in class since when the students are asked such questions they just ignore them and never answer, so that the teacher ends up answering the questions. But at times the teacher does not give the students enough thinking time either. Should the students be lazy to read on their own, and just rely only on what the teacher gives them in class, then they are more likely to get some things wrong just because the teacher made a mistake in class. This is with reference to the third stage of the procedure where the teacher just said the leaf needs to be rinsed in water. He did not make it clear that it should be rinsed in *hot* water. The hot water softens the leaf so that it can easily be spread on a white tile for application of iodine solution and observation of any colour change. The point here is if the students were indeed following the lesson and had verbal input, they would seek clarification from Mr. Sameline right away.

Another thing Mr. Sameline does in this lesson is to restate and even extend a student's answer. This is done as a way of showing appreciation and approval of the student's answer and is also a way of motivating students to talk during lesson time. Extending a student's answer enriches their semiotic resources and formations and also improves their conceptual understanding, thus moving them from the proximal end of the continuum of conceptual locality towards the distal end. When the students use the classroom science resources and formations during classroom discourse they then gain confidence in the topic investigated and do even better in tests and examinations.

The issue of language comes in again in this lesson as it did in the previous lesson on food tests (reducing sugars and fats). But this time it is not with regard to interference, instead it is a little use of SiSwati when explaining the danger of using a naked flame from a Bunsen burner when boiling the leaf in water. From my observation of the students during the lesson the students tend to pay more attention to what the teacher says once he starts putting it in SiSwati. The code-switching interests and alerts them that something good or important is now being said by the teacher, so they should listen attentively. Some authors support the idea of code-switching to the mother tongue of the students as they say it improves their understanding of the concept taught. The same argument applies to allowing students to even use their mother language when talking in class, it improves their confidence and even the reserved ones begin to talk. At times students do not answer in class because they find that they do not have or cannot immediately recall the appropriate English or science vocabulary to use and thus keep quiet.

Sarah was the only student of the three (in fact of all) to answer Mr. Sameline's questions during the lesson. She answered the first question posed by the teacher. Her answer ("… to see if there is any starch in the leaves") was not exact and the teacher reinforced it. When Mr. Sameline reinforced her answer it was his kind way of correcting her ("You can add by saying that to find out if photosynthesis takes place.”) and at the same time move her towards the distal end of the conceptual locality by using classroom science formations. She was using life/world or everyday science resources and formations when saying “… to see if there is any starch” and the teacher improved that everyday science discourse to the more domain specific classroom discourse “… to find out if photosynthesis occurs”. So, when a student talks during a lesson the teacher gets the chance of telling where they are along the continuum and then knows how much to move them towards the distal end. The teacher may even be able to decide whether to repeat the lesson using different teaching strategies and aids or give the students more work for practice sake. When a student talks the teacher gets the chance to know if the student just has a narrow understanding of the concept or holds misconceptions about the concept. With Sarah’s answer it was clear to the teacher that she just had a narrow understanding and needed her answer to be extended. The second answer she gave to another question was satisfactory and the teacher only restated it as a way of conforming it to the other students that they could take it like that (permeable means “to allow some molecules to pass through it”). Gestures were used during the lesson by both the teacher and his students. The students raised their hands as a way of indicating their willingness to answer a question from their teacher (as they never asked him any question nor asked each other through the teacher). At times some students would nod their heads when saying “Yes” to the teacher. The teacher at times pointed at the student he chose to answer a question and even demonstrated some aspects of pertinent concepts by using gestures.

4.3.3 Cross-sectional structure of a dicotyledonous leaf

The third Biology lesson I observed was a 40-minute period where Mr. Sameline was teaching his students about the cross-sectional structure of a dicotyledonous leaf. The lesson was dominated by teacher talk (teacher-centred). Student-student communication during the lesson observations was restricted to very quiet whispers and mostly gestures. The most frequent interactions were the teacher-to-student talk (which accounted for about 70% of class time), followed by student-to-teacher talks (which accounted for about 30%of lesson time). The teacher engaged his students in the lesson by making them identify parts of the leaf from the cross-section by using a fully-labelled diagram given in a handout at the beginning of the lesson. They also had to relate the features (the size, structure or position) of those leaf parts to their functions (objective 4). the students, with their teacher, were expected to use descriptive semiotic resources and formations (they had to identify and give characteristics of the features of the leaf using the appropriate vocabulary and phrases or sentences without relating the features to their functions) and then relational and explanatory semiotic resources and formations (they then had to connect the descriptions of the features to their functions and also explain the relationships between the features, their functions and photosynthesis using the appropriate vocabulary). In an effort to enhance understanding of a cross-section of a dicotyledonous leaf Mr. Sameline picked a leaf from outside the laboratory to demonstrate to the class how to make a cross-section. He then compared the cut edge of the leaf with that presented in the handout.

The issue of students being afraid to ask the teacher questions came up again in this lesson. At one point during the lesson, the teacher (Mr. Sameline) made a grammatical mistake and the students did not venture to make him aware of it. When he said "…the larger air spaces are found only in the spongy mesophyll cells" instead of saying the larger air spaces are found only between the spongy mesophyll cells or "the larger air spaces are found only in the spongy mesophyll layer," the students simply kept quiet and wrote what the teacher said. In the present case when the teacher asked the students, "Do you notice that?" they sang the usual chorus, "Yes." instead of alerting the teacher about the mistake. Of course it could not be that not a single student noticed the teacher's mistake, but those who did would not venture to make him aware of it. That these students have a tendency of keeping content problems to themselves during a lesson is evident in this example and in the under-mentioned case:

Teacher: That is, if you're able to label all the different parts of the cell it means that you're able to identify each and every cell in the cross-sectional structure of the what, of the monocotyledon what, leaf. Siyevana mosi? (Are we all clear?)

Students: Yes (faintly).

This time it was clear that some of the students realised their teacher had confused things. Only a few responded to his common question. "Siyevana mosi?" which can loosely be translated to "Do you hear me?" Even this time not one student was bold enough to inform the teacher that his last statement was confusing because he had now referred to a monocotyledonous instead of a dicotyledonous leaf they were working on during the lesson. May be the teacher should also have interpreted their faint response as a signal that something was wrong with the explanation he had just given them. The teacher's explanation at that point could potentially be confusing and difficult to follow.

Another important issue that keeps coming through in the teacher's discourse in the science classroom is the issue of the use of "everyday talk" by the teacher. The use of the word "thing" was observed in several lessons as highlighted earlier in the discussion. For instance, when the teacher was talking about the position of the cuticle in the cross-section of a dicotyledonous leaf, he said "Another thing that we can add here is that the, the cuticle we have it on the upper part of the what, of the leaf."

The problem that results here is that of the delay in the development of the proper scientific vocabulary by the students since they would copy from their teacher and generalise, instead of using appropriate and specific vocabulary. Another problem with students is the use of a pronoun such as "thing" without having first mentioned the name of the "thing" (noun); a practice that places their use of scientific resources and formations at the proximal end of the continuum of conceptual development. Similarly, the use of prepositions by students in science discourse is a big problem at times. Students tend to use prepositions without having earlier mentioned their nouns or pronouns. This tends to confuse students, however, when their science teacher does the same thing during the development of new concepts, especially concepts that involve describing a biological process with several stages. During the present lesson for example, the teacher used the prepositions “there” and “it” several times when explaining the diffusion of gases in and out of a leaf during photosynthesis. Though the teacher would first mention the noun before using its preposition, the repeated use of the prepositions could be a problem to students who are still trying to follow the process and at the same time trying to understand the concepts during the lesson. Below is an extract from the transcript of the lesson to illustrate this repeated use of the prepositions “there” and “it” during the lesson on photosynthesis:

> Teacher: Ehh, we move on to where?
>
> Sarah: Air spaces.
>
> Teacher: Where are we? Okay air spaces. That is, the spongy mesophyll allows gaseous exchange. So, like carbon dioxide to the cells and oxygen from the cells during photosynthesis. We know that in the process of photosynthesis carbon dioxide is used. Angitsi? (Isn’t it?)
>
> Class: Yes!
>
> Teacher: So, it comes from the atmosphere and it has to get into the plant through the stoma. Angitsi?
>
> Class: Yes!
>
> Teacher: And from there it diffuses into the leaf cells. And then after photosynthesis we know that one of the products is what, is oxygen. So, the oxygen has to diffuse out of the cells. So, when it diffuses it diffuses from there into the air spaces. From there, out through the stoma. Are we together? That is why there are some air spaces there. And we have the vascular bundle. The vascular bundle consists of the xylem vessels and the phloem what, vessels. The xylem vessels and the phloem. So, this is the leaf vein made up of xylem and phloem. The xylem consists of what – koja? The xylem carries water to where?

Class: Water to the leaf.

The repeated use of prepositions by the teacher could potentially affect the students' conceptual understanding of the concepts and processes. Some students consequently use prepositions without introducing their nouns or pronouns first.

As the lesson proceeded, we encountered another confusing part where the teacher's explanation was not clear. The teacher approached the discussion as if the students already knew the biological term he was introducing. The word is translocation and here is how the teacher introduced it:

Teacher: From the leaves. The sugars are made from the leaves during photosynthesis and they have to be carried from where they are made to where they are needed, which is the other parts of the cells, for what? For respiration. Do you see the site? The xylem supplies the leaf with water and the phloem carries the sugars to where they are needed. For what? For?

Class: Respiration.

Teacher: Because we know that respiration requires what? Sugar, angitsi? To be combined with oxygen and then energy is given out. So, the vascular bundle is made up of xylem and phloem. Xylem brings water to the leaf. Phloem vessels transport sugars and amino acids away. This process is called translocation. So, this process is called translocation. Any problem? We move on. We're just relating the features to the function. Are we together?

Class: Yes.

In the above extract it is not clear what exactly the definition of translocation is. Only someone who already knows the definition would be able to pick it from the teacher's explanation. So, the teacher's explanation at this point is rather confusing. The term translocation could have been better introduced in the teacher's earlier introduction in the extract. Confusion and misunderstanding might have arisen when the teacher asked the students if they could see the site since the teacher did not specify what site he was referring to. So, the students did not answer that question, a pattern of the classroom discourse where students keep quiet when in doubt, rather than alerting the teacher about their misunderstanding or confusion. Again, during the next explanation, after introducing the term translocation, the students simply mumbled when the teacher asked them for any problem (the teacher paused at that point but did not follow up in order to clarify what their mumbling was about).

Another vivid influence of language on the classroom discourse that was evident in this lesson occurred when the teacher was discussing the lower epidermis. The teacher said that the stomata are "located below the leaf". That was a direct translation from the mother tongue, SiSwati. This explanation of the location of stomata may lead to misconceptions to a learner whose mother language is not SiSwati or in whose mother language this carries a different meaning.

I was also interested in understanding potential links between student classroom discourse and their performance in the subject. During the present lesson Sarah (the best student in Biology in her group) answered five of the teacher's questions, Vincent (the average student) answered four questions, while Sharon (the below average student) answered only two questions. Knowing the performance of each of these students in Biology, I was left wondering whether the student talk and participation in class could result in the observed patterns in terms of performance. From this observation therefore, I am wondering about the difference it would make to learners' performance if the teachers were to encourage student talk during class time, for active learning of all the students. Active learning makes students feel like they own the responsibility to learn and achieve better in the subject. An interesting thing about Sarah is that in her answers she was using relevant semiotic resources such that her talk can be classified as classroom science talk instead of everyday science talk. An example is her answer to Mr. Sameline's question about the reason for the presence of air spaces in the spongy mesophyll, where she said they are present "to allow gaseous exchange". Though the answer is not complete a she should also have stated that the gaseous exchange would be between the leaves and the atmosphere, but the science semiotic resources and formations used were evident.

Vincent too gave an interesting answer when the teacher asked the class why there were more chloroplasts in the cells of the palisade mesophyll than in those of the spongy mesophyll. His answer was that: "Because it is a main region for photosynthesis". Though his answer is correct, it is weakened by the use of the pronoun "it" without introducing the noun first. As for Sharon, on her first attempt to respond to the teacher's call for the naming of more leaf parts from the handout, she gave the cuticle as the next part they could discuss as a class. When she pronounced the term "cuticle" that sparked giggling and soft laughter from the other students, which quickly died though. Mr. Sameline made no comment about Sharon's unusual pronunciation of the word or about the other students' giggling and laughter. This giggling and laughter were exactly what the teacher mentioned during our pre-observation interview as a deterrent to the students from talking during a lesson. Mr. Sameline just brushed everything aside and led the class in the discussion. He did not caution the class against such misbehaviour as it discourages the students themselves from talking in class. From the students' point of view one only has to answer when one is sure about the answer to the teacher's question, otherwise by answering in such a class you are exposing yourself to possible humiliation and embarrassment.

In the instance described above, Sharon gave a correct response but she just pronounced the word in an unusual way. One then wonders how the other students would respond had she given a wrong answer or one that was completely out of context or topic. Would any student in this group then dare try to answer if they are not sure of their answer or if their pronunciation or vocabulary is not up to what is expected? These factors obviously relate to the theory that embarrassment and humiliation are some of the greatest threats to teenage students' active participation during the natural science lessons. To make matters worse for Sharon, the incident occurred about twenty minutes into the forty-minute lesson, which means that for about half the lesson time Sharon was trying to recover from the humiliation and probably not learning as actively as she could have. No wonder she admitted to Mr. Sameline that she had not done the homework he had given them when it was her second turn of talk (and the last one) during the lesson. One may never know if she indeed had not done the homework or she was still feeling embarrassed. The teacher did not acknowledge her or any understanding of her feelings. Below is a short transcript of their talk:

> Teacher: You did not write!
>
> Sharon: Yes.
>
> Teacher: Why? (Teacher moves on to next student)

Here the teacher did not wait for an explanation from Sharon for not doing the homework. He simply moved on to the next student like he was ignoring Sharon. Considering what happened to the girl during the lesson and the way the teacher handled the matter, it is not surprising that the girl was performing below class average.

4.3.4 Practical: The cross-sectional structure of a dicotyledonous leaf

I was also able to observe another forty-minute practical lesson on the cross-sectional structure of a dicotyledonous leaf in the science laboratory. The lesson was, like the first practical lesson I described earlier, dominated by student-student talk. Student talk (student-student and student-teacher) took about 80% of lesson time while about 20% was taken by teacher-student talk. Comparing what transpired in the last practical lesson with the present lesson, one may conclude that practical lessons, in this case study, allowed students relatively more time to interact freely during lesson time. The most common and notable kind of interaction was “classroom talk”. During a practical lesson students get the time to share information, laboratory equipment, as well as practical materials. Their social lives are developed in addition to their academic lives. Teacher talk was common only during the introduction and conclusion stages. Between these two stages teacher talk did not dominate class talk as the teacher was moving from group to group facilitating the smooth running of the practical.

4.3.4.1 Student engagement with the teacher

The teacher’s movement between groups was helpful to some students who would not normally engage, like Vincent, who had the courage to ask Mr. Sameline a question, something he would not ordinarily have done during lessons. Here is an extract to illustrate this point:

> Vincent: The, the, sorry sir! That thing can stay for more than ten years?
>
> Teacher: Yeah! It can stay for long. It’s a prepared slide. Okay, you can prepare your own, but it won’t last. It was specially designed for. So, we have got many types of slides. Some are plant cells, blood cells. So, please try to be fast because now we don’t have enough time.

From the way Vincent called for the teacher’s attention one can tell that he was hesitant about his action. The fact that he repeated “the” shows that he somehow felt he was doing the wrong thing or else the right thing but using the wrong approach. The problem of non-use of scientific vocabulary comes up again in his second sentence where he referred to a prepared slide as a “thing”. The teacher, in his reply, gave Vincent the proper name for the “thing” and thus helped him move from the use of everyday science resources to classroom science resources. However, it is worth noting that the teacher did not openly discourage Vincent from the use of the word “thing” instead of the exact word.

Another advantage of a practical lesson is that it gives students hands-on experience of what they have been taught or are going to learn. During practicals the students also get the opportunity to familiarise themselves with the appropriate vocabulary. Arguments are one way of improving concept development, classroom scientific resources and formations, as well as the ability to talk (scientifically).

4.3.4.2 Argumentative classroom discourse

Two arguments broke out during the practical lesson among the students in the observed group. The first argument was about specimen identification, while the second was about an insectivorous plant. Here is a transcript of these discussions:

Turn	Transcript
1	Sarah: It is bitter. This thing
2	Sharon: It is this thing. Is umdolofiya.
3	Vincent: Let's wait for the teacher mani!
4	Sharon: This is a dolofiya. What is this? The inhlaba.
5	Girl: An aloe.
6	Sarah: It is not inhlaba.
7	Sharon: Emahala.
8	Sarah: You are lying.
9	Sharon: No! Don't say I'm lying. In my grandmother's field there is this thing.
10	Vincent: Please, somebody take this thing and put it somewhere.
11	Sarah: May you please borrow me a sharp pencil?
12	Teacher: So, besides using the leaf model, you can also use the microscope. It is there.
13	Vincent: Let's ask the teacher.
14	Sarah: About what?
15	Vincent: If it is the same with this.
16	Sharon: When it is cut?
17	Vincent: Yes!

18 Sarah: I think is the same.

19 Sharon: What type of a leaf is this?

20 Sarah: It is like this.

21 Girl: Is it a monocot or a dicot?

22 Sharon: Is a monocot.

23 Vincent: Who told you?

24 Sharon: I know.

25 Vincent: Who told you? (even louder)

26 Girl: Just be specific.

27 Sharon: Where are the xylem and phloem here?

28 Girl: Can I find the same thing here?

29 Vincent: That's why I said we must ask the teacher.

The students had problems with the identification of most of the plants shown on the chart. Their serious problem was whether those plants on the chart were dicotyledons like the one they had in the handout they were given in the last Biology lesson. From turns 13 to 18, we see the core of the argument, that is: Are cross sections of the leaves of the plants on the chart the same as the cross-section of the dicotyledonous leaf given in the handout? Sarah was for the idea that the cross-sections would be similar. Vincent and Sharon were not sure while Vincent insisted that the answer be sought from the teacher (turns 3 & 13). Turn 19 also reveals the same problem of identification, but now involving comparison. They simply had to compare the leaf model with the cross-section in their handout; which Vincent and Sharon were failing to do. But Sarah identified the cross-sections as similar (turn 20). Sharon made a mistake and said the model was a cross-section of a monocotyledon (turn 22), while Vincent was not sure of Sharon's answer (turns 23 & 25). Vincent could not believe both girls and insisted on asking the teacher for help (turn 29). Again it becomes clear in this conversation that Vincent appears to be a student who does not believe in getting information from other students but relies on the authority of the teacher. In this case, and previously, he insisted that the group needed to ask the teacher. So, with Vincent only the teacher is a more capable peer and is the only one to help him along the continuum of concept understanding. This poses particular problems for learning through discourse simply because of the way it pre-determines and structures the discourse in the classroom. With this understanding of authority on knowledge, it would be clear why Vincent would prefer a teacher-dominated discourse pattern rather than the other students in the group.

From this extract we again observe the use of the word “thing” by the students to refer to different entities. In turns 1, 2 and 9, by the word “thing” the students were referring to one of the plant species from the chart, whereas in turn 10 Vincent used the word “thing” to refer to the researcher’s voice recorder. So, the usage of the word “thing” is now habitual to the students and this might be what one may expect to find in their written work as well. The present argument seems not to have benefited the students since they did not come to a consensus on the species identification and also did not make progress on the work they had been tasked with, that is, making the drawing of the cross-section of a dicotyledonous leaf as seen under the light microscope or of the model. The value of this particular discourse for learning is thus unclear.

The second argument broke when Sharon identified one of the plants from the chart as insectivorous. Next is an extract of the transcript of the argument:

Turn	Transcript
1	Sharon: Here is the plant that eats insects.
2	Sarah: Ha! Ha! Ha!
3	Sharon: Really! It eats insects.
4	Sarah: I also know it in Malolotja.
5	Sharon: In the wetlands. When a fly came.
6	Sarah: Look, when it came it close and then.
7	Sharon: It close not eat.
8	Sarah: And then it digest the animal.
9	Sharon: It doesn’t get nutrients in the soil but it gets it from the insects.

10 Sarah: It digest it.

11 Girl: Does it chew it?

12 Vincent: It does not chew mani! Don't be lunatic mani! It does not eat. You won't see it chewing! It digest the insect.

13 Sarah: Yes!

14 Sharon: Who asks the whys?

15 Girl: What happens to the bones?

16 Sarah: We don't know.

17 Vincent: You have to ask the teacher.

18 Sarah: Does insect have a? It doesn't have bones. Not a bone.

19 Sharon: It is a hard thing.

20 Sarah: Not a bone.

21 Sharon: It was closing and then I opened it up and found the insects.

22 Vincent: At, at Malolotja?

23 Sharon: Yes!

24 Sarah: I was there. Even me I went there! I didn't open it.

25 Sharon: It takes a long time to digest. The old madala told us.

In the above transcript Sarah and Sharon were the ones who knew more about the insectivorous plant. Vincent did not know about the existence of an insectivorous plant but he supported his two colleagues when bombarded with questions by the other members of the group. In this case, the argument leads to some learning in that it tests their conceptual understanding as well as their semiotic resources and formations on the particular subject under investigation. A student may even develop confidence to talk in front of others and be able to speak aloud and defend his/her stand on the matter. The argument helps meet most of the objectives. Sarah and Sharon really had to defend themselves from the barrage of questions directed at them by their colleagues who found it difficult to believe that there is a living plant that feeds on insects. Their disbelief led them to asking such questions like the one about the bones of the insects (turn 15). The issue of insects with bones was a good one since it made the students revise the characteristics of insects; though they ended up not remembering the proper name for the "hard thing"– the exoskeleton made of chitin (turn 19). From this argument therefore, one can see how serious the issue of the use of “thing” by these students is. It is remarkable to note how a simple disagreement allowed the students to discuss several concepts or topics at the same time. This permitted more engagement with the subject matter than the teacher could have asked for. In this argument Sarah and Sharon got a chance to explain to their peers the process of how the plant catches the insects. Again this is more interesting when viewed against the background that these are the same students who ordinarily would avoid questions by the teacher that required them to explain their answers. In this case, they were forced to explain in order to defend their stand, as the other students kept on asking how the plants capture the insects.

The girl who strongly challenged Sarah and Sharon about the insectivorous plant, which they claimed to have seen in one of Swaziland’s nature reserves, started telling a story about her encounter with a carnivorous plant. It was a mythical story in which she told Sarah how she once found a tree in the bushes that cried like a goat. The girl was enjoying the argument and wanted them in turn to challenge her but they just dismissed her story as a lie. Here is a transcript of their short debate:

> Girl: In the bushes at Luhhelo I once found a tree crying like a goat. (Laughter)
> Sarah: Hhayi! Hhayi! Hhayi! I live there! Don’t lie. You’re lying!
> Vincent: Not at Luhhelo!
> Sarah: What is the name of the tree?
> Vincent: Don’t be lunatic mani! You cannot see the plant!

The argument was cut short by Vincent who said the tree cannot be seen. According to Vincent the tree has supernatural powers and they did not have to even talk about it. As if not satisfied with the arguments the girl then immediately pursued the issue of the insectivorous plant. Here is how it continued:

Turn	Transcript
1	Girl: Me I want to ask the teacher about this thing.
2	Vincent: Let's ask Mr. Sitselo. There is a question sir, this side! We're told that this plant feeds on insects.
3	Girl: How does this plant eat insects?
4	Sharon: No! No! They want to answer your question.
5	Vincent: We're told that this plant feeds on insects.
6	Girl: How do they hold the insect?
7	Vincent: Who said so?
8	Mr. Sitselo: Okay! Okay! They say it's an insectivorous plant. So, it's a plant that feeds on food.

So, whenever these students need a convincing or correct answer they use the teacher as the immediate source of knowledge. Vincent opted for the researcher who had no chance but to attend to their problem. But Sharon did not want the involvement of the teacher in the argument (turn 4). However, the girl went on and asked Mr. Sitselo about the insectivorous plant. Despite the fact that Sarah and Sharon answered all the other students' questions about the plant, they still needed the teacher's confirmation. This bears out that they believe the only person to help them with conceptual development is the teacher not their more capable peers (also typical of Vincent). The researcher had to immediately stop another heated discussion (turn 8) about whether to involve him or not in the issue of the insectivorous plant. In all these arguments there is no mention of the task they have been assigned by the teacher. Indeed, when Mr. Sitselo comes in he takes them to a better conceptual locality by mentioning that the insectivorous plant feeds on food, when most plants acquire raw materials and use them to make the food before using it. From this one case it is clear that though arguments are good interactive practices they need to be facilitated by the teacher in class to avoid verbal, emotional and physical abuse among those involved. Students need to be taught to be constructive and argue in a polite and respectful manner in order for such discourse to enhance learning.

After Mr. Sitselo's explanation the students' tempers calmed down. They exchanged a few words and then remembered that the voice recorder was recording all of their conversations. They then switched over from the argument to the tasks of making observations and drawings, and the flaring tempers calmed down. Sharing of materials and information is recommended during lesson time, but not the way it happened with this group. This was a group of six students and they had only two pencils to share, one eraser and one ruler. So, the issue of borrowing went on throughout the session and at times sparked quarrels. Here is an extract of such a quarrel which could have been nasty had it not have been among friends:

Turn	Transcript
1	Sarah: It's this fatty one.
2	Sibongumusa: Please borrow me when you finish.
3	Sarah: Hey! Don't give Sibongumusa!
4	Sibongumusa: I will beat you!
5	Vincent: Bring me a pencil.
6	Sharon: Why are you so aggressive these days Sibongumusa?
7	Sarah: May be she's pregnant.
8	Sharon: Sibongumusa why are you so aggressive? Tell us? (Laughter). Why? You're like a brooding chicken.

In turn 1 Sarah is using a derogatory word (fatty), something which teachers should discourage among students. Derogatory language may lead to hatred, quarrels and even fights among students during and after lesson time. The consequences of derogatory language may discourage student learning. The issue of the shortage of basic stationery among students was so severe that teachers need to seriously address the situation. This delays students' progress as they have to wait for each other. Things like erasers, rulers and pencil sharpeners are not a problem when shared during a practical lesson, but not pens and pencils.

4.3.4.3 Drawing skills

Some of the students in the group realised that the arguments and shortage of necessary equipment prevented them from finishing on time. They then made plans either to trace the diagram from the handout, or cut the diagram from the handout and paste it in their notebooks instead of drawing it themselves, as well as asking the librarian to make them more copies of the handout. The teacher gave them a chance to practise drawing which reinforces learning yet they wasted it and some of them admitted that their drawing skills were poor. Here are extracts of the students' talk taken from different instances:

> Girl: Please draw it for me!
>
> Sarah: You see it is tincobo without something inside.
>
> Girl: It doesn't matter.
>
> Sarah: Hha! I can't draw it shem!
>
> Sarah: I want to trace this thing.
>
> Vincent: Because I can't draw let me write this. I will cut this now.
>
> Sarah: Even me I think of cutting it using a pair of scissors and then. Is this important to us?
>
> Vincent: We're not drawing. We've got to cut this.
>
> Vincent: I will give Kappa Kappa the paper to photocopy. When it comes to drawing it's a disaster. I have to give Kappa Kappa. I cannot draw.

If these students avoid drawing, how can they be expected to perform well in the practical paper? In the practical paper they are expected to observe certain features of specimens and then draw and label them. Even if a student can opt for an alternative during the practical they would still be expected to draw and label certain micrographs given in the paper. When the best student in Biology in the group (Sarah) is poor in drawing and confesses to wanting to bypass the task, then poor results in science at the end of each year are not surprising. Another problem revealed by the conversations is the issue of the relevance of the assigned task. In the above extract Sarah asks Vincent if the task at hand was important to them. The significance of the task was therefore not clearly explained to the learners, and this probably partly explains their lacklustre performance during the class. The good thing about the class was that they would never leave the laboratory even after the ringing of the bell unless they were dismissed by their teacher. By the end of the lesson, members of the focus group had not finished the class work and had to take it home for completion.

Class work talk in the Biology lesson is not always courteous and about learning, as the following case of misbehaviour by Vincent illustrates:

Turn	Transcript
1	Teacher: After observing all the structures from the different models you then move on. You draw the structure, you label it and then when you finish you then write the function. You copy the table in your handout. Siyevana mosi?
2	Class: Yes!
3	Vincent: You must not agree. Always yes!
4	Sharon: You're sick!
5	Vincent: Ah! This microscope thing. It does not function well. Please don't move this thing here. We're tired of it.

In turn 3 Vincent challenges the students' habit of saying "yes" to almost everything the teacher says. In a sense, he might have been correct but in another sense he might have been defending himself seeing that he had not done all the tasks the teacher had given them. Sharon reacts by using disparaging language (turn 4). In turn 5, instead of calling the teacher to help him in putting the specimen into focus, Vincent blames it on the poorly functioning microscope. Then after that he complains that he is tired of the voice recorder, so the other students should not move it closer to him. In fact reaction to the voice recorder was shown by him only; Sarah and Sharon did not react much to it. Vincent would react many times to the voice recorder positioned on their bench somewhere around the centre. As a researcher, I began to wonder how much reaction there would have been from Vincent had I used a video recorder. Turns 1 to 7 in the transcript below reveal another instance during the lesson in which Vincent and another girl were reacting to the voice recorder:

Turn	Transcript
1	Vincent: Somebody may you please remove this.
2	Sharon: Don't remove it!
3	Girl: Serious! Because this thing is recording me.
4	Sarah: May you please borrow me your ruler.
5	Vincent: May you put it here. It cannot record now.
6	Sharon: Cancel that stop. The stop.
7	Sarah: No! Stop what you're doing!

In turn 5 when Vincent said, "May you put it here." he wanted it brought closer to him and then he pressed the stop button, but unfortunately for him it continued recording them. Indeed, as a researcher I had to be sensitive to the students' reactions towards the voice recorder in class. Although proper permission and arrangements had been made with the teachers and the students, the students still had the right to opt out by switching off the recorder at any stage during the data collection. I therefore did not interfere and pretended not to be involved as they discussed the matter.

As if not enough Vincent commented rudely immediately Mr. Sameline had said something about the microscope. Here is an extract of the conversation:

> Teacher: in the microscope slide you can observe spongy mesophyll cells.
> Vincent: Hhayi, imicroscope iyasiyenga! The microscope is lying to us!

Again Vincent does not seek the teacher's help on how to use the microscope properly; instead he accuses the microscope of lying to them. So, it is now a combination of not being able to draw and not being able to operate the microscope. It is clear from these extracts how student discourse can affect learning both negatively or positively. For Vincent, there was little or no learning throughout the whole Biology period.

4.3.5 Malnutrition

The last lesson to be observed was on malnutrition and it was teacher-centred. Teacher talk took more than 90 per cent of lesson time. Student talk took the form of responses to the teacher's questions either as a class or an individual student. The lesson was interesting to the students, more so because the teacher did not give the students examples of the effects of malnutrition. Instead he asked the students to give the effects of malnutrition; his was to explain those effects. As usual the natural science students never asked their teacher a single question during the lesson. When Mr. Sameline was questioned about students asking questions in class he commented that usually they are afraid of embarrassment in front of the other students should they say something wrong. The teacher spent most of the lesson time giving the students formal notes on the chalkboard. He read the notes aloud as he wrote them on the chalkboard. He would now and again stop to ask the students a question and then continued writing the notes on the chalkboard. After defining malnutrition it was straightforward for the students to contribute the effects of malnutrition. That exercise kept the lesson alive and the students actively engaged.

The topic was embarrassing to some of the students, especially the effects of malnutrition. But that did not stop the students from engaging in the lively lesson. The effects of malnutrition which were given by the students were kwashiorkor, marasmus, obesity and constipation. The teacher added that coronary heart disease emanated from obesity. The teacher wrote all his explanations on the chalkboard in continuous writing and the students copied those formal notes into their notebooks. At times there would be long pauses (about five minutes) during which only the writing of the chalk on the chalkboard could be heard. The teacher would at times repeat (orally) sentences or phrases while writing them on the chalkboard as a means of emphasising or clarifying them to the students. The teacher still requested that students raise their hands if they had the answer or wanted to be given a chance to talk.

From the beginning of the lesson the students did not want to talk. Mr. Sameline had to force them to talk. They had difficulty defining malnutrition, yet the teacher did not necessarily expect an altogether correct definition but their views of what they thought it was. To make matters worse, out of the seven questions that needed explanations, the students answered only three. Questions that seemed problematic to students were those that needed the students to explain or apply their knowledge. Here is an example of a transcript in which the students failed to explain how pot bellies develop in people who drink alcohol:

> Teacher: So, once you're rich ucala kuzimuka (you begin to get fat). And we sometimes see people with pot bellies. Angitsi? Kusuke sekunjani lapho? (Why?) Mostly it is these people who take alcohol.
>
> Class: Yes!
>
> Teacher: Like nawunatsa nje bomcombotsi. Then uvamisa kuba nani? Nesisu lesikhulu lesibitwa ngekutsi ngumkhaba. Angitsi? (Laughter from class). Bantfu kungatsi bayakutsandza kubanemkhaba. How can you explain that situation?

It was interesting to note that the students still did not answer the question even though this was asked immediately after the teacher had finished explaining how obesity develops. The teacher started over again explaining how people become obese and then he linked that to the development of the pot bellies in those who drink lots of alcohol, especially our traditional brew (umcombotsi). The teacher used even SiSwati which drew the attention of every student since there was laughter from the students. It could be that the students were just reluctant to explain as suggested by the teacher.

The teacher explained malnutrition and its effects thoroughly except for one mistake: that of describing malnutrition as a disease. Constipation and marasmus were also defined as diseases by the teacher when in fact they are health conditions. Writing complete formal notes on the chalkboard for these senior students also seemed to distract and slow down the conversations. While this is another dimension of the classroom discourse, its utility and effectiveness for promoting student learning was unclear. The students did try to engage though. Sharon did talk during the lesson by answering the teacher once when she contributed that marasmus was an effect of malnutrition. Vincent too contributed once during the lesson by saying obese people can be identified by the fact that they are stout. Lastly, Sarah answered on two occasions, first by defining malnutrition and second by stating kwashiorkor was an effect of malnutrition. During a post-observation interview Mr. Sameline said students' participation during the lesson was as he expected, and could be described as normal. When answering all three students used classroom science semiotic resources.

To conclude the lesson the teacher gave the students a question to answer at home. The question needed the students to apply the knowledge they had acquired in class to solve a real-world problem. The question was: As a doctor or a nutritionist describe how you would help someone suffering from (a) marasmus and (b) obesity. The way the students avoided questions that needed application of knowledge made me wonder how successful they were going to be in answering that question. My doubts were based on the responses to homework they were given after learning about the greenhouse effects. The students had been asked to describe how a greenhouse would help a maize grower under adverse conditions get better yield. Some of the students did not do the assignment while those who did, did not explain how the greenhouse would help the maize growers get better yield, instead some just stated the advantages of a greenhouse. Thus in most cases the students failed to be specific, that is, to relate their knowledge to the given situation. One may think, in such cases, the students tend to lack classroom science semiotic formations even if they have acquired the classroom science semiotic resources. That is, the students seem to have understood the concept and thus the key terms, but are unable to express themselves when asked to apply the knowledge they have acquired. Such practice questions given by the teacher are essential in preparing them for tests and examinations as they make them think and talk like real scientists.

4.4 Student scripts

Natural science scripts were collected from the three purposely selected students in Mr. Sameline's Biology group. The Biology scripts were collected for evidence of the semiotic resources and formations used by students during meaning-making. They were taken from a homework, tests and examinations. The scripts helped me explore whether the students presented or reported the tasks appropriately. In the following sub-sections analyses of the students' scripts are done as a way of finding out if the appropriate academic science semiotic resources and formations have been used and also to establish the students' locality along the continuum of conceptual understanding.

4.4.1 Homework – food tests

The homework comprised three questions. Unfortunately the teacher did not allocate marks to the questions to indicate to the students the significance of their answers. The first question was framed thus:

What part of the body in humans has a large amount of glucose?

Sharon answered the question with a one-word answer, "Liver." Since there was no allocation of marks the girl correctly gave a one-word answer. In fact questions that ask "what" usually need a one-word or brief answer. The answer given by Sharon was not wrong but nevertheless according to the teacher there was a better answer than that. The better answer was ileum or small intestines.

The teacher gave a small tick for the liver. Vincent gave the part and a reason. It is the liver because glycogen is stored in the small intestine. The teacher gave a small tick to the liver and a big tick to the reason. Unfortunately, the reason is confused. Glycogen is stored in the liver and results from the conversion of excess glucose in the blood. The reason shows Vincent had some understanding of the digestion of starch, absorption and assimilation of glucose but is confused about the precise details. He held some misconceptions about human nutrition. In his answer he used the relevant classroom science semiotic resources but in a confused way (wrong semiotic formations). The teacher's big tick for the reason would convince Vincent that he had answered correctly and as a result the boy would sit for a test and examination with that misconception. Sarah gave a correct part and reason. Her answer was: It is the liver because glycogen is stored in the liver. Because the teacher wanted the answer to be small intestines, he only put a small tick at the end of the sentence. The small tick for Sarah's correct answer might have discouraged her and even the teacher's best answer confused her. She was likely to go for a test and even an examination confused by the teacher's answer as students tend to trust their teachers. Should the students read more Biology books and find that the teacher was somehow wrong they would start losing confidence in him; although with this group it is unlikely that they would alert their teacher about the mistake.

The second question required the students to apply their knowledge of food tests. It was framed as follows:

How can you prove that glucose is present in your answer to question 1?

They all answered this one correctly by stating that that they would perform a test for reducing sugars on the liver. They only made grammatical and ethical mistakes. Vincent and Sarah began the spelling of the word Benedict's solution with a small letter. Another serious mistake was that of reporting in the active voice instead of passively. Science reports are often not made in the first or second person; and all three students made the mistake of writing the procedure for the test for reducing sugars (glucose this time) in the first person (Sharon) and second person (Sarah & Vincent). Vincent and Sarah also made the mistake of not specifying quantities in the procedure. All these mistakes when added up could lower a student's score considerably.

The third and last question for the homework was:

Sunflower oil comes from sunflower seeds. How can you show that there are fats in the sunflower seeds?

Something that is wrong with the framing of this question is that it depicts plants as having fats yet plants have oils, only animals have fats and oils. All three students knew a test for oils had to be performed on the sunflower seeds but made mistakes when giving the procedure. First, the procedure was given in the active voice (Sarah & Vincent – second person, Sharon – first person). Secondly, Sarah and Sharon did not include what the final observation would be to prove the seeds contained oil.

4.4.2 Topic test – nutrition

The test was written by less than half the class as most form fours had been sent home to get the school fees they were owing to the school. Among the three participants of this research only Vincent was present to write the test. When Sarah and Sharon returned to school their Biology teacher declined to set them another test. So, only Vincent's test script is analysed here. The school sent the students home in preparation for the mid-year examinations which were to commence towards the end of July. The test was written within forty minutes (one period) and covered only three concepts: food tests, photosynthesis and food additives. It comprised four short-answer questions: the first question on food tests and photosynthesis; the second and third questions were on photosynthesis; and question four was on food additives.

In question one Vincent did fairly well as he scored five out of eight marks. The vocabulary Vincent used revealed classroom resources. The three marks he missed in this question were because of poor knowledge. He answered part C like a student who did not know what a variegated leaf was. He predicted the wrong result and also gave the wrong reason for his prediction. At that point he operated at the proximal locality of the continuum of conceptual understanding. Another lack he had, which appeared in all the four parts of the question, one was that of semiotic formations. In all the four parts his grammar was poor because of "there". He used "because the is" instead of "because there is". Another serious problem is observed in his answer to part D which displayed his misconception about photosynthesis. He got the result correctly but gave the wrong reason. He said there would be no starch because there was no light and the green pigment had moved towards light. He seemed to somehow confuse chloroplasts with auxins. To him it seemed like chloroplasts could leave their cells in search of light.

In question two grammatical mistakes were evident, as well as poor content mastery. He also scored fairly in this question too, getting four marks out of seven. He operated not far from the proximal locality of conceptual understanding. Considering his score for question one too it appears he needed to study even harder and get help from the teacher as far as his misconceptions were concerned; otherwise he would perform even worse in an external examination. Again the questions that needed him to explain were incorrect; the very kind of questions he avoided during lessons so that his teacher ended up answering them. Question three was the one in which Vincent scored well. He scored a 100 per cent. It was a recall question requiring only a one word answer. His spelling was also correct (demonstrating correct science resources).

In question four Vincent performed better as he scored 75 per cent. He did however make grammatical mistakes and used both everyday and classroom science resources and formations. This was a relatively straightforward question where students had to read a short paragraph about each food additive and then answer three questions on each food additive. His performance was not very good in spite of the fact that the answers were contained in the paragraphs.

4.4.3 Final examination – Biology (6884) Paper 1

The examination paper comprised six questions totalling fifty marks. The paper was, according to the teacher, supposed to be the easiest in the subject as it only examined the basic concepts in all the topics covered in the syllabus. Students were asked to be as brief as possible, therefore, no questions demanding students to describe and explain had been asked. Going through the question paper, though, revealed three questions with some parts that needed the students to either describe or explain certain processes and phenomena. This paper was not set according to the prescriptions of the syllabus which asserts that only recall questions had to be set and not application questions. The paper was 75 minutes long whereas, according to the syllabus, it should have been one hour long with a total of 40 marks. In short the structure of the paper was not what the students would have expected.

In question one (a) Vincent displayed poor classroom science semiotic formations when he stated that an insect has a compound pair of eyes instead of a pair of compound eyes; which the teacher marked as correct. In the second part of question one all the three students failed to underline the generic names of the larvae they were identifying and the teacher did not penalise them for that. In question two the teacher showed inconsistency in marking by penalising Sarah for wrong spelling and not penalising Vincent. Sarah wrote calciam instead of calcium and Vincent wrote insisors instead of incisor. In part (c) of question two Sharon and Vincent had difficulty since they had to explain how bacteria enter the dentine during tooth decay. Vincent got the part wrong by not explaining the process of tooth decay from the surface of the tooth through the enamel into the dentine. He also used everyday science resources and formations and failed to answer the question which needed him to explain how a tooth decayed. Sharon used the appropriate science resources and mentioned some of the steps involved in tooth decay. The teacher penalised her for leaving out some of the essential steps involved. In her last sentence though, she mixed scientific vocabulary with everyday science resources when she said “The plaque causes the tooth to be rotten and form a hole.” In her explanation Sharon proved to be operating at the proximal end of the continuum of conceptual understanding since she had incomplete and more proximal understanding of dental decay. She deserved about half the marks though. Sarah’s explanation was good and close to the distal end of conceptual locality. She only missed out a few things like mentioning that the bacteria respire on the sugar to result in the acid that tends to dissolve the enamel.

In question three, the students were given a graph to interpret about the rate of reaction plotted against temperature. All the three students were able to observe the general trend of variation of enzyme activity with temperature. Differences were in the science semiotic resources and formations used in explaining the variations. Sharon’s explanation of what happens from 10°C to 40°C was poor since she mentioned that the enzymes were increasing in temperature, which is incorrect. Her understanding at that point could be described as confused and its locality as proximal. Vincent failed in his science semiotic resources and formations. All three students failed to read the exact optimum temperature from the graph indicating poor relational and numerical skills. The second part of the question was about enzyme activity from 40°C to 60°C. The students interpreted the graph well and gave the correct reason. Only Sharon did not give the full explanation for the observed rate of reaction. She left out a key term “denature” yet the teacher awarded her full marks.

Question four needed the students to know the characteristics of living organisms together with their definitions. In the question they were given a list of six characteristics from which to choose and fill-in four missing terms in a passage about a truck. Vincent and Sarah scored full marks in the question but Vincent wrote the wrong spelling of excretion which he gave as “excreation”. This is a common mistake among students and it becomes worse when a student has to copy it from the question paper and rewrite it. Sharon only got two correct. In question five students were examined on the human digestive system, a topic the students had done several times earlier in their academic lives. It was poorly answered by all three students considering that out of nine marks Vincent scored three, Sarah five and Sharon one mark. Their answers revealed that they never prepared for a question on this topic. They were all operating around the proximal locality of conceptual understanding, though Sarah proved to be a bit better. Their main problem seemed to be content mastery. Their descriptions of the roles of the liver in digestion and assimilation were incomplete and difficult to follow. Sharon even held a misconception about the functions of hydrochloric acid in the stomach as she said it is for neutralising the digested food in the stomach instead of providing an acidic pH for the proper functioning of proteases, as well as killing germs reaching the stomach with the food from the mouth.

Question six examined the students on the cross-sectional structure of a dicotyledonous leaf. This question too was poorly done by Sharon and Vincent. Only Sarah did it well with 70% while Sharon and Vincent scored 40% each. This was a recall question and needed one-word answers. One would have expected all the students to do extremely well in this question as they did a practical in addition to a normal lesson where they identified the parts and gave their functions. During the practical lesson the teacher also brought many teaching aids for the students to use, including charts, microscope slides and models. Therefore, one would expect the students to operate at the distal locality of the continuum of conceptual understanding. The total scores for the students in this paper were: Sharon 42%, Vincent 54% and Sarah 72%.

Writing is part of classroom talk, and in most cases is what is assessed in the tests and examinations. The rather low performance of the students in this kind of classroom talk and its dominance in our assessment systems should be worrying to all educators and policymakers alike. Should not classroom discourse be more embracing and its assessment more comprehensive?

4.4.4 Interviews with learners and teacher

When interviewed about communicating among themselves during natural science lessons the learners had the general understanding that such discourse was important as it helped them catch up with the rest of the group; in case they needed clarification on some concept. They also agreed that such communication had to be done such that it did not disturb the progress of the lesson. When asked about communication with the teacher their understanding was that such discourse enabled the natural science teacher to gauge them against the continuum of conceptual understanding; something the natural science teacher (Mr. Sameline) pointed out too when posed with the same question. Mr Sameline even added that classroom discourse with his students allowed him to choose the appropriate teaching strategies for subsequent lessons with the group. He noted that both spoken and written discourse with his students enabled him to know whether or not the learning objectives had been accomplished. Brown et al (2005) support the learners' and teacher's claims about the role of classroom discourse by stating that classroom discourse develops science literacy.

However, Mr Sameline complained that the majority of the group would be too quiet (that is, reserved) such that he would at times force them to answer questions. It would even be worse with asking questions. They would generally not ask him any conceptual questions. The lesson observations revealed that Mr. Sameline would ask the students to raise up their hands whenever they had something to say. That was a way of maintaining order during the lessons. The students then interpreted that to mean that for order to prevail during lessons they had to keep quiet or communicate secretly.

4.5 Summary

An introduction opens this chapter. Then the case study of Tfolani High School is discussed. This section is followed by a discussion of the teaching and learning of natural sciences at Tfolani. The discussion section is divided into subsections. The first subsection is about food tests and describes an example of a practical lesson. The next subsection involves a lesson on how a leaf is tested for the presence of starch. This is then followed by a description of a lesson on the cross-sectional structure of a dicotyledonous leaf. Another lesson on malnutrition is analysed. Scripts collected from the three sample students were collected and are analysed in this subsection. The first is a set of scripts on a homework the students were given to do covering food tests. The next subsection is that of scripts for a topic test on nutrition. The next subsection analyses the interviews which were conducted with the learners and their Biology teacher (Mr Sameline). The final subsection analyses final examination scripts on Biology Paper 1.

CHAPTER FIVE

Discussion; Limitations of the study; Aspects of future research; Recommendations and Conclusion.

5.1 Introduction

The researcher discusses the findings from chapter four in this chapter and the study is concluded. Also given are limitations of the study, recommendations and other aspects for further research. The aim of this study was to get into the natural science classroom and observe student interactions and thereafter suggest teaching strategies that can be used to encourage student talk during natural sciences class time. The aim was pursued by conducting a small-scale research project at Tfolani High School in the Lubombo District. It was a case study of how Biology students interacted during biology lessons and what meaning they gave to those interactions. The interactions between students were observed as well as with the teacher and the Biology content. The students and their Biology teacher were interviewed on the meaning they gave to the student talk during Biology lessons. The study aimed at answering the following research questions:

(a) What characterises student discourse in a natural science classroom in some schools in Swaziland?
(b) What is the meaning and role of such student discourse within the context of the natural science classroom?
(c) How can the observed student discourses and meanings be understood and explained?

In the preceding chapter I identified some of the major themes arising from the data in the form of a case study of student interactions in a natural science classroom. In the following section a discussion of some of the main findings from the case study of Tfolani is given, in relation to the literature given in chapter two, the research questions and the objectives of the study.

5.2 Discussion

The active participation of Sarah, Sharon and Vincent during Biology lessons was taken as examples of student discourse in a natural science classroom. Each student offered some evidence of interaction and science understanding along a continuum from proximal to distal, thus meeting all the objectives of the study. The discussion of the findings of this research will be in two segments. The first segment consists of the natural science classroom talks between the students and their Biology teacher (Mr. Sameline) as well as talks among the students themselves. This will also include a focus on the tasks discussed during the pre- and post-observation interviews between the researcher and the Biology teacher (Mr. Sameline) and between the researcher and the three purposely selected Biology students. The second segment of discussion will be the student interactions through written discourse (homework and test scripts).

5.2.1 Student talk during natural sciences lessons

In this subsection student talk is discussed as observed during five Biology lessons, two of which were practical lessons. Discussion of student and teacher talk during pre- and post-observation interviews will also be analysed. The teacher and student talks are discussed under five themes: who talks; to whom; what do they say; how often/long; and how are they talking? The two practical lessons were conducted, to a reasonable degree, according to syllabus specifications. They were student-centred, while the three ordinary lessons were teacher-centred. Whether a lesson was teacher- or student-centred was decided by the teacher when choosing teaching strategies during lesson planning. The three ordinary Biology lessons were dominated by teacher talk. On average teacher talk accounted for about 80% of lesson time and student talk about 20%. It was the reverse during the practical lessons with student talk taking about 80% of lesson time and teacher talk about 20%.

5.2.1.1 Biology practical lessons

During the pre-observation interviews with me, Mr. Sameline told me in advance whether the lesson would be dominated by teacher talk or student talk. The students also knew that the Biology lessons were dominated by teacher talk. When interviewed about it, they argued that it was a good idea that lessons be dominated by teacher-talk and student-talk regulated by the teacher. They reasoned that such an approach allowed them more time to concentrate on what was being taught and it helped to maintain order in the classroom. Based on this belief, it is not surprising therefore that sometimes students take learner-centred lessons, like practical lessons, as some form of playtime. This is possibly one reason why the observed group may have been involved in so many arguments during the two practical lessons and did not finish their tasks in class. But what is good about such lessons is that they help students learn in a relaxed and fulfilling atmosphere. Debates do benefit students during learning time, as suggested by the literature reviewed in chapter two but it is essential that the debates are not promoted at the expense of other learning activities. Arguments are good when properly controlled by the teacher and may help in the critical evaluation of an idea or discovery; and so answering questions 1 and 2 of the research. During the practical lesson on the cross-sectional structure of a dicotyledonous leaf the students who were busy asking the “how” questions were critically evaluating the idea of an insectivorous plant. Both the students who challenged the idea of an insectivorous plant and those who defended it gained from the discussion in terms of their semiotic science resources and formations and also in conceptual understanding (Gomez 2007). Listening to the students argue becomes interesting and edifying as one hears the students trying to make their ideas explicit, putting their ideas so as to convince their peers, and simply hearing the students take up a stand on the matter . At one point, as the researcher, I was drawn into their argument although I tried to stay on the sidelines as much as possible. These arguments seem to help move the students even further towards the distal end of the continuum of conceptual understanding. That was so since each time they were corrected by their teacher after failing to follow the laid down procedure they would realise their mistake and often discuss it among themselves. The disagreements, therefore, seem to have benefited the students in making the leap in terms of conceptual understanding but may not have improved their skill in drawing and completing tasks within the specified time limits. The significance of this analysis lies in the observation that the benefits of such classroom discourse need to be balanced against the limitations in terms of other classroom objectives.

During the first practical lesson which was on food tests (fats and reducing sugars), the procedural mistakes the students made due to their disagreements might – on the one hand – be taken as beneficial for them. That is, students who had to start the food tests over because they did not follow the correct procedure may end up even better than those who did the wrong thing but never corrected their mistakes. It is often said that in life we learn through mistakes, but it is only when one has identified and corrected the mistake that one is considered to be in a better position or to have learnt from the mistake. So, the three observed students would be in a better position in future to remember temperature as an important factor when testing food for reducing sugars since they experimented on what would happen if cold water was used instead of hot water for a water bath. This was the advantage of a practical lesson over an ordinary classroom lesson, students were able to explore new ideas or experiment on “what if” ideas (alternative ideas), though this could be dangerous if not monitored. The practical lessons answered all the three research questions.

The practical lessons allowed the students plenty of time to talk among themselves and to learn from each other. Social constructivists maintain that knowledge is acquired through social interactions. The practical lessons taught the students other social skill, such as tolerance for other students who held views differing from theirs, as well as the social skills to accept criticism as a challenge not a declaration of war. In the observed classroom the deliberate use of mixed sexes and ability groups during the practical lessons meant that the less capable students could learn from their more capable peers. The girls, for example, during food tests helped the boys with identification of colour changes. It is these groups that also helped to foster student discourse in the observed science classroom. The teacher's presence as a facilitator also helped the students, for instance with the use of proper scientific vocabulary. In that way he put his students in a better position to talk and think like scientists.

Talking during the practical lessons exposed the students personal characters; Vincent as a student that did not believe in acquiring knowledge from other students but only from the teacher, while Sarah and Sharon were noted as students who believed in sharing knowledge and information with peers. Vincent's character did not enable him to admit the mistakes the teacher was making during the lessons because he strongly believed in what the teacher said. Vincent even disregarded an explanation from a textbook in preference to the teacher's. Practical lessons give students the chance to actually demonstrate the application of vocabulary the students have acquired in class. Take, for instance, when the students had to make a solution of the food before testing it. That was where they made a mistake by not making a solution of the food before testing it. They made a mistake by not making a solution of the food which yielded unexpected results. It was after considering the word "solution" that they got back on track. They had learnt in class what a solution was but neglected the term in the procedure and thus got negative results. It was through talking (re-considering the meaning of solution) that they identified their mistake, and also through talking that they got help from their Biology teacher. Had they not talked they would have left the laboratory without the expected results from the practicals, something they did during ordinary science lessons (a good example being Vincent during the teacher-centred lesson on the cross-sectional structure of a dicotyledonous leaf).

The practical lessons provided students with a conducive atmosphere to question their teacher. Discussion during these lessons enables students to realise the teacher is human too. They may even gain confidence to inform him should he make a mistake while teaching. A discourse pattern, such as talking, enables the teacher to know how much knowledge students already know about a concept before teaching it and even after teaching the concept. Mr. Sameline said in one of the interviews that student talk enables him to gauge his students' level of knowledge. When he asks them questions in class he only expects responses from them not strictly correct answers. It is through student talk that a teacher can first tell if students hold misconceptions and can help them change so that they do not take those misconceptions to the examination room.

During the interviews with the teacher and the students, and also during lesson observations, the issue of the use of English as a medium of communication during Biology lessons surfaced as a matter of concern. Most of the problems associated with the use of a language, other than one's mother tongue, for learning sciences arose. These are addressed in the literature review (chapter two). Teachers and students need to work co-operatively to manage such problems during lesson time so that language does not become a hindrance to learning but facilitates it. Students need to learn about parts of speech like pronouns and prepositions. Students need to be taught the language of science so that they can communicate like young scientists, both through speech and in writing. Teachers too should be explicit in their talk so that students are left with no room for uncertainty. It is vital that teachers should avoid, at all costs, the use of the noun "thing" when they are teaching and they should also discourage their students from using it. At times it is better to know your students' mother language so that you can easily perceive the meaning of a word or phrase when they have translated directly from their mother language to English (research question 2). It is beneficial to even understand the current slang or colloquial language used in student social circles so that, as a teacher, one can at times use those to clarify some concepts for the students. Teachers should also take extra care with the use of science vocabulary like “boil” and “heat” and not use them carelessly as if they have the same meaning. From the way the practical lessons engaged all the students, science teachers should organise more practicals for students as such lessons cater for all the students’ learning styles especially when planned carefully.

The challenges students encounter during debates and arguments inspire them to use other sources of information to gain knowledge to substantiate their point of view. The sources could be cell phones, computer programmes and the internet. The world we live in demands that all students be computer literate right from primary school or the beginning of secondary school at least. The social skill of talking is not practised only through arguments but also through storytelling. During the practical sessions students got time to tell stories. Knowing how to tell a story in science is helpful since after discovery or invention then the discoverer or inventor has to convincingly narrate to the other scientists how the discovery was made, an idea supported by literature. Storytelling teaches students to be fluent, logical, humorous, creative and bold. All these are necessary qualities expected from a future scientist.

The unfortunate thing about the student arguments during the two practical lessons was that they could run concurrently with the lesson activities. That might be the reason for the students being unable to finish the practical within the lesson time. It would be after arguing that the students would start talking about lesson activities such as drawing, observing and conducting the experiment. Science teachers therefore need to warn students about letting debates interfere with experimental activities in the laboratories. Rather, a teacher should guide debates as one of teaching strategies in the sciences rather than become hindrances during lesson time. Students can become overly aggressive and hostile toward each other if they are not constructively directed when disagreeing.

From the practical lesson on the cross-sectional structure of a dicotyledonous leaf the derogatory language used by some of the students indicates the need for science teachers to integrate ethical behaviour into the natural sciences curricula. Students need to be taught about the consequences of using derogatory or offensive language through constructive alternatives. Good manners and moral values need to be instilled in children as they grow up so that they become responsible future citizens. It was better the offensive language was used by a group of friends; had they not been friends a fight may have erupted. The use of derogatory or offensive language causes the focus of the offended student to deviate from achieving the objectives of the lesson to proving a point to the offender.

As good classroom management practice teachers need to rebuke misconduct by students on the spot. This is with reference to Vincent's behaviour on several occasions during the same practical; one of which was when he shouted that the microscope was lying to them. He rudely shouted immediately the teacher called students to view the specimen under the microscope. Mr. Sameline just ignored Vincent's misconduct and let the class continue as if nothing out of line had happened. Students need to behave appropriately when doing practicals in the laboratories and, indeed at all times, so that productive learning can occur.

5.2.1.2 Ordinary Biology lessons

Turning to the three normal Biology lessons which were dominated by teacher talk (teacher-centred), we note that in two of those lessons the teacher engaged the students in the lessons by making the lessons class discussions. In the third lesson the teacher wrote notes for the students on the chalkboard. He stopped now and again to explain every step involved in preparing a leaf for a starch test.

The students were copying the notes and listening to the teacher's explanations simultaneously. So, in this one lesson teacher talk accounted for more than 90 per cent of class time. The teacher was preparing the students for a practical lesson which was to follow on testing a leaf for starch. During the lesson the teacher was always the one to initiate student talk by asking the students questions. Students never asked the teacher a single question during this lesson – a possible cause for poor understanding and thus poor performance in the subject for most students. Apprehension in the students has to be managed as it is the main cause of their being reserved during lessons. Encouraging students by praising those who attempt to answer or ask questions could make a difference. Discouraging teachers from punishing students for giving wrong answers is also a solution. This is because Mr. Sameline informed me that one of the reasons students fear answering, not to mention asking questions, is that the students are often punished severely at the junior level for failing tests and for giving wrong answers during science lessons.

Humiliation of a student by other students must also be discouraged by natural science teachers as a way of encouraging student talk in natural sciences classes. The humiliation could be in the form of laughter by the students when one of them gives a wrong answer (something one observed during one of the practical lessons). The natural science teacher can also try to make sense of a student's answer even when it seems far from being correct by reinforcing it or re-structuring it until it takes the acceptable form. Positive encouragement by the teacher to talk in class will drive away anxiety in the students and empower them ask whatever they do not understand. This is with reference to Vincent who kept quiet during the lesson just because he had been left behind and was trying to catch up when he was quiet. Students should be discouraged from piling up academic work unnecessarily. They should seek help immediately; supported by research question 3 and the learning objectives.

Some of the questions the natural science teacher asks in class should be those that require elaborate answers, not only short answers. The questions should be of varying cognitive demand. In probing students for understanding the teacher should not wait for them to raise their hands before pointing at them to answer. The teacher needs to look at them in the eyes to judge their comprehension and then pick those few students across the classroom for questioning. Natural sciences teachers need to be very careful when it comes to the use of everyday words that have different technical meanings when used in some topics or concepts in science. Such terms should be stressed or highlighted and used properly by the teacher.

Mr. Sameline needs to encourage student talk and active learning. This should be encouraged among all teachers so that the students are exposed to them every time they have a lesson with a teacher. These practices include reinforcing a student's answer, gesturing and even code-switching when necessary. Even introducing a concept or topic by telling a relevant and interesting story is beneficial. The story could be about how the concept was discovered or invented or just a story of the history of the discoverer or inventor. It could include the achievements of the discoverer or the significance or application of the discovery or about aspects the students can immediately associate with in the environment. Gestures are good in that they usually give students a practical sense of what an abstract or amazing discovery/invention is. Students remember their teacher's gestures even in the examination room when asked a question or still long after completing school in adulthood.

The lesson that was done to prepare the students for the practical on the cross-sectional structure of a dicotyledonous leaf was well done in that it engaged the students and their teacher in descriptive, relational and explanatory semiotic resources and formations. The teacher even brought teaching aids like handouts and a dicotyledonous leaf picked from outside the laboratory for demonstration purposes. The leaf helped in providing a concrete reference to the teacher's descriptions and explanations which were more abstract than concrete. During this lesson Mr. Sameline made conceptual and grammatical mistakes about which the students kept quiet. One would not expect all the students to realise their teacher's mistakes but those few who did should have informed the teacher so that information was corrected. Mr. Sameline would have used the students' awareness of the mistakes as indicators that the students were indeed following the lesson. It is crucial for a Biology teacher to have complete mastery of the content because once students learn the wrong content then it becomes difficult for them to replace it with the correct content in future, even if the correction is made by the same teacher who made the mistake. In their minds the two contents (wrong and correct) lie side by side and compete for recall; as stated in literature. The existence of such contrasting contents in students' minds is not good in trying times like tests and examinations. Student talk, therefore, during natural science lessons is essential because it helps prevent the development of misconceptions in students' minds, as in the above example. Teachers should also teach using the language of science so that their students emulate them and stop using words like "thing" in their formal talk or writing.

From this same lesson student talk in the form of answering in class improved with better performance by the students. Sarah engaged in more talk than her two counterparts and Sharon engaged in least talk. Sarah answered five questions and Sharon only two questions from the teacher. One may then appeal to natural sciences teachers to encourage even the low achievers to engage more in classroom talk as it seems like the more a student contributes during a lesson the better that student achieves in the subject. The teacher talk and writing should be rich in the semiotic science resources and formations and also be well-informed with literature on that subject.

Teachers need to give their students individual attention for them to get to know their students' problems and difficulties. But if the class is a group of forty plus students then it becomes difficult for a teacher to give all the students adequate individual attention during a forty-minute period. Even if it is a double period, marking class work or homework in class, making comments to the students and giving solutions to students' personal problems becomes impossible to fit within class time. It is therefore understandable why Mr. Sameline could not wait for a reason from Sharon as to why she had not done the homework. He was rushing to assist as many students during the lesson as possible. Administrators need to be involved in finding a solution to the issue of large classes since it contributes to poor discourse patterns in class and low performance by students; fourth objective.

The last issue is that of English language among the students. The students needed to have a good command of English to do well in Biology. The good command of English language will help the students express their knowledge/questions accurately. Grammatical mistakes and direct translation from mother tongue to English language will be avoided. The natural science teacher need not struggle to figure out what the student is trying to say when the English is good; nor will there be a need for the teacher to share the same mother language and culture with the students. Natural science teachers need to help their students with their language problems in collaboration with the English language teachers in the school. When students struggle with English language, the problem gets compounded by scientific language.

The last lesson observed was on malnutrition. It was a forty-minute teacher-centred lesson in which the teacher spent most of the time giving the students formal notes on the chalkboard. The spoon-feeding, instead of telling students to read from their textbooks, library books and the internet and then make their own notes, encourages the students to rely on the teacher's notes only. Should the teacher make mistakes, as was observed in some lessons, the students still took those mistakes with them into the examination room. The teacher's explanations about the effects of malnutrition dominated the lesson and as usual student talk was mostly initiated by the teacher. So, no questions were asked of the teacher by the students; only the teacher asked questions. This practice is a contributing factor to students' poor performance in the natural sciences examinations.

When discussing the effects of malnutrition Mr. Sameline caused discomfort to some of the students by some of his questions or examples, for example, when he asked the class if there were students in the group who were suffering from kwashiorkor. To the undernourished students the question could be humiliating. Teachers need to be sensitive to the students' feelings when handling such topics or subtopics . The other effects of malnutrition, like obesity, marasmus and coronary heart diseases were also accompanied by thoughtless comments from the teacher. Students may end up with an aversion to a subject or even the teacher if such concepts are dealt with negatively. In addition there is a problem when the teacher makes an example out of some of the students or their relatives. Some of the students may then decide to switch off and not participate in classroom discourse regardless of how relevant that concept or topic might be for them.

From this lesson one realises something significant. Teachers should consider the chorus "yes" from their students with great care because at times the response may be misleading. While discussing marasmus with the students the teacher asked them if they ate enough. Their response was the usual chorus "yes". Then he went on to say at their homes they share the food no matter how little it may be. Therefore, teachers should not rely on a class response for concept or lesson evaluation but on individual evaluation (and in writing especially). Natural sciences teachers should engage their students more in applicable questions or questions that require explanation during lessons. The students need guidance with such questions as they tend to give inadequate answers and thus do not get full marks. To train students on giving complete answers teachers can engage students in debates. A topic like "Coronary heart diseases are not as bad as kwashiorkor and marasmus" could be a good debate topic for cultivating the culture of talking in class and giving accurate and full explanations. The students in the debate teams should be of mixed abilities to motivate the low achievers.

5.2.2 Student scripts

This subsection covers a discussion of the second segment of student interactions through written discourse. From each participant student are discussed: a homework script and a test script. The scripts are discussed using science resources and formations by students as they answer questions and also on the basis of student meaning making and understanding.

5.2.2.1 Homework – food tests

Towards the end of the lesson on food tests Mr. Sameline wrote practice questions on the chalkboard for the students to copy into their notebooks and answer as homework. In all three questions the students used relevant science resources and formations. Even when the answer was not up to the teacher's expectation but the vocabulary used was pertinent to food tests. Differences among the three students were the extent to which each would answer a question. This indicated different levels of understanding. The three students were at different localities along the continuum of content understanding and content meaning making. Sarah, the most vocal student during Biology lessons, was the closest to the distal end of the continuum of understanding than the other two students. She was followed by Vincent while Sharon was the one closest to the proximal end of the continuum. From the relationship between student classroom discourse and achievement, as observed in this study, one may say that the appropriate classroom discourse by students reflects good meaning making of content and thus good understanding. Therefore, a student who is good at classroom discourse is likely to achieve better in the subject. Observed from the homework scripts were certain mistakes that would lower a student's achievement in a subject even if the student has used classroom discourse. The mistakes the students made were: giving incomplete answers; grammatical errors; as well as not observing technical aspects. By incomplete answers one refers to such mistakes as not specifying quantities of substances to be reacted, and also leaving out some steps involved in a procedure. Grammatical mistakes were those such as students beginning a person's surname with a small letter, for example in Benedict's solution; as well incorrect spelling. A technical error was when the students reported a science procedure in the active voice instead of the passive voice. Content mastery by the subject teacher cannot be left out since content mistakes made by the teacher result in misconceptions by students.

5.2.2.2 Topic test – nutrition

The test concentrated too much on photosynthesis. Three out of four questions (75 per cent) covered photosynthesis leaving out nutrients and the human digestive system. The test also included information the students did not require such as page numbers where answers to the questions could be found, which showed the test was prepared haphazardly. The teacher only photocopied two pages of his Biology Study Guide, wrote the topic and date by hand at the top and simply multiplied the two pages for the students to write as a test. Question four did not carry marks (no indication), questions three and four were numbered by hand. Being a topic test it should have covered, without any bias, all the different sub-topics of the content. Its layout showed students that the teacher did not value the test and that would put serious students off. No wonder this kind of sloppy work showed up even in the examination paper. Teachers are required to set their tests carefully and present them well including the typing.

Vincent made grammatical mistakes and that could be rectified by collaborative work between natural sciences teachers and English language teachers, The natural sciences teacher would help with the content and the scientific language (classroom discourse) while the language teachers would help with the English (everyday science discourse).The students need to be given a lot of practice questions requiring knowledge application since such questions are always found in examination papers and carry a lot of marks compared to other types of questions. Teachers should not allow their students to avoid such questions during lesson time. Vincent’s keeping quiet while learning about the cross-sectional structure of a dicotyledonous leaf did not help him catch up as it appeared in this test in the form of a misconception about chloroplasts. Therefore, natural sciences teachers need to encourage their students to talk in class, especially when there is something that they do not understand.

Coming to the issue of Sarah and Sharon not writing the test since the school administration sent them home to get school fees; one may say that is one of the greatest set-backs in students’ achievement at school. During the time the students are away learning continues and the absentees lose a lot as some may be away for as long as a week or more. The school committee, together with the school administration, need to devise a strategy of getting school fees from parents other than disturbing and making the students responsible to obtain them. Sending the students home for fees stresses them immensely. Some are aware that their parents do not have the money or are not there at all. If a student comes back to school after a week then it becomes problematic for the student to catch up. Take the incident of Sarah and Sharon; their Biology teacher declined to set them another test when they returned, which meant their Biology final score was affected. Finally, the consequences of such losses show up in external examinations at exit points (Standard 5, Forms 3 & 5). All adult stakeholders should shoulder the responsibility of school fees rather than passing it on to the students.

Despite all the limitations stated above the study has made a thorough effort of exposing the discourse patterns in the natural science classroom that could lead to poor performance of students in external examinations.

5.3 Recommendations

Recommendations arising from the findings of this study are:

● to encourage teachers to employ teaching methods that cater for students' different styles (visual, auditory and tactile/kinaesthetic learners). From the five observed lessons, the two practical lessons seemed to be the best to cater for all the students with their different learning styles. It may be to the advantage of the natural science student if their natural science teacher intersperses ordinary lessons with practical lessons wherever possible. Practical lessons, when well organised, allow students to sit, look and listen, as well as move about and work actively; and so address all the aims of this study. They also engage students in varied communication patterns such as talking, drawing, writing and gesturing; meeting research question 1.

● to further enhance classroom discourse in the form of student talk during ordinary natural science lessons and accommodate debates; debates develop and sharpen students' critical thinking skills and conceptual understanding; arguments help students to give complete answers so that they can better tackle questions that need them to explain and also apply conceptual knowledge; during the lesson observations students avoided questions from their teacher that asked them to substantiate or apply learnt concepts; thus answering research question 2.

● a little humour during natural sciences lessons is necessary to encourage the concentration of students and even develop interest in the subject; teachers can do this by telling the history of the concept at hand and even acting out some scenes; students like listening to and telling stories, they may even tell their own stories that depict the usefulness of the concept even better and more interestingly; interesting stories make the concepts stick in the minds of students.

● natural sciences teachers should encourage their students to ask them questions in case there is something on which they need clarification; they should be concerned when they are not asked questions by their students for the whole lesson; this is an indication that there is something wrong either with the teaching method, the students, the content or the teacher; teachers need to protect students that ask or answer questions from humiliation by their colleagues; they need to teach their natural sciences students how to explain or apply scientific concepts in class before they encounter such questions in tests and examinations.

● misconceptions held by students should not be because of their teacher's mistakes; instead teachers need to prepare thoroughly for their lessons and make sure they carefully select the resources and semiotic formations they use; they should also have a good command of the content; misconceptions linger in students' minds long after they have been given the correct concepts or explanations.

●natural sciences teachers need to plan for their lessons together with English language teachers (inter-curricular co-operation) for improved understanding and application of English by their students; natural sciences teachers will brief the English language teachers about the grammatical mistakes the students make in the natural sciences so the English language teachers include those grammatical aspects in their lesson plans; once the students are fluent in English language then they are in a better position to acquire and use the language of science.

● teachers should not spoon-feed their senior students; the education policy requires students to take responsibility of their learning, and to own it, therefore, teachers should not give students full notes on the chalkboard to copy into their notebooks; students should be guide on how to get the information from different sources and make their own notes and so enhance their understanding; prepared notes by the teacher do not promote understanding.

● teachers should not make examples of students or their friends or relatives when teaching about topics/concepts that may mortify the students; once embarrassed or humiliated by their teacher the students will no longer feel comfortable with the teacher or the subject and may end up losing interest in the subject or in schooling; teachers need to be cautious when teaching about sensitive topics like malnutrition.

● internal examination papers should be similar to the papers students write in the external final examination; this is with reference to the duration, layout and style of questions set; the final external examination should not be a shock to the students by having a different layout and kinds of questions; poor results are likely to ensue.

Addressing all these recommendations can help meet all the aims of the study.

5.4 Limitations of the study

This case study on student discourse in a natural science classroom has the following limitations:

First: as the study was conducted in one natural science class in a rural high school in the Lubombo District, its findings are taken to be unique to that group in the school and cannot be generalised to the other natural science groups in the same school or to all high schools in Swaziland. But if one considers the contexts and conditions are similar to one's natural science high school group one may then use the findings of this research.

Second: the study was conducted on one natural science subject, Biology. Therefore, it would not be reasonable to generalise the findings across all the natural sciences, unless one deems the conditions and contexts are comparable.

In essence, because the teaching strategies needed by the natural sciences subjects are not in the same pattern, in one subject a practical or demonstration may be needed after every concept, yet with another subject a practical or demonstration may be needed at the end of a topic or chapter.

Third: the research did not consider teacher qualification yet it could be a factor influencing the teaching and learning of natural sciences.

Fourth: the study was conducted at the classroom level and did not consider the school level or the district or national level. It may happen student discourse is better or even worse in this natural science class considering the school or national level.

Fifth: language might have been a barrier during the interviews with the students as all of them have English as a second language, even though care was taken to make the questions as understandable as possible. The language factor also influences student discourse in the natural science classroom.

Despite all the limitations stated above the study has made a thorough effort of exposing the discourse patterns in the natural science classroom that could lead to poor performance of students in external examinations.

5.5 Future research

This research can be taken further to include all the natural sciences at the same level in that school. It could also be conducted in all the natural sciences in that particular school or be taken further to involve a number of school types in the country such as rural, suburban and company schools so as to obtain a wide spectrum of what student discourse in the natural sciences is like in other schools across the country.

A more comprehensive research can also be conducted to include factors that may influence student classroom discourse in the natural sciences. These may be motivational factors and English as a language barrier for example. This study may even include administrators as a possible negative factor in the school.

This study can also be adapted to other subjects like mathematics to investigate the factors that influence academic success. This investigation can also be used as a starting point from which further research can be conducted on how to select and use teaching strategies that enhance student classroom discourse in the natural sciences.

5.6 Concluding remarks

In proposing this research focusing on student discourse patterns that occur during the teaching and learning of natural sciences, I wished to find out how natural sciences students interact with each other, with their teacher and with the natural science content. I also wished to know what meanings the students and their natural science teacher gave to such classroom discourse. The case of Tfolani High School has demonstrated answers to some of these concerns. The case of Tfolani has revealed the discourse patterns that take place in some natural sciences lessons in some high schools in Swaziland.

In the group that was observed at Tfolani High School most of the natural science lessons were teacher-centred. Prevailing discourse patterns were found to be student and teacher talk, as well as written work. Student talk only dominated practical lessons. In all the lessons talk was initiated by the natural science teacher which involved the students and the teacher. The students never asked their teacher any content-based questions during the observed lessons. They only answered questions from their teacher and even with those questions they avoided those that needed explanations or exact answers. Instead of asking their teacher for clarification the students preferred reserving those questions for later research or would secretly enquire from their peers during the lesson, as they were not allowed to talk among themselves without permission from their teacher.

To improve school results in the natural sciences teachers need to stop spoon-feeding their students with already prepared notes to copy from the chalkboard into their notebooks; instead they should let them make their own notes according to the way they understand the sources. Students need to be encouraged to spell correctly and to use scientific resources and formations when communicating through talk and in writing. Teachers need to employ teaching methods that engage the students in classroom discourse, such as the inquiry process, using science talk especially.

When interviewed about the meaning natural science students give to classroom discourse it transpired that they valued such discourse as necessary for proper learning. They concurred with literature that classroom discourse was one of the ways through which meaningful information exchange could occur. Their teacher too (Mr Sameline) valued classroom discourse as the most important tool for communication in the natural science classroom. In fact literature reveals that all discoveries in science are communicated mainly through spoken and written discourse. In the natural science classroom the natural science teacher uses discourse to impart knowledge to students and also gets feedback from the students about how much information they have acquired through discourse too. So, the interviews conducted with Mr Sameline and his students gave answers to research question two.

Natural science teachers should leave no room for humiliation in their classes, either of themselves or of their students. Every student should feel free, happy and comfortable during natural science lessons for active and meaningful learning to happen. It would be good if the teacher announces the next lesson’s topic at the end of every lesson so that students are given the opportunity to read ahead and attend the next lesson well prepared. The natural science teacher may even photocopy the syllabus for the students and give them individual copies. Student groups for performing practicals need to be of mixed ability, for example, a student who is more capable in written tasks in a subject may be less capable in practical skills and vice versa. Students of different capabilities will complement each other through sharing knowledge and skills. Finally, classroom science discourse should be encouraged among all students during lesson time as it gives the teacher immediate feedback on where the students are along the continuum of conceptual locality.

5.7 Summary

Chapter five is the most diverse chapter as it opens with an introduction, then followed by a discussion of the study; recommendations; aspects of future research; limitations of the study; and lastly a section concluding the study. Under the section on discussion there are subsections like student talk during natural sciences lessons in which are discussed all the lessons mentioned in chapter four, and the students' scripts.

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APPENDIX X

STUDENT DISCOURSE OBSERVATION PROTOCOL

A Student Discourse Observation is a 20-40 minute classroom observation in which one or more observers document student actions and interactions that are examples of student scientific discourse. The observer(s) could include a principal or other school administrator, science coach, classroom teachers, and/or an outside consultant. The purpose here is not teacher evaluation or to "fix" a teacher or students. Rather, this process is intended for situations in which a teacher is actively working on the development of student discourse to promote science learning, and the teacher has sought support for reflection and inquiry regarding that work. In addition to providing rich data about the observed classroom, the process is designed to provide the observers meaningful context for reflection about their own practices.

The Student Discourse Observation Protocol provides a structure that focuses the observation and the professional dialogue between the observer(s) and teacher on the important science in the lesson, the students' thinking about science, and the key characteristics of productive scientific discourse. This protocol supports collaborative inquiry by the teacher and the observer(s) regarding the students' scientific thinking and ways to move student thinking and discourse along a continuum of cognitive levels — from short answers and explanations/demonstrations of scientific processes to justifications, conjectures, and generalisations.

THE PROTOCOL

Phase 1 Predictions - Framing the Observation

Guided by the Pre-Observation Dialogue Questions, the teacher and observer(s) engage in dialogue about the lesson content and design, the science ideas they predict students will understand and struggle with, the role of discourse during the lesson, and particular individuals/groups on whose discourse the observation should focus.

Phase 2 Observations - Collecting and Classifying the Data

The observer(s) record student discourse data on the Student Discourse Observation Tool. The students may use a variety of "discourse tools" for communicating their thinking — written and oral explanations; sketches, diagrams, charts, graphs, and models; gestures and physical demonstrations; calculator and computer simulations and demonstrations; and/or science symbols and formal scientific notation. All such interactions are appropriate for documentation. However, since the inquiry centres on student thinking and discourse, the observation focuses on interactions that are student to student, student to class/ group, student to teacher, and/or student to self (e.g., journaling), but not teacher to student/class. The observer(s) record facts only - no inferences or judgments.

After the lesson, the observer(s) and teacher review the data recorded during the lesson and classify each piece of discourse data as PF (procedures/facts),} (justification), and/or G (generalisation). If there are data entries that do not fit in one or more of these classifications, those should be classified as NA. The observer(s) and teacher dialogue about facts only - i.e., what students actually said and did and the types of discourse those interactions and actions represent. No inferences yet about students' science understandings or needs, instructional implications, or inquiry possibilities. It is very important to first reveal as many facts as possible regarding the things that students actually said and did.

Phase 3 Inferences - Inquiry Dialogue and Action Steps

Guided by the Inference and Inquiry Dialogue Questions, the observer(s) and teacher discuss their curiosities and speculations about science understandings and learning needs revealed by the student discourse data. They design strategies for continued collaborative inquiry regarding students' scientific thinking and ways to deepen students' scientific understanding by "moving" discourse along a continuum of cognitive levels from explanations of science processes to justifications, conjectures, and generalisations. At the conclusion of the 3-phase dialogue, all participants always report to each other one or more ways they intend to change/refine their individual practices as a consequence of the observation and dialogue, and they discuss ways to continue their collaboration.

Repeated use of this protocol by a group of educators can dramatically impact the ways in which they listen and respond to student thinking on an everyday basis, and ways in which they interact professionally about their practices. When first experiencing the process, it may feel a bit awkward or controlled and a group may be tempted to abandon the structure; however, to learn and maximise the benefits of the process, it is recommended that a facilitator keep the group interactions moving according to the protocol. On the other hand, it is important to remember that the purpose here is to promote deep and thoughtful dialogue and reflection, which should never be sacrificed for the sake of "following the protocol."

STUDENT DISCOURSE OBSERVATION TOOL

Teacher______________Class_____________Date___________Page___of _____

PF PROCEDURES /FACTS	J JUSTIFICATION	G GENERALISATION
• Short answer to a direct question • Restating facts/statements made by others • Showing work/methods to others • Explaining what and how • Questioning to clarify • Making observations/connections	• Explaining why by providing scientific reasoning • Challenging the validity of an idea by providing scientific reasoning • Giving a scientific defence for an idea that was challenged	Using scientific relationships as the basis for: • Making conjectures/predictions about what might happen in the general case or in different contexts • Explaining and justifying what will happen in the general case

	Discourse – Based Evidence of Student Thinking