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Construction of meaning by second language students in access physics classes in Lesotho.

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

This chapter outlines the general background of the study. It does so by first giving a brief review of the background to this study. The chapter outlines the problem to be investigated, the aims of the study, the research questions to be answered and justifies why this study is pertinent now. Then it gives a brief review of the status of Science Education in Lesotho. Finally, it outlines the structure of the rest of the chapters of this thesis.

1.2 STATEMENT OF THE PROBLEM

The main driver of this study was the observed students' learning difficulties in a Physics course of an access programme, **Technician Induction Programme** (TIP), at the Lerotholi Polytechnic (LP) in Maseru, Lesotho. The concept of access programme refers to initiatives whose aim is to provide an access into the institution to students who otherwise do not meet entry requirements of that institution. Students who are enrolled in TIP often do not make a coherent meaning of application of force in electromagnetism. Some of these problems were reported earlier (Qhobela and Stanton, 1998a). In addition to difficulties reflected when students respond to questions either verbally or in writing, the experience is that the majority of students generally remain silent for the whole lecture irrespective of whether they are given a chance to ask questions or to answer them. This obviously makes the lecture a one way process and leaves the success of such a process in serious doubt. Initially it was believed that this problem was related to being unable to communicate due to low proficiency of the language of learning and teaching, English. Of course this feeling causes a dilemma; if students must be encouraged to talk in a science classroom does a science teacher also teach English? The second problem was believed to be the tradition which some of these students come from. That is the tradition of authority of the more knowledgeable adult. Problems related to low

proficiency of English language are evident in Lesotho where teaching, both at upper primary and secondary levels, should be conducted in English which is a second, or even a foreign language to others. However, it later became clear that the perceived problem of language is more complex than just being an issue of communicating in the language of teaching and learning. It became clear that the problem involved the issues of Discourses of science, in particular of physics. Students' understanding of physics register, or set of specialised meanings belonging to the language of physics, hardly forms a meaningful unit. For instance, the experience was that when a student talks about **existence of force**, e.g. tension in a rope, their understanding of **presence of point of application** and **what applies push/pull** gives an impression that the student does not relate the three elements. That is, though the relationship between elements of a concept may appear coherent at first it breaks when probed. As a consequence of this complex language problem, it was felt that the students' noticeable lack of understanding of subject matter was inevitable.

In conclusion, there were two problems which access students had at LP: firstly, they had learning difficulties in electromagnetism and secondly, they had problems coping with the language of physics. Problems were compounded by English language as a language of teaching and learning.

A reflective analysis of the problem stated above and of the teaching practice I had been involved in suggested another problem. It was the fact that the past teaching strategies did not really address the problems stated above and/or it might have exacerbated them. The problem was that the teaching approaches that I followed did not explicitly address the language issues. At the root of the concept of the discourses of science is the prevailing suggestion that advocates a more sociocultural approach where issues of language are addressed. Because language issues were not attended to it makes sense therefore that the majority of students would have conceptual problems. Thus the teaching methods were clearly a contributing factor.

This study therefore identifies the following problems affecting access programme students at Lerotholi Polytechnic in Maseru, Lesotho:

- students had learning difficulties related to concepts of electromagnetism,
- students had problems in coping with both the academic language and language of teaching and learning, and
- teaching methods which had been tried did not make much difference.

1.3 MAIN CONCEPTS

In this study certain concepts form a central thesis and thus need to be briefly defined. These concepts are **discourses of science, natural language, social language and language of teaching and learning**.

Natural language: The operational definition of a social language in this thesis is a language, such as Sesotho or English, which people use to communicate in a day to day situation.

Language of learning and teaching: The natural language when used in a classroom to communicate intended academic meaning becomes the language of teaching and learning.

Social language: Social language refers to a specialised language used within a social setting such as a community of scientists. The social language used by the community of scientists is referred to, in this study, as the language of science.

Discourses of science: The operational definition of Discourses of science concur with Gee (1999)'s definition of Discourses of science. They are the ways of talking, doing, reading and writing accepted within a community of scientists.

1.4 AIMS OF THE STUDY

The main aim of this study is to uncover issues related to the use of second language and teaching strategies in a Physics classroom of access students at LP. The study hopes to suggest teaching strategies that can best redress learning difficulties of access students particularly in electromagnetism. This study also seeks to contribute towards addressing students' problems of learning and of teaching in a second language. The study will finally make recommendations, in terms of possible mediation strategies and policies,

which can be put in practice to address problems facing science teaching practices in Lesotho.

1.5 WHY THIS STUDY?

The statement of the problem and the aims of this study stated above naturally lay the basis for consideration of why this study had to be undertaken. Earlier studies (Qhobela and Stanton, 1998a; 1998b) on the problems of access students in Lesotho's tertiary institutions - Lerotholi Polytechnic (LP) and National University of Lesotho (NUL); and my experience of teaching at this level, suggested that students have problems in understanding concepts of electromagnetism. Primarily, students tend to disassociate the existence of magnetic field and the resulting action. Qhobela and Stanton (1998a), for example, concluded that access students at these institutions confuse names and field patterns and went further to attribute these problems to the possible influence of teaching and printed text. The observations that they made were not new. In Qhobela (1996) high school students in Lesotho were identified as having problems with understanding electromagnetism related concepts. Students entering tertiary institutions attend access programmes carrying over these conceptual problems to this next level. There was therefore a strong view at the time of designing this study that students entering access programmes in Lesotho's tertiary institution inherited learning problems which were then viewed as alternative conceptions.

Literature on alternative conceptions points to the problems brought by use of both the language of teaching and learning and academic languages (e.g. Head, 1986; Driver, 1994; Curtis and Millar, 1988; Sanders, 1988). The problem arises when both the languages employed in the science classroom are foreign. Obviously in a science classroom the academic language is new and foreign to students. The problem of both the language of teaching and learning and academic language being foreign is certainly the situation in Lesotho's secondary education level. Lesotho's education policy requires that teaching/learning at secondary level is done in English, which is a second language to majority of the student population from urban parts of the country and foreign to the rest of the population. The situation in Lesotho is such that, like in many other

developing countries, two main languages, namely Sesotho and English, are used. According to Khati (2001) Sesotho, mother tongue to majority of student population, is mainly used as a symbol of patriotism, nationalism and as an instrument of formal and informal local communication while English is used largely for Educational and official uses. Khati (2001) noted, however that the level of proficiency of English is so low that some teaching at secondary level is done in Sesotho. In summary therefore in Lesotho both the academic language and the language of teaching and learning are foreign to most students in secondary education.

In conclusion therefore, there was need in Lesotho to conduct a study that addresses language issues that were perceived to be complicated. In addition it was felt that learning difficulties which access students had in electromagnetism must be addressed in conjunction with the language issues. Such a study would inevitably address these learning difficulties, paying interest to the issues of teaching/learning scientific concepts using a second language.

1.6 RESEARCH QUESTIONS

The study will address the following main research questions:

1 What strategies can be employed to enable access students to construct meaning through Discourse of science when learning about electromagnetism?

2 Which elements of the strategies enable or constrain the students' use of the language of science?

3 What is the effect of mediation strategies on the students' learning?

1.7 THE FOCUS

The statement of the problem discussed above indicates that students enrolled in an access programme at LP had learning difficulties related to basic concepts in electromagnetism. Though students' models in electromagnetism have been reported in the literature (Borges and Gilbert, 1998; Andersson, 1986; Arons, 1990), students at LP had their own problems observed over the years. The following are the problems that had to be addressed:

i) Students at LP are familiar with, and often use, the phrases "Like poles repel, and Unlike poles attract". However, one is not convinced that in doing so students always have a sense of magnetic field around a magnet. The problem here is the lack of bringing together all that is in the Physics register associated with the phrase and thus formation of a coherent meaning. The Physics register associated with the phrases mentioned above stretches from mechanics, where the concept of force forms a basic and crucial foundation, to electricity, where the concept of current is also basic and important. For instance, if the concept of application of force in mechanics is not clear, students fail to understand that there must be

   a) presence of something pushing/pulling, and then
   b) presence of something that is being pushed/pulled

   Thus, attempting to answer these two points leads one to thinking about the presence of a magnetic field. Though the statement is so known to most students the problem of the inability to relate it to application of force sometimes leads them to talking about presence of force of attraction between magnets only.

   What is clear is that reference to this phrase is really more of a repetition, with a very weak relationship to other directly related concepts. Due to this, the meaning that students have is not likely to be the same as what an expert, in any related field, would have.

   The second problem, observed to be related to the phrase, is the kind of cognitive picture that students have about magnetic field. The majority of these students would draw the magnetic field lines which could be a mixture of models that Borges and Gilbert (1998) report, as illustrated in diagram 1.1

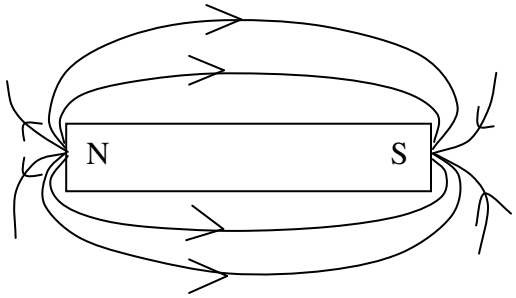


Diagram 1.1: LP's access students' model of magnet field around a magnet

In drawing magnetic field lines as shown in the diagram above, students have other related problems

a) they normally associate magnetic field with lines that start from one end of the magnet to another.
b) they see a magnet as having two distinct parts (North and South pole).

ii) Access students at LP tend to apply Fleming's Rules (The Right-Hand Rule and Left-Hand Rule) without full understanding of the concept of interaction of magnetic fields. To apply any of these rules, students need to be aware that there has to be a mention of "Current", "Magnetic field lines" and "Motion". The relationship between the three does not exist except that they are applied on fingers of a hand. Students do not relate the presence of two different sources of magnetic fields. In some cases they do not always realise that a current carrying conductor has a magnetic field around it. As a result students do not see any possibility of interaction of magnetic fields. Thus any reference to these rules carries a weak meaning.

The foregoing discussion addressed the core question of why this study. In the next section I am going to provide a brief background to science education in Lesotho, indicating also the socioeconomic challenges that the country faces.

1.8 SCIENCE EDUCATION IN LESOTHO

Lesotho is a mountainous developing country totally landlocked by the Republic of South Africa. Its size is 30 355 square kilometers and the population is estimated to be 2

million (See Appendix 8). Lesotho has faced a number of challenges in the science education sector ever since its independence from Britain in 1966. These challenges include low numbers of learners graduating from tertiary institutions such as universities and polytechnics, low pass rates at secondary education level and serious shortages of science teachers at the secondary education level. Different initiatives have been tried in the past to address some of these challenges. Examples of these initiatives include the Lesotho Introductory Science Improvement Program (LISIP) introduced in 1973 and the access programmes introduced in early 1980's. According to Towse (1983) LISIP was designed to address students' attitudes towards science and to improve performance in the sciences at junior secondary education level. At the time it was clear that the students' performance in science subjects at secondary education level was poor and beginning to influence students to lose hope of ever being in science related fields. LISIP was therefore designed to address this problem. According to Towse (1983:167)

> The LISIP course emphasized student-centered, investigative activity and many teachers, and others, felt that this course would inevitably promote much more positive attitudes towards science than the traditional physical science course it was to replace.

Towse (1983)'s analysis showed that the LISIP programme did not have the impact that was expected of it. In general the status of science education in Lesotho still causes concern.

In reporting on the status of science education in different countries Caillods, Gottelmann-Duret, and Lewin (1996) have found it essential to cover issues such the following:

i) Participation of students in secondary science education
ii) Teaching and learning conditions in science education
iii) Science teaching in practice
iv) The cost of science education

To understand the status of science education in Lesotho, therefore, I briefly contextualise the above issues to the country's situation.

1.8.1 Students' Participation in Science education

The nature of participation of students in science education at secondary education level can be determined by consideration of issues such as the organisation and duration of secondary education, enrolment and specialisation (Caillods *et al.*,1996). Secondary education in Lesotho takes the form of a 3 + 2 structure. That is, it takes five years and is divided into two levels; namely the Lesotho Junior Certificate (LJC) and the Cambridge Overseas School Certificate (COSC). The LJC takes the first three years while COSC takes the last two years of the secondary education. Science Education accordingly takes this format. At LJC level certification is conducted by a semi-autonomous body known as the Examinations Council of Lesotho (ECOL). However the curriculum is designed by another body, the National Curriculum Development Centre (NCDC) which is a department of the Ministry of Education (MoE). Science is compulsory, though it is not mandatory for success in the overall LJC examination at LJC level. It is intended to introduce students to basic concepts in Biology, Chemistry and Physics and does not entail any specialisation at all. The objectives of science education at this level are outlines to be as follows

- develop the scientific skills of observation, estimation, measurement, experimentation, construction, interpretation and analysis of data, inferring, hypothesising, predicting, scientific communication and thinking
- be able to solve problems scientifically
- acquire knowledge and understanding of basic concepts and of the practical application and use of scientific equipment, in preparation for life and further training (MoE, 1986).

It has been my impression that most people generally believed that the pass rate at LJC is satisfactory. Anecdotal evidence also suggests that people think that there is too much standardisation done by the marking board. One gets the impression that this refers to the practice of normalising of scores.

At the upper level, COSC, certification is done under the auspices of the University of Cambridge, which is also responsible for designing the curriculum. At COSC level students are offered a wider range of options, including not to do science at all. This

level therefore marks the first leg of the introduction of specialisation in science. Broadly, one of the intentions of the system is to influence students so that when they leave this stage and progress to the tertiary level they may opt for science and technology related fields. Table 1.1 (adapted from Molapo, 2003) shows the number of students who sat for Biology, Chemistry/Biology, Physics/Chemistry options and Mathematics from 1997 to 2004. English language is included as a comparison because all students must take this subject since it is mandatory for grading at this level. The Table shows the total number of students who wrote the examinations, the number of students who passed (i.e. obtained grades 1 to 6) and the percentage of students passing.

Subject	**Candidates who**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Biology 5090 (3 papers)	Sat	3107	3474	3547	3782	4249	4370	4340	4029
	Passed	421	477	437	531	498	543	601	644
	Percentage	*13.6*	*13.7*	*12.3*	*14.0*	*11.7*	*12.4*	*13.8*	*16.0*
Chemistry & Biology 5126 (3 papers)	Sat	1028	1220	1198	1325	1741	1884	2046	2383
	Passed	166	243	233	273	309	366	396	463
	Percentage	*16.1*	*19.9*	*19.4*	*20.6*	*17.7*	*19.4*	*19.4*	*19.4*
Physics & Chemistry 5124 (3 papers)	Sat	1924	2119	2124	2420	3162	3289	3326	3343
	Passed	443	532	476	573	803	858	898	859
	Percentage	*23.0*	*25.1*	*22.4*	*23.7*	*25.4*	*26.1*	*27.0*	*25.7*
Mathematics 4024 (2 papers)	Sat	6686	7616	7967	8311	9573	10028	10565	10700
	Passed	525	364	546	679	884	1122	778	1051
	Percentage	*7.9*	*4.8*	*6.9*	*8.2*	*9.2*	*11.2*	*7.4*	*9.8*
English Language 1123 (2 papers)	Sat	7972	9039	9321	9509	10853	11232	11807	11579
	Passed	560	240	413	449	913	747	910	1126
	Percentage	*7.0*	*2.7*	*4.4*	*4.7*	*8.4*	*6.7*	*7.7*	*9.7*

Table 1.1: Comparison of COSC core subjects results

Most schools tend to offer two science options: Biology (5090) and Physics and Chemistry (5124). Many schools prefer Biology (5090) because of the view that it is less demanding compared to Physics and Chemistry as single subjects. Secondly they think that it is cheaper compared to these other science subjects. They also think that it is easier to find biology teachers compared to other science subjects such as Physics. The option Chemistry & Biology (5126) is also common. This option is offered by schools which offer only one science subject. Such schools explain this as a result of lack of Physics teachers and the expense associated with introducing the second science option. By comparing the numbers of candidates taking any of these science options with English language, which had to be done by every candidate, it is clear that the enrolment of

students in sciences has remained low. The pass rate for both Biology (5090) and Physics & Chemistry (5124) remains very low, though it is improving. Of concern is the pass rate of mathematics since it has direct impact on enrolment at tertiary level. For example, students seeking admission into NUL's Faculty of Science or LP's Schools of Technology and Built & Environment must obtain a grade 6 or better at COSC to be considered for admission.

1.8.2 Teaching and Learning Conditions

The teaching and learning conditions in Lesotho's secondary education system certainly cause concern. The conditions that cause concern include the absence of laboratories and/or lack of laboratory equipment and chemicals, empty libraries (where available), overcrowded classrooms/laboratories, lack of other teaching/learning facilities such as computers and teaching aids. It is noted however, that teaching and learning conditions in developing countries in general have had a variety of problems (Kahn and Rollnick, 1993; Lewin, 1992; Stoll, 1994) and Lesotho is no exception. Commenting on teaching and learning conditions in developing countries, Caillods *et al.* (1996:44) argue that

> …conditions deteriorated in the 1980s in a large number of developing countries due to the economic crisis and associated adjustment programmes.

Indeed Lesotho went through the experience of IMF's adjustment programmes in 1980's and its secondary education was adversely affected. The consequence of this is that the bulk of the country's budget (just over M800 million (**US$114** million) for education), still goes to salaries and other expenses. A smaller amount goes to investments.

Though the government of Lesotho has recently been building laboratories in some schools around the country, Peko and Mokoteli (2001:8) reported that

> The number of laboratories that schools have range from one to five. Out of the sampled schools 30 %, has no laboratories. The majority of the schools have one laboratory (46 %) and less than 1% of the schools have five laboratories.

Laboratory equipment has been, and remains, a rarity (Kahn & Rollnick, 1993) with unproved public opinion that most of the funds which schools collect through school fees are misappropriated. As a result, it is highly likely that some students complete

secondary education without having done basic experiments. It is a common observation, though, that some teachers, not only in Lesotho, elsewhere as well tend to avoid conducting experiments even when their schools have the necessary equipment (Mashimbye and Szubarga, 1994). Most schools have no other teaching facilities except chalk and chalkboard. Except for a few most will have a computer in the Head Master's Office only and there is no access to internet. Such a computer is often not accessed even by teachers. Most schools do not have libraries and if they do, they are poorly equipped. The only resource students have is the prescribed textbook and the notes that teachers give. Anecdotal evidence suggests that teachers depend on the prescribed textbooks and on one or two books they bought when they were students.

The issue of morale in the schools has affected the general working conditions in schools negatively. Teachers' salaries have been a thorny issue since 1995 when the then Prime Minister withdrew an increment that was given three months earlier. Anecdotal evidence shows that since this withdrawal, teachers' morale in schools has been negatively affected. However, politicians normally associate the problem of morale with other conditions such as job satisfaction and availability of teaching aids rather than salaries and other related benefits. Another thorny issue closely linked to teachers' morale is the ownership of schools. According to Ministry of Education (2001) [MoE, 2001] in Lesotho 92% of schools are owned by churches yet teachers are paid by government. Inevitably, tensions of who has the final say on issues of policies of schools are set to arise. In 1994 the government introduced an education act which sparked dissatisfaction amongst churches. The act therefore could not be implemented fully and recently the Minister of Education and Training has been holding public gatherings with the purpose of introducing another act which may be more acceptable to all parties involved.

Availability of science teachers, especially of mathematics and physics, has been a problem for some time. Experienced teachers in Lesotho and many other developing countries leave for greener pastures. They leave schools with mostly inexperienced novice teachers (Maqutu, 2002; Gray, 1999). According to Maqutu (2002), most teachers in Lesotho are qualified but are at a novice stage and need extensive support. Lerotholi

(2001) highlights the situation in Lesotho. She shows that in 1998 there were 542 teachers at secondary level with 0 to 4 years teaching experience and 177 with 20 to 34 years of experience. Maqutu (2002) observes that the government of Lesotho, through its Ministry of Education, does not have a clear policy on how to help these novice teachers in the secondary education. For example schools are rarely inspected and teachers hardly attend workshops. Mathematics and Science Advisory Centres appear to be overloaded and handicapped by availability of expertise, resources and finances. The NUL's faculty of Education has a one year optional Induction Programme which supports their Science Education graduates during the first year of their teaching. The number of science and mathematics teachers is low and this problem is compounded by minimal assistance from the government and other institutions.

1.8.3 Science Teaching in Practice

Actual learning/teaching activity in a science classroom is another mirror through which the country's status of science education can be reflected. Researchers have argued that lack of facilities and equipment and inappropriateness of the teaching and learning conditions are major reasons for the poor teaching strategies employed by teachers in practice (Caillods *et al.,* 1996; Gray, 1999). The issue of unavailability of facilities in Lesotho's secondary schools remains one of the major obstacles towards a better teaching practice (Mokuku, 2001; Talukdar, 1995). There is evidence that most teachers in the secondary schools tend to use traditional methods (Qhobela, 1996; Khoboli and Malcolm, 2004).

Class size in Lesotho's secondary schools is another factor which affects teaching in practice. Literature reflects slight disagreement on the actual teacher-student ratio. In Lewin (2000), Lerotholi (2001) and MoE (2001) the teacher-student ratio is reflected as 1:24 while Maqutu (2002), whose interest was science classrooms, shows a ratio of 1:22. However, Qhobela (1996), with same interest as Maqutu (2002) reported a ratio of 1:24 with the range varying from as low as 1:5 to as high as 1:45. There is nothing substantial to suggest drastic changes over the last decade. The problem is that schools with low ratios are mostly in the highlands where there are no qualified teachers while ratios are

high in the lowlands. High numbers in a classroom obviously affect the choice of teaching strategies negatively. However, Caillods *et al.* (1996) argue that low ratios do not mean automatic success in examinations. Success can also be influenced by factors such as suitably trained teachers, sufficient space, books and equipment, motivated students and appropriate curriculum design.

How teaching occurs in classrooms is also influenced by adequacy of the teachers' knowledge of science content and the sophistication of their conceptions of science (Caillods *et al.,*1996; Gray, 1999). The teachers' knowledge of science content goes along with the teachers' knowledge of his/her students. Qhobela and Stanton (1997) and Qhobela (1996) have shown that some teachers in the Lesotho's secondary school did not know what conceptions their students have in electromagnetism and that some of those teachers could be having the same conceptions as their students. Khoboli and Malcolm (2004) reported that teachers in their sample did not show a convincing understanding of learner-centered learning. However, Maqutu (2002) shows that one of the factors that contribute to good results in some schools in Lesotho is the fact that teachers in such schools work hard to avoid chalk and talk teaching as a single strategy.

1.8.4 Cost of Science Education

Caillods *et al.* (1996) argue that developing countries face the same problems of the high cost of science education. These problems include the expense of teaching facilities compared to other subjects, textbooks and practical facilities being expensive to build and equip. The same observations have been made with regard to the cost of science education in Lesotho's secondary level education (Maqutu, 2002; Middleton, 1990; Kahn & Rollnick, 1993).

One way of overcoming high costs would be to use locally produced materials. However, with regard to developing countries, this does not appear to be a solution. The cost of producing needed material is still high. The issue is made even more difficult when considering the fact that the curriculum is by and large foreign in the sense that it is developed by former colonial rulers. In the cases where some localisation took place

foreign examples were merely substituted with local ones (Gray, 1999). Stoll (1994) argues that most developing countries have adopted curricula from their former colonial masters, who happen to be financially capable of implementing them, while most of these developing countries do not just have such capacity. Lesotho has adapted its secondary education from the British system. According to Lewin (2000), rich countries such as Britain use about $5000 per child per year while poorest countries can only afford $50. According to Lerotholi (2001) the government of Lesotho's expenditure and the parents' together added up to $420 per secondary-pupil in the financial year 1998 – 1999. This therefore raises serious problems in assuring science education of reasonably good standard.

1.9 Overview of the thesis

This chapter outlined the general background of this study. It briefly reviewed the background to this study outlining the problem to be investigated, the aims of the study, the research questions to be answered and justifying why this study is necessary now. Then it reviewed the status of Science Education in Lesotho. Chapter 2 briefly discusses the history of science education initiatives, access programmes, which were put in place as temporary measures and whose impact was thought to be addressing the problem of low enrolment once and for all. It does this by discussing, in general, the concept of access programmes. Then it discusses the access programmes in Lesotho.

Chapter 3 discusses the literature that informed and guided this study. In particular it discusses Vygotskian contributions that helped to construe the sociocultural theory, and consequently perceive its thesis to be that learning is a social activity which occurs within a social setting with a distinct culture and history. The chapter draws similarities between sociocultural theory and situated cognition insofar as they inform classroom practice. It ends by discussing the theoretical framework of this study. Chapter 4 discusses the analytical tool that is used to analyse data. The chapter presents the SAMPS system of Discourse analysis. Then it discusses the additional tools the communicative approaches & discourse patterns and Toulmin's Framework.

Chapter 5 discusses how, and why, data was collected the way it was collected. It does so by breaking the presentation in two broad categories. The first issues treated are theoretical. This was done by describing the study, data collection methods, validity and reliability, the limitations of the study, and the ethical issues. To define the study, the design and justification of why generic qualitative paradigm was chosen, are discussed. Then the chapter discusses what actually happened. The first thing was to explain the context of the study, and then the intervention and the data collection methods used. Then the chapter discusses the pilot, that is how the pilot data was used.

Chapters 6, 7, 8, and 9 are results chapters. Chapter 6 discusses the result of the activity aspect of SAMPS system of analysis, the emergent categories. This is done by discussing emergent categories of each predetermined stage. Chapter 7, presenting the first results of the semiotic aspect, discusses initial situation definitions that Lerotholi Polytechnic's access students had on magnetic field prior to the learning of magnetic field interaction. In order to discuss these definitions, analyses of concept maps that students drew and discourse patterns that unfold as they are engaged in concept mapping is made. Chapter 8 discusses the second set of semiotic aspects results, with interest on Conceptual Initiation stage. Chapter 9 discusses the last set of semiotic aspect results and, in particular, discusses the results of the Conceptual Formulation and Conceptual Application stages.

Chapter 10 consolidates the results of the study and directly responds to the research questions.

CHAPTER 2

Access Programmes in Lesotho

2.1 Introduction

The discussion of science education at secondary education level in Lesotho in chapter 1 reflects a wide range of problems that Lesotho faces. For example, the pass rate at higher secondary level, COSC, has been, and remains, low. The immediate consequence of this has been low enrolment at tertiary level. The success rate at tertiary level, particularly in the first year of study, also remains poor. This chapter discusses the history of initiatives, access programmes, which were put in place as temporary measures and aimed at addressing the problem of low enrolment once and for all. The chapter discusses access programmes as a concept which in the 1980's, in Lesotho in particular, became a mechanism of addressing the problem of poor performance at secondary education level resulting in low intake at tertiary level. The concept also helped to address problems of low success rate at tertiary level.

2.2 The Concept of Access Programmes

The concept of access programmes in Lesotho adapted a world wide short term mechanism of responding to problems of access to tertiary education (Thijs, 1993; Hayes, 1997; Rollnick, 2005; 2006). The concept was fashionable in the 1980's in Southern Africa, resulting from the cooperation that existed between different bodies in the region with Free University of Amsterdam (FUA). The implementation of this concept, in Southern Africa, was first realised in Botswana, Lesotho and Swaziland. The University of Botswana (UB), the National University of Lesotho (NUL), and the University of Swaziland (UNISWA) had cooperation agreements with FUA and consequently different access programmes were initiated. Because of different circumstances, access programmes are implemented for varying reasons. In Boleswa countries the main reasons were:

- Poor performance at secondary education level: Many institutions of higher learning faced a reality that secondary schools leavers hardly meet entry requirements because of poor performance.
- Un-readiness of secondary school leavers to cope with learning demands at tertiary level: The general observation is that even in cases where students meet entry requirements they are not ready to cope with learning at universities or other institutions of higher learning.
- Equity: The issue of representation in science related fields has been a problem. Because of a variety of factors, participation of females would be lower than that of males hence a need for a correcting initiative.

In Lesotho, the first access programme, within the science education sector, was the Lesotho Science Pre-Entry Programme (LESPEC). The cooperation agreement between NUL and FUA, under which LESPEC was established, necessitated another programme, not necessarily access programme, though. The programme was called the Accelerated Mathematics and Science Teachers Improvement Programme (AMSTIP). Diagram 2.1 below, adapted from Thijs (1993) and Rollnick (2005), summarises the role that these two programmes played.

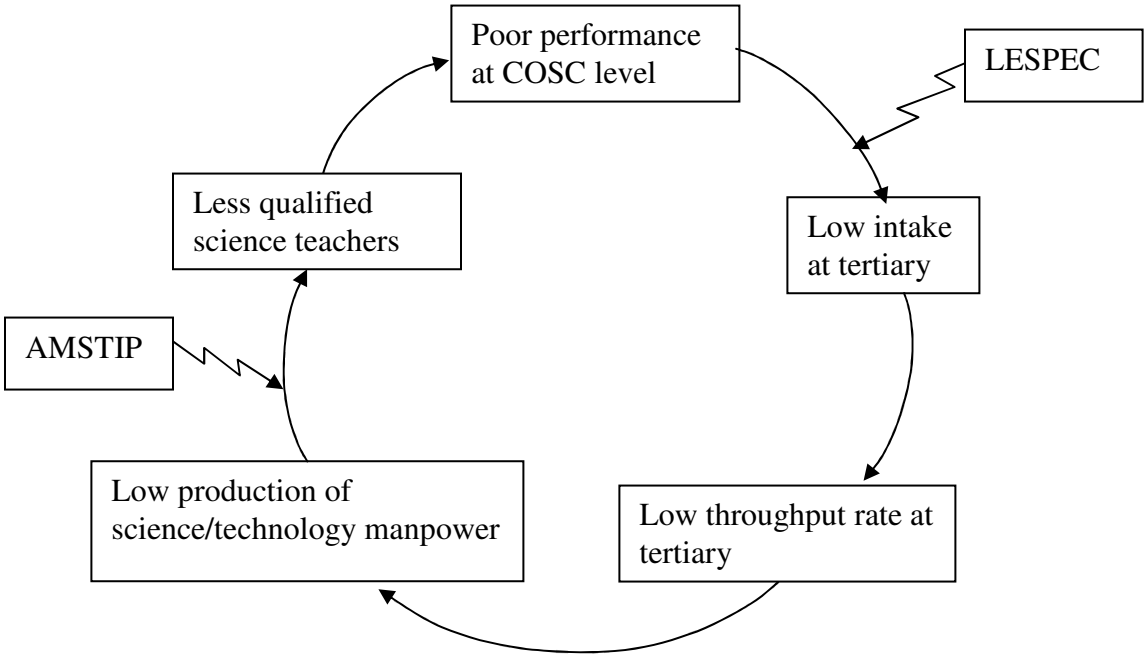


Diagram 2.1: Access programmes in Lesotho

The diagram shows a vicious cycle of problems, one causing the other. The role of the access programme has been primarily to break this cycle. LESPEC was aimed at breaking the relationship between poor performance at secondary level and the inevitable result of low intake at tertiary institutions. On the other hand, because of generally low science related fields graduates at tertiary institutions, the production of science teachers was low and AMSTIP was aimed at breaking this cycle.

An access programme therefore is an initiative designed to address the problem of low-intake at tertiary institutions by offering learners, not meeting primary entry requirements, admission into an institution. The initiative meets the task by addressing the problem that leads to low intake. Thijs (1993:283) shows that the access programmes in Southern Africa were addressing, since their inception, a scenario where

> Teacher training programmes for secondary teachers have also increased, but have not been able to meet the increasing demand for mathematics and science teachers. As a result, secondary education does not sufficiently prepare students for further education in science-based studies.

Of course meeting the demand of teachers can either be in the quantitative sense or in the qualitative sense and in Southern Africa, and in particular in Lesotho, both cases were true. In chapter 1 it is argued that the number of science teachers in Lesotho's secondary level has been low and that this has resulted in some schools avoiding to offer subjects such as Physics. Equally, some researchers (Talukdar, 1995; Maqutu, 2002; Khoboli and Malcolm, 2004) are doubtful about the quality of teaching at secondary level.

Because the driver for an access programme differs from place, to place access programmes also differ. Broadly, there are two factors that differentiate access programmes. These are microscopic or macroscopic factors (Rollnick, 2005). When considering microscopic factors Grayson (1996) argues that an access programme can either play a bridging role or a science foundation role. Microscopic factors entail the teaching/learning issues. A bridging programme assumes that

> …students enter at a level close to what is needed for university work, and then attempts to provide an intermediate stepping stone…(Grayson, 1996:993).

On the other hand, a science foundation programme would assume that

"…students need to build a foundation for meaningful learning…"(i*bid*).

These assumptions influence how teaching and/or learning should be perceived. Grayson (1996)'s classification matches well with Rollnick (2006)'s academic support category that is offered by access programmes. Rollnick (2006) argues that there are three types of support that an access programme can offer, namely academic, cultural, and internal type. She defines these support types as follows:

> Academic: Support provided is aimed directly at assistance or offering of relevant content.
> Cultural: Support provided is aimed at providing broader epistemological access, other than pure academic assistance.
> Internal: Students are enrolled on the target programme and support is provided either through an extended curriculum or add on support (Rollnick, 2006:616).

Osborne (2003) discusses a classification similar to Grayson (1996) but emphasises macroscopic considerations. Macroscopic factors are broader than just considerations of teaching and learning issues. An institution designs a policy that allows more people to access its programmes. The categories that Osborne (2003) discusses are In – reach provision, Out – reach provision, and Flexible provisions.

- **In-reach provision**: In-reach provision refers to initiatives, designed by a tertiary institution, to create a new and sustainable way for students to access its existing programmes. Osborne (2003) refers to this as "getting in" action where the institution focuses on making it easier for people to enroll for programmes that the institution is offering. He offers a number of ways to achieve this, namely the use of entry tests, relaxation of entry requirements and customised programmes.

- **Out-reach provision**: Out-reach provision refers to initiatives where the tertiary institution goes out to the community to offer an access programme. Most of these programmes target underrepresented groups in the society. Out-reach provision is mostly achieved through partnerships with and in collaboration with schools, communities and employees. Discussing out-reach provision in Ireland, Murphy and Fleming (2003:27) note

  > Access programme activities in the Partnership areas typically include guidance and support to students; assistance with travel expenses, books, course fees,

accommodation; local study facilities; sponsorship for participation in summer programmes such as language camps; and university visits.

- **Flexible provision**: Flexible provision refers to other structural modifications of programmes which results in such programmes being accessible to larger population. Morgan-Klein (2003:43) notes that

  > These arrangements imply a process of de-differentiation that is presumed to benefit students by making study more accessible and by facilitating the movement between one course of study and another or by facilitating the fit between work, personal life and study.

  Examples of such initiatives include part-time programmes, open learning and distant programmes.

- **Systemic provision:** Rollnick (2006) adds to this list a category of systemic provision. Systemic provision refers to larger scale initiatives whose purpose is to improve access by improving school system within communities that are under-represented.

The diagram below is adapted from Osborne (2003) and Rollnick (2006) and summarizes different types of access programmes discussed above.

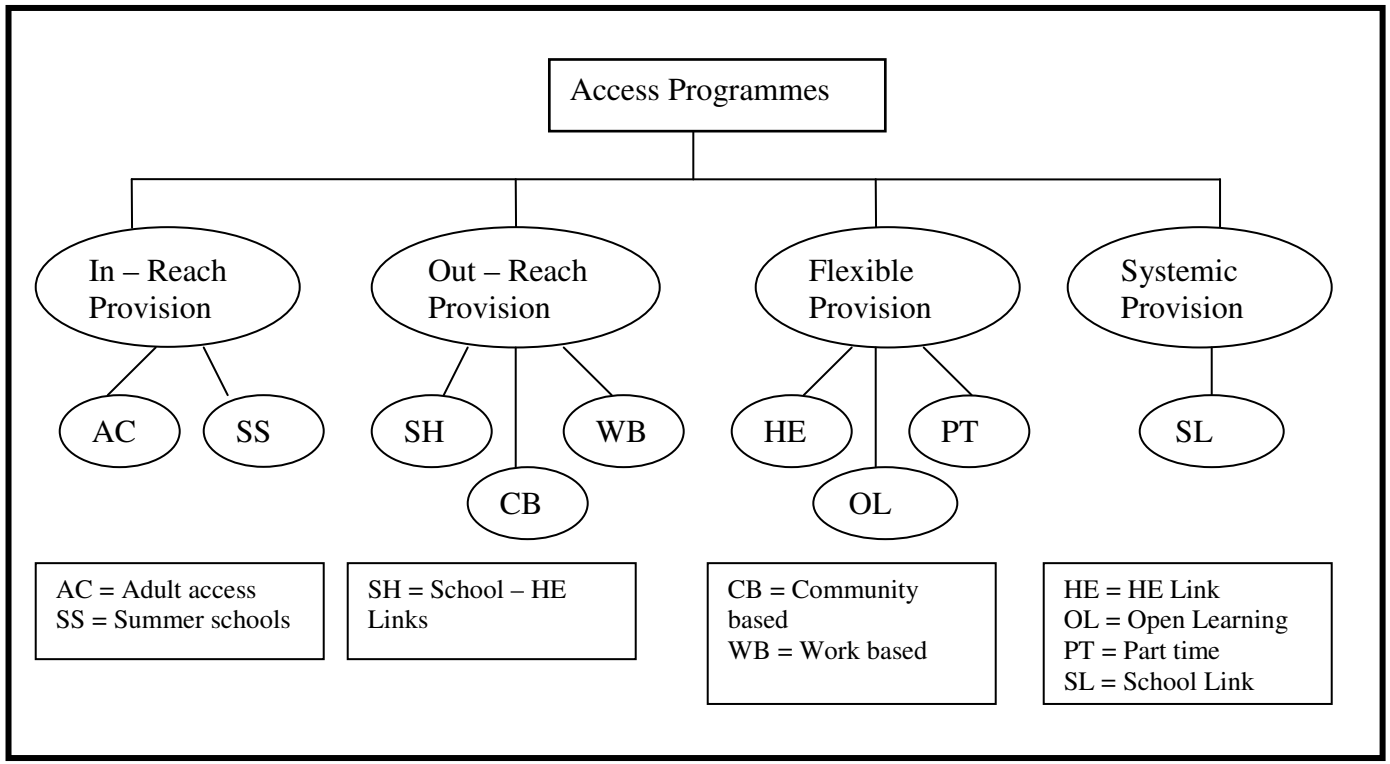


Diagram 2.2: Access Initiatives

The forgone discussion suggests that there are basic questions that access programmes must address. For example, an institution may be concerned about how to address both access and equity issues. Another may be concerned about how to address access and maintain the standard of the institution. These concerns are important and may sometimes be political. Rollnick (2005) lists admission ideologies outlined by Brennan (1989). One of those is the relation between admission and quality and/or reputation of the institution. There is a notion that the ability of an institution to attract good applicants, in terms of their performance at qualifying examinations, is a sign of the institution's quality and/or standard. Understandably, in countries such as Lesotho, performance in O'level examinations is poor and could no longer be the sole requirement. Access programmes had to have other options of criteria to be used. Some institutions in Southern Africa used to run selection tests believed to measure aptitude towards science. Students would be offered places in access programmes on the basis of such tests. But as Thijs (1993) shows, there were still problems. Fifty percent of students qualifying, after all this selection procedure, came from about 4 secondary schools in Lesotho and Swaziland. The number of girls was, in many cases, lower that of boys.

In Botswana, Lesotho and Swaziland (Boleswa) countries the primary responsibilities of access programmes in the science sector addressed, though the exact nature of how to achieve them was influenced by the status of the problem being addressed, remediation, upgrading and streaming (Thijs, 1993). Thus, using Osborne's (2003) classification, these programmes were mostly in-reach provisions. The remediation function refers to a process of addressing deficiencies, resulting from the secondary level problems, which may place a learner at a disadvantage of coping well at tertiary level. The philosophy that LESPEC adopted for example, in achieving the expectation of this function, was heavily influenced by constructivist approaches. In Physics, for example students were expected to do practical work in which the core of the approach was an underlying view that each student was going to learn as an individual.

The upgrading function refers to a process of providing learners with what they missed at secondary level and working on introducing skills and attitudes needed to meaningfully

learn at tertiary level. There were two ideas built in the function; namely bridging and preparing students for tertiary studies. LESPEC assumed that secondary school leavers were missing learning styles that would allow them to cope at tertiary level. Students would be prepared for tertiary studies by including things such as demystifying the university system, learning styles and study groups and reading to understand academic texts. The idea of bridging the gap between secondary and tertiary levels was also tackled by inviting not only qualified students, in terms of O'level exams, but also students identified to have the potential to do further studies and providing them with what their higher secondary education missed.

The streaming function on the other hand refers to a process of establishing and directing learners into a more suitable line of study that such a learner can best perform. Though the cooperation was between universities and FUA, access programmes in Boleswa countries served more than one institution. Their responsibility was therefore to advise students on which institutions and programmes to follow. They did this by basically relying on students' performance, interest and providing career guidance.

2.3 The first programme: LESPEC

Access programmes in Lesotho came into being as a result of the cooperation between the National University of Lesotho (NUL) and the Free University of Amsterdam (FUA). The cooperation was made possible through financial assistance of institutions such as the Netherlands University Foundation for International Cooperation (NUFFIC) and European Union (EU). The core of the cooperation between these institutions was to strengthen the educational and research capacity of NUL to allow it to meet its national obligation. This cooperation, which started in the late 1970's, concentrated on the following areas:

- Basic Sciences,
- Teacher Training,
- Micro computers, and
- Geography Research Development

The first two areas of cooperation are of interest since they are the main issue of this chapter and access programmes emanated from them. The vicious cycle of problems, discussed above, highlights the driver of intervening in both areas as the fact that secondary education in Lesotho was faced with a serious shortage of science teachers, which resulted in a poor pass rate in science subjects. It was therefore necessary to devise ways of addressing issues of teaching/learning science and training secondary science teachers.

As early as the late 1970's and early 1980's two major problems were clear in Lesotho's education sector. Firstly, there was the issue of low pass rate. Secondly, there was a low enrolment in tertiary institutions such as the National University of Lesotho (NUL), the National Teacher Training College (NTTC) (now called Lesotho College of Education) and the Lerotholi Polytechnic (LP). For example in the period 1979 to 1982 the pass rate ranged from 26.6% to 19.1% and the Secondary Teachers Certificate (STC). Enrolment at NTTC was 212 to 240 respectively. According to the records of the Ministry of Education (MoE), there were 130 candidates qualifying for admission into the university in 1970 (MoE, 1990). The trend was not changing in any significant way in the subsequent years, hence the conclusion that Lesotho, at the time, was facing severe shortages of qualified middle and higher level manpower in science based fields. As a result of the low intake and poor success rate at these institutions, the number of Basotho graduating as science teachers caused a serious concern. To redress the problem, the Lesotho Science Pre-Entry Course (LESPEC) was started.

In 1981 a six months access programme, LESPEC, was established as an offspring of the basic sciences field of cooperation between NUL and FUA. The central responsibility of LESPEC was to increase the number of students admissible to Lesotho's tertiary institutions such as NUL, LP, NTTC, and the Lesotho Agricultural College (LAC) and to bridge the gap between the tertiary and the secondary education levels so that students admitted into these institutions could perform better. According to the project documents of LESPEC phase IV (NUL, 1990a; NUL, 1990b), the long term objectives of LESPEC were as follows:

- Through the LESPEC course the BSc programme at NUL will be able to admit a larger number of students of a more acceptable and uniform quality…
- The technician programme of the Lerotholi Polytechnic will be able to increase its intake considerably to cater for the increased demand for technical manpower…
- The teacher training programme at NUL and NTTC will be able to provide additional trained teachers in science and mathematics to cater for the growth of the secondary school system…

These objectives are in concurrence with the Thjis (1993) classification of responsibilities of access programmes in Southern Africa. Specifically therefore LESPEC was charged with responsibility of increasing the intake at tertiary level, in particular at NUL, and offering remediation, upgrading, and streaming of secondary school leavers.

In order to offer remedial instruction and to give a second chance to senior secondary leavers, LESPEC would administer selection tests throughout the country and select 120 students without having to wait for COSC results, which are published two to three months after the examinations. Students who qualified to sit for these tests would be those at the 5th year of secondary level and had done at least one science subject and mathematics. The test was also open to candidates sitting for COSC privately. The tests were basically measuring students' aptitudes for mathematics and science. Selected students would attend the course at the end of which they would be recommended for admission into one of the tertiary institutions mentioned above. In this way students were given a second chance route to enrol in these institutions, after attending a remedial process. Since the programme had another element, namely closing the gap between tertiary and secondary education levels, additional students would be invited to attend the course, following the announcement of COSC results.

The notion of closing the gap between tertiary level and secondary level was influenced by the widely held view that students entering tertiary education, by virtue of qualifying through COSC performance, are not ready to cope with tertiary learning. Most people refer to this (e.g. NUL, 1995; NUL, 1990a; 1990b) but the nature of the problem does not appear to come from a scientific study. The understanding is that this problem results

from secondary level teaching which concentrates on preparing students for examinations thereby putting less effort on understanding of content and being able to apply it. As suggested in Chapter 1, these students had conceptual difficulties of basic concepts such as in electromagnetism. Thus, at micro level, LESPEC concentrated more on offering students a chance to do laboratory work they possibly missed and relating it to the content. The course covered the O-level material that should have been covered during the last two years of secondary education.

LESPEC was finally institutionalised in 1993. At the time of institutionalisation of LESPEC, a number of evaluations had been done with the purpose of determining its future. The LESPEC phase IV project document (NUL, 1990b) gives the following points about LESPEC's phases I to III (1982 – 1990).

- The LESPEC course has worked well so far. This conclusion is, amongst others, based on (analysis) which shows that over the year the LESPEC students (L) have performed better than 'direct entries' (DE, COSC qualification) or LESPEC students who also qualified through COSC.
- LESPEC has increased not only the enrolment numbers, but also improved the efficiency of higher education: more students who enroll in tertiary programmes also complete them.
- The figures presented in the LESPEC 90+ report (NUL, 1989) show that for the continuation of LESPEC for NUL entry until at least 1993 if only quantity of intake is taken in consideration…
- Despite the fact that data on intake numbers and quality for science based course at the Technician Training School, the National Teacher Training College, the Lesotho Agricultural College and the National Health Training Centre, as well as developments with respect to COSC success rate are insufficient to make accurate projections, the impression is that these institute can in the future benefit more from the LESPEC course than they do at present. This is especially so for NTTC and LAC.

The document recommended that

- it should be considered seriously to integrate LESPEC-type of teaching into the Lesotho educational system. The selection procedure, career guidance scheme, integration of practical and theory are positive elements which should remain part of the system
- LESPEC should continue to serve all tertiary institutes
- Given the enrolment projections it is advisable to expand LESPEC as soon as possible.

Other evaluations showed that LESPEC had been a success (Stanneveld, 1991) and ought to be institutionalised (Ralise *et al.,* 1992). According to NUL (1995) one of the impacts of LESPEC was to reduce the failure rate at first year of BSc and BScEd. These evaluations suggested, however, that the problems which LESPEC had to address still existed even if it was on a smaller scale.

2.4 The Accelerated Mathematics and Science Teachers Improvement Programme (AMSTIP)

The second field of cooperation between NUL and FUA gave birth to AMSTIP. The problem of poor performance at secondary levels is related to the unavailability of qualified teachers. The enrolment at NTTC quoted above only underlines the problem which called for an action. Since 1975 only two institutions, namely NUL and NTTC, were assigned responsibility of teacher training. Candidates graduating from NTTC were awarded a three year post "O" level Secondary Teacher Certificate (STC) qualifying them to teach at the lower secondary level. However, in the highlands, teachers with STC used to teach at upper secondary level due to shortage of teachers (Qhobela, 1996). According to the Ministry of Education's report in 1982 there were 51 local science teachers and 6 non-local science teachers in the country with STC or equivalent (MoE, 1990). The same report shows that in the same year there were 48 local science teachers and 145 non-local science teachers, with a first degree or higher.

In trying to address the problem of the shortage of science teachers, another access programme, AMSTIP, was established in 1979 by FUA and NUL (NUL, 1990b). The

definition of access programmes above may not encompass AMSTIP but there was a tendency to treat it as such. The project document (NUL, 1990b), for example, refers to it as STC Pre – Entry Course. The responsibility of AMSTIP included increasing the number of science student-teachers at NTTC and NUL. There were two AMSTIP courses; AMSTIP I and AMSTIP II tasked with this responsibility. AMSTIP I trained unqualified science teachers for a period of one year, composed of seven months part time in-service course in science, mathematics and study skills, followed by 4 months of full – time study. Upon successful completion of the course learners would be admitted into the STC programme at NTTC. Qualified STC or equivalent teachers not admissible at NUL would also be trained through AMSTIP II for a year and, upon completion, they would be admitted into Diploma in Science Education at NUL.

2.5 The Lerotholi Polytechnic's Technician Induction Programme

LESPEC was phased out in 1993, primarily because the funds were drying up (NUL, 1990b). After consultation with interested parties and financial organisations such as the European Community (EC), two institutionalised sister programmes were initiated in 1994. At NUL a Pre Entry Science Programme (PESP) was launched, inheriting movable LESPEC assets and staff. At Lerotholi Polytechnic, a Technician Induction Programme (TIP) was started at the same time. TIP inherited immovable assets and both the government of Lesotho and EC became partners to guarantee the smooth taking off of the programme.

TIP, just like LESPEC, maintained features of an In - Reach programme whose main responsibility was to bridge the gap between secondary level and the polytechnic education. The main difference between LESPEC and TIP was in the responsibility of increasing the intake. TIP did not address the issue of increasing intake at LP but maintained offering remediation, and upgrading functions.

TIP was introduced to prepare students for the Lerotholi Polytechnic admitted into one of the four diploma programmes; Electrical Engineering, Mechanical Engineering, Civil Engineering and Construction Science. Students qualified for any of these courses on the

basis of two criteria: Firstly, applicants had to have an "O' level pass with at least grade 6 in Mathematics (this is the lowest grade to achieve a credit pass), one science subject and at least grade 7 in English language. The Polytechnic lowered its English requirement with the hope that TIP would still offer English and study skills, thereby raising the students' standard of English. The other consideration was the notion of improving access into the institution. Secondly, applicants would sit for a selection test comprised of English, Mathematics and Science (Chemistry and Physics). The average of the two tests was used to determine who gets admission. For each course, only 20 students would be admitted.

At the time of study, the model that TIP followed was a three months programme, run as part of first year. Students were taught Chemistry, Mathematics and Physics during this period. The syllabuses covered material which should have been covered at secondary school level with more emphasis on practical work in Chemistry and Physics. They were also taught English and Study Skills. Before TIP was phased out in 2004, there was a view that TIP had, to a large extent, achieved its objectives and was no longer necessary.

2.6 CONCLUSION

The concept of an access programme has been one mechanism that has been used widely to address problems such as those raised in chapter 1. An access programme refers to an initiative of higher learning that an institution puts in place to allow for better access to courses it offers. One of the main obstacles to access to institutions of higher learning is the entry requirements that are often not achieved by majority of secondary school leavers. This chapter has discussed the general idea and has shown how in Lesotho, in particular, access programme was conceptualised within science education sector.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This chapter discusses literature that informed the design of this study. In particular, it discusses two theories; sociocultural and situated cognition. The chapter argues that the two theories inform classroom practice in such a manner that they can be viewed to support each other. The chapter then introduces the notion of enculturation as a central concept advocated. The chapter also discusses a theoretical framework drawn from earlier studies.

3.2 Sociocultural Theory

This study is informed primarily by two theoretical constructs, sociocultural and situated cognition constructs. It is important, as a starting point, to acknowledge the difference between the two perspectives, yet both can inform classroom practice (Cobb and Bowers, 1999; Sfard, 1998). In particular the two theories are viewed to have a potential of addressing the challenges of a second language learning setting. The sociocultural theory's unit of analysis, drawing from Vygotsky (1978), is an individual who is assisted to learn. However, the notion of enculturation, promoted in this study, advocates a concept of language as a social institution. This changes the unit of analysis to a group of participants rather than an individual. The thrust of the concept of situated cognition is that learning is not only social, but is also distributed and situated within a community of practice (Adler, 1998; Lave and Wenger, 1991; Stein, 1998).

The perception of sociocultural perspective that this study adopts draws its basic tenet from the work of the Russian psychologist Lev Semenovich Vygostky (1896 – 1934). In order to appreciate Vygotsky's contributions, it is perhaps important to note that he wrote most of his contributions, originally in Russian, in the 1920's to 1930's in the then Soviet Union, when the influence of socialism was strong. However, his work only received

recognition in the West long after his death. Vygotskian contributions toward learning are today widely viewed to form the basic foundation towards a definition of sociocultural theory. Some writers argue that Vygotsky was driven, at the time of writing these concepts, by his desire to understand human functioning, and how it reflected and constituted its historical, cultural and institutional background (Wertsch, 1990). He understood that the process was crucial if meaningful conclusions were to be drawn, otherwise, not pursuing these issues would lead one to looking at fossilised behaviours (Vygotsky, 1978). Thus a teaching strategy not paying attention to these issues runs the risk of addressing the problems that Rollnick (2000) identifies as main obstacles, using a second language in teaching. Two of Vygotsky's concepts inform this study. These are *internalisation* and the *Zone of Proximal Development (ZPD).*

Internalisation: This is the process where a concept that existed externally is internalised by the individual. The concept of internalisation draws its meaning from the Vygotsky's assertion

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (*interpsychological*), and then inside the child (*intrapsychological*). (Vygotsky, 1978:57)

Adopting the broadest meaning of the internalisation, the concept refers to how learning occurs in an individual. The important aspect of this assertion is that the knowledge that an individual finally acquires is first known to actors within a sociocultural setting. The process of acquiring it is also a social enterprise. Internalisation, therefore, is a process where a social concept is reconstructed to become an individual's concept. Most importantly, through internalisation, an individual is viewed as a learner within a social setting in which knowledge is owned, but the process of learning maintains its complexities.

Internalisation is not a simple process of transfer of social knowledge into an individual's mind, as some critiques of sociocultural theory (such as Steffe and Thompson, 2000)

would suggest. It is certainly more complicated than the long rejected concept of the *tabula rasa*. By internalisation, the individual is able to appropriate and use for him/herself psychological tools available on the social plane (Leach and Scott, 2003). The key contention is that internalisation is a social process that results in meaning-making of something within an individual. Internalisation should not be equated to a suggestion similar to that of radical constructivism whose basic arguments are:

- knowledge is not passively received but actively built up by the cognising subject, and
- the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality (Jaworski, 1994).

In simple terms radical constructivism suggests that knowledge is actively constructed by the individual and not passively received from the environment. It emphasises learning as an individual's process taking place in his head (Driver and Bell, 1986; Hewson and Hewson, 1988; Cobb, 1994) and does not necessarily acknowledge a critical role played by the social setting surrounding the individual. It is perhaps important to note Wertsch's (1985) position on this nature of internalisation. Wertsch (1985) broadens the understanding of the notion of internalisation. The main views of Wertsch (1985) are

- internalisation is not a process of copying external reality on a pre – existing internal plane; rather, it is a process wherein an internal plane of consciousness is formed;
- the external reality at issue is a social interactional one;
- the specific mechanism at issue is the mastery of external sign forms; and
- the internal plane consciousness takes on a "quasi - social" nature because of its origins.

The views of Wertsch (1985) can be taken as defining characteristics of internalisation. According to this concept therefore learning is a social process where the student is going through a process of adaptation of social practices. It must be acknowledged, though, that any social setting is so defined because of its distinct culture. What the student finally reconstructs in his/her mind has been influenced, to a large extent, by the culture of that social setting.

Unpacking the notion of culture of a social setting is an important aspect of what internalisation means. In a classroom setting, questions of culture bring a number of variables such as the culture that must be promoted by instruction in the science class. The teacher is faced with a choice to promote the classroom's or the scientists' culture. Perhaps it is also important to note that definitions of culture vary widely depending on the interests at hand (Guisasola *et al*., 2004). Wertsch and Tulviste (1990) discuss the idea of culture in Vygotskian work, and observe that Vygotsky was more interested in the relationship between culture and mediation.

> …Vygotsky's account of culture suggests that humans are never as autonomous and as free of outside interference as it might at first appear. Instead, human mental functioning, even when carried out by an individual acting in isolation, is inherently social, or sociocultural, in that it incorporates socially evolved and socially organized cultural tools. (Wertsch and Tulviste, 1990:60).

According to Wertsch and Tulviste (1990) therefore, an individual's learning process is shaped by some kind of a culture. The challenge then becomes what teaching or learning culture must be promoted when, for example, students come from a situation where teaching methods are traditional (Caillods *et al.,* 1996; Maqutu, 2002). Equally important to be noted here is the fact that a process of learning has a history associated with it.

The Zone of Proximal Development: The second concept is the Zone of Proximal Development (ZPD) which Vygotsky (1978) defines as

> ...the distance between the actual developmental level as determined by independent problem solving, and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. (Vygotsky, 1978:86)

As with internalisation, the Vygotskian concept of ZPD characterises learning as a social activity. Thus the ZPD challenges a notion that learning is an individual construct (Lerman, 1996; 2001). Since its proposal, the Vygotskian concept of the ZPD has attracted a number of educators from different spheres of the academic world (*e.g.* Wertsch, 1984; 1990; Moll, 1990; Wertsch and Tulviste, 1990; Lantoff and Appel, 1990). A contribution informative in understanding how ZPD should be construed is offered by Wertsch (1984).

Wertsch (1984) has argued that to conceptualise the ZPD, three basic theoretical concepts need to be construed. These three interrelated concepts are **situation definition**, **intersubjectivity**, and **semiotic mediation**. Generally, the first concept, **situation definition** refers to how a concept is defined by actors. Wertsch (1984) contests that working within the ZPD requires a clear appreciation of the notion of situation definition because

> …one and the same object can be represented or defined in quite different ways … one essential aspect of a situation definition in such task settings is the representation of objects. (Wertsch, 1984:9)

Two important features of a **situation definition** come to the fore from how Wertch defines it. Wertsch (1984:8) defines a situation definition as

> …the way in which a setting or context is represented – that is defined – by those who are operating in that setting.

An important point to note from this definition is the ownership of a representation of a concept. Representation of a concept, according to this definition, is a function of membership of a setting that uses the concept. Within the ZPD actors in a learning situation are characterised in terms of old timers and novices. Clearly, if a student, a novice, has to be helped by old timers to understand and construct this representation, such a student will need to understand how members of this setting operate.

It is vital to note that different settings, whether defined by virtue of academic, political or social interest, represent the same concept word differently. This is a critical language issue. Viewing meaning as situation definition and ZPD as helping a student to construct meaning within learning in a second language environment requires a critical understanding of this notion. Ownership of a representation of a concept is therefore important. Further, it suggests that students must not only be helped to understand a concept but be encouraged to become members of this community, a process defined in this study as **enculturation**.

There is another important perspective of a situation definition. Wertsch (1985:159) defined a situation definition as "…- the way in which objects and events[1] in a situation

are represented or defined…" Firstly, from this definition it can be drawn that an object must be defined in relation to a specific activity. Secondly, there must be actors, in a situation, that are defining the object.

Analysis of this definition reflects at least two things. Firstly, the teacher and the student must hold the same meaning of a concept. This is not always the case. Secondly, they must be aware of the similarities in the meanings they hold. Inevitably, in a learning situation, for the teacher and the student to know whether they share the same situation definition or not requires some processes aimed at establishing that. There must have been what Vygotsky (1978) calls interpsychological functioning. Wertsch (1984) notes, however, that intersubjectivity does exist between teachers and students at different levels. He argues,

> At one extreme, it can consist of no more than agreement on the location of concrete objects in communication setting. At the other extreme, nearly complete intersubjectivity exist when two interlocutors represent objects and events in identical ways. (Wertsch, 1984:10)

He also warns

> …the adult and child can negotiate an intersubjective situation definition that differs from both of their ways of understanding the situation on the intrapsychological plane. (Wertsch, 1984:11)

In other words the process leading to intersubjectivity must not merely be barred by coming from opposite ends. This is the reason for mediation, in any case.

A slightly different position can be taken however. When people do not represent an object the same way there is certainly a lot that can be learnt from such disagreement. The issue of intersubjectivity as only reflecting agreement between parties involved in a talk is challenged by Matusov (1996:17) who refers to "…intersubjectivity… as sharing subjectivities among participants". On the contrary she advocates

> …intersubjectivity as a coordination of individual contributions to the joint activity [that] allows researchers to incorporate both participants' understandings and misunderstandings of each other, and their similarities and differences as the participants are simultaneously in agreement and disagreement. Matusov (1996:29)

This view recognises both agreements and disagreements between individuals involved in a talk. According to Matusov (1996) therefore, there is a lot that can be learned from disagreement between two or more people involved in a talk even if they do not agree. Intersubjectivity, regardless of whether it represents disagreement or agreement, characterises learning as a social activity (Lerman, 1996).

The third construct which, according to Wertsch (1985), must be well understood in order to function within the ZPD is that of **semiotic mediation**. Semiotic mediation refers to an interpersonal communication aimed at establishing intersubjective situation definition between parties involved in the process of communication. In other words, semiotic mediation refers to the appropriation and use of signs as a way of facilitating psychological development. Semiotic mediation, within the concept of the ZPD therefore places the use of language, maps, diagrams, signs, and other artifacts as crucial for the process of meaning making to occur. Wertsch (1984) argues that there are four levels under which interpersonal communication can establish intersubjective situation definition. The four levels are characterised by the following.

- Firstly, the child's situation definition of an object is very different from the adult's definition.
- Secondly, the child's situation definition shares some basic similarity with the adult's.
- Thirdly, the child is able to respond appropriately to other regulations by making necessary inferences to interpret the adult's directive.
- Lastly, the child takes full responsibility for achieving a task. Interpersonal communication therefore between the child and the adult must recognise these levels, and if it calls for directives from the adult, they must also resemble these levels.

In conclusion, sociocultural theory viewed through the Vygotskian contributions is a proposal that higher order functions within an individual develop as a result of social interactions (Palinscar, 1998; Scott, 1998; Shepardson, 1999). In a learning situation, social interaction comprises the interaction between and among students and between students and their teacher. This study puts particular interest on the interaction between students. Two critical issues inform this study therefore. Firstly, development is

foremostly cultural. Secondly, it is also social. The definition of internalisation suggests that there should be a mechanism through which what was first at interpersonal level appears at intrapersonal level. In this study language, and its use, is viewed to be providing this cultural bridge between interpersonal and intrapersonal levels. Leach and Scott (2003:99) noted

> language provides the very tools through which those thoughts are first rehearsed on the intermental plane and then processed and used on the intramental plane.

It is noted that there are challenges implied in this view. Language can be a social language, such as the language used within science, or natural language, such as Sesotho or English (Gee, 1999). The challenge comes in when a student is expected to learn the natural language, which is not his/her mother tongue because it is the language of learning and teaching (LoLT), and at the same time learn the social language of science (Rollnick, 2000). The Vygotskian perspective therefore is interpreted to place the role of language in science learning as a critical issue. Duran *et al.* (1998:314), noting this critical role of language, argue that

> learning lies in the appropriation of the socially constitutes meaning and semiotic practices encountered during instructional activity.

The operational definition, adopted in this study, of sociocultural learning is that

> …learning and meaning-making are portrayed as originating in social interactions between individuals, or as individuals interact with cultural products that are made available to them in books or other sources. (Leach and Scott, 2003:92).

Classrooms therefore, in which learning occurs, are viewed as a social setting in which social interaction occurs. Vygotsky's (1978) notion of ZPD, which defines the potential for cognitive development for an individual, is crucial to defining actors in a social interaction. A conclusion can be drawn from ZPD therefore about who the actors are in a social setting, classroom; student and adult. The Vygotskian sociocultural theory then places a student to be a unit of analysis. This study intends to analyse how students contribute towards meaning – making process within small groups. Thus, actors must be viewed as students. Situated cognition provides such a perspective. The notion of situated cognition is discussed in the next section.

3.3 SITUATED COGNITION

The concept of enculturation into a community of practice necessitates yet another related theory; situated cognition. Vygotskian sociocultural theory, as discussed above, suggests that meaning, thinking, and reasoning are associated with a social activity (Lerman, 2001) in contrast to the view that learning is entirely an individual's business (Fensham, *et al.*, 1994). Wertsch's (1985) notion of situation definitions also suggests understanding of representations of a concept as related to membership of a setting. These form basic understandings in situated cognition. The theory, evolving from Vygotskian sociocultural theory (Cobb, 1994), extends these arguments to further propose that knowledge is not only social but also located in particular forms of situated experiences. It posits that learning is a social phenomenon rather than the action of an individual acquiring knowledge from a decontextualised body of knowledge (Kirshner and Whitson, 1997; Stein, 1998). The notions of co-operation and participation within a social practice are critical themes in situated cognition perspective (Adler, 1998; Cobb and Bowers, 1999; Lave and Wenger, 1991; Putman and Borko, 2000). As means of further defining situated cognition, Putman and Borko (2000) provide a language within which this theory can be perceived. They argue that situated cognition has three perpectives, namely situated, social and distributed perspectives.

Cognition as situated: According to situated perspective, physical and social contexts under which an activity occurs are crucial elements of the activity, which in turn is an integral part of learning that is taking place within it (Brown *et al.*, 1989; Putman and Borko; 2000). The social context under which cognition occurs include questions of power relationship, politics, organisation and norms and values of the community the student finds himself/herself in (Stein, 1998) or aspires to be part of. Context, viewed in relation to this study, addresses an instructional environment which takes into cognisance the task students are engaged in. In a situated cognition perspective, therefore, understanding the context under which learning occurs is a crucial element. Putman and Borko (2000) argue that

> How a person learns a particular set of knowledge and skills, and the situation in which a person learns, become a fundamental part of what is learned. (Putman and Borko, 2000:4)

This element of situated cognition, situatedness of cognition, critically suggests that knowledge construction would be perceived with conducive situation. The merit in this view is that knowledge construction must be expected to be minimal in a chalk and talk environment. Mediation addressing the situatedness of cognition must provide environment much richer than chalk and talk teaching approach. It must also provide adequate opportunity for students to practise using tools of an aspired community. However, context and intentions must also be considered imperative for they form an integral part of the learning process. As Lerman (2001) argues, the manner in which individuals want to develop leads to particular goals which will influence their behaviour. This is the assertion that Gee (2005) also makes. Thus, attitudinal factors contribute toward situatedness of cognition.

The nature of activity is as critical as the context. That cognition is situated suggests the role of authentic activities in classrooms (Brown *et al.*, 1989). Putman and Borko (2000) define the authentic activity as an activity which resembles what the actual practitioner does. In other words, in a classroom situation authentic activities would be classroom activities that foster thinking and problem solving skills similar to what the actual practitioner would do. They would be aimed at equipping a student to become a lifelong intentional learner.

Cognition as Social: The situated perspective claims that the student's interaction with people within the environment surrounding him, and the role they play, is important in determining what is learned and the process of learning (Putman and Borko, 2000). In any one classroom there are more than three people; more than just a student, a peer and their teacher. There are material things brought, intentionally or otherwise, by the actors. All these contribute towards learning. Explaining the social nature of learning using only the Vygotskian concept of ZPD restricts us to only the student and the teacher or a peer. But the situated perspective views the social nature of learning to include all the dynamics of a classroom. According to Lerman (2001), factors such as gender, ethnic stereotypes and abilities valued by peers are more important to the student than just learning what the teacher is offering. Because people participate in discourse

communities such as classrooms (Mortimer, 1998), these discourse communities provide cognitive tools for an individual (Moje, 1995). Stein (1998) observes that through the community, students interpret, reject and form meaning. This is why the concept of enculturation of individuals to understand discourse practices of a community, so as to develop competence to use concepts, reason and argument that characterise that particular discourse community, is of utmost importance.

Cognition as Distributed: The situated perspective, according to Putman and Borko (2000), also claims cognition to be distributed over individuals, other people and artifacts such as physical and symbolic tools. In other words, a person is likely to learn more than what he/she could on his/her own because of contributions of his colleagues and appropriation of both physical and symbolic tools. Putman and Borko (2000) argue that learning in our schools must reduce focusing on the importance of individual competence, and rather emphasise sharing of learning and cognitive performance. There is of course a national interest for schools to perform. But, as Putman and Borko (2000) suggest, schools must balance activities that incorporate ideas of distributed cognition and those that stress only individuals' competence.

Interpreting learning through the notion of situated cognition supplements the view that learning is social and cultural. The perspective suggests that learning occurs better

- within an environment that provides more than chalk and talk approaches,
- when learning activities foster thinking and problem solving skills typical to what actual practitioners do, and
- where interaction between actors is assumed to be important.

Situated cognition has more than Putman and Borko's (2000) discourse. Stein (1998) adds two more elements of situated cognition, **content** and **participation**. The instructor, in placing content within the daily transactions of life in dialogue with students, negotiates the meaning of content, and frames it in terms of issues and concerns within the students. In other words, content viewed relevant by students motivates them to want to understand it further. The other element that Stein (1998) proposes is participation.

He defines participation as the interchange of ideas, attempts at problem solving, and active engagement of students with each other, and with the materials of instruction. The concept of enculturation calls for consideration of this notion of participation.

The work of Lave and Wenger (1991) has added a deeper understanding of situated cognition, and in particular the question of participation within a community of practice. They proposed a notion of "legitimate peripheral participation" intended, among others, to address the crucial issue of participation and access into a community of practice (Adler, 1997;1998). According to Lave and Wenger (1991), legitimate peripheral participation should be seen as a descriptor of engagement in social practice that entails learning as an integral constituent. To become a legitimate peripheral participant therefore, a newcomer needs access to the community of practice and to what its membership entails. Adler (1998) views the Lave and Wenger (1991) concept of legitimate peripheral participation as a means of explaining developing identity and the reproduction of community of practice as well as its production.

Lave and Wenger (1991) further argue that full membership of a community of practice requires access to resources of the community that, in turn, requires careful consideration of the concept of **transparency**. The concept of transparency combines two seemingly contradicting and yet very important characteristics that resources must have; invisibility and visibility. To them

> Invisibility of mediating technologies is necessary for allowing focus on and thus supporting visibility of, the subject matter…, visibility of the significance of the technology is necessary for allowing its unproblematic – invisible – use. (Lave and Wenger, 1991:103).

This concept suggests that for a novice to participate in a social setting, resources must allow access to meanings of a concept. At the same time it must not allow its structure to be visible. Academic language used by a community of practice is one of the resources that must be availed to a student, and a student be helped to talk it. Adler (1999:63) argues that

> For talk to be a resource for mathematics learning it needs to be transparent; learners must be able to see it and use it. They must be able to focus on language

> per se when necessary, but they must also be able to render it invisible when they are using it as a means for building mathematical knowledge.

In situations where the language of teaching is a second language, then language can become visible and hide the subject matter. How this becomes possible is discussed by Rollnick (2000) who argues that there are two categories of difficulties which cause use of a second language to be visible and therefore obstruct students' learning.

From the foregoing discussion of sociocultural theory and situated cognition the following issues emerge:

- learning science is a social activity,
- learning science is a situated activity, and
- learning science is a process of enculturation into a discourse community.

The concept of enculturation is discussed in the next section.

3.4 Enculturation into a discourse community

The two theories of learning above are conceptualised to imply a theoretical construct of enculturation. Enculturation refers to the process of the individual's adaptation of social and cultural practices of a community of practice (Roth, 2001). The acknowledgement is that any community of practice is different from the other and the determining feature is the culture of such community. In this study Lerotholi Polytechnic (LP)'s access students are encouraged to adapt the use of Discourses of science as a fruitful way of learning science. When Gee (1999) proposes the concept of Discourses he acknowledges the importance of cultural models as tiny theories that inform action of members within a setting. Understanding these cultural models is certainly crucial for a novice to know what, how, and when to do something. However this process of adaptation of social and cultural practices is a give and take process. As Gee (2005) points out

> To acquire an academic social language, students must be willing to accept certain losses and see the acquisition of the academic social language as a gain.

Enculturation therefore, viewed with reference to situations of this study, suggests that students must be willing to give away some learning practices acquired at secondary level and put effort in the activities introduced. The main practice that students are influenced

to give away is the practice of sitting down and watching as the teacher talks science. On the other hand, the process, enculturation into a Discourse community, must provide individuals with cognitive tools that will in turn foster thinking and problem solving. This study achieves this by encouraging talk, as a major constituent of Discourses of science, and use of "other stuff" Discourses of science (Gee, 1999), and bringing together the phenomenon understudy along with the practice of Discourses.

Encouraging talk is done with the basic understanding that successful engagement of talk promotes a feeling of belonging into a community of practice. The issue of belonging is equated to developing identity within a community. In the next section, talk and identity are discussed.

3.5 TALK AND IDENTITY

Three studies, Christie (1998), Duran *et al.* (1998), and Scott (1998) which have been instrumental in designing the theoretical framework of this study, have several concepts associated with both situated cognition and sociocultural theory. These concepts are the issue of identity within a community of practice, structuring and ordering of experience by a novice, and talk and talking the language of science. Science and mathematics educators have argued that participation within a community of practice embraces inseparable elements of identity and experience (Lave and Wenger, 1991; Roth, 2005; Wenger, 1998). Enculturation into the community of scientists comprises learning to talk the language of scientists (Lemke, 1990). Talking a language, and/or practising of Discourses in general, of a community impacts on one's identity. That is, if an individual can engage Discourses of a community he/she can easily associate him/herself with the aspired community. There are different forms of identities. Wenger (1998) characterises identity as

- Negotiated experience. The intrinsic view of how one participated within a social group gives one a sort of identity. There are different ways of attaining feedback on how one participated. Negotiated experience, as identity, reflects how one feels and thinks others feel about him/her.

- Community membership. Membership to a certain community of practice gives one an element of identity. This is related fundamentally through the forms of competence.
- Learning trajectory. Identity is given by changes that occurred to an individual due to participation. That is, what was known by someone before and the situation at the end of participation gives one some identity.
- Nexus of multi-membership. The way various forms of membership are reconciled to form an identity.
- Relation between the local and the global. Identity is also defined by negotiated local ways of belonging.

The argument that identity relates a student, participating in social activity, to a community is important. But such a student is not just as a person; rather he/she is viewed as a person-in-the-world (Lave and Wenger, 1991; Lerman, 1998). Thus, sociocultural theory and situated cognition already give a special identity to students. Nero (2005:195) suggests that

> …identity formation can be attributed to a high level of individual agency, thus framed as 'acts', and that such acts are motivated by the desire for establishing social / ethnic affiliation with, or distinctiveness from, identifiable groups… not only is identity linked to desire for affiliation and recognition, but that what one is or is in the process of becoming is directly related to what one can do materially, that is to one's socioeconomic condition, which can shift over time.

On the other hand Roth (2005) argues that identity is strongly related to knowing a language and being able to use it. Inevitably, for student learning science mastering the language of science has the potential of identity building.

Promotion of talk therefore is a critical element in science classrooms if identity is so crucial. According to sociocultural theories and situated cognition, talking is critical insofar as learning is associated with building students' identity. The idea of Legitimate peripheral participation advocates the notion of encouraging students to learn to talk the language of a community of practice (Lave and Wenger, 1991; Adler, 1998). The position is taken that talking the language of science and deliberate promotion of this talk

in science classrooms should be beneficial to students. The operational definition of talking the language of science is given by Lemke (1990), in his notion of "talking science". According to Lemke (1990, ix) talking science includes

> …observing, comparing, analysing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science.

According to Lemke (1990) it is imperative therefore to offer students opportunity to observe, discuss among themselves, argue different interpretations of a phenomenon, and finally reach a conclusion.

There is growing evidence that talk in a science classroom is beneficial in a number of ways (e.g. Dawes, 2004; Swain *et al.,* 1999; Rivard & Straw, 2000). Swain *et al.* (1999) show that different opportunities for talk in the chemistry class offered students different benefits. Similarly, Rivard and Straw (2000) conclude that talk has impacted their subjects positively in sharing, clarifying, and distributing knowledge among peers. Their conclusion is in conformity with Lemke's (1982) argument that

> Science classroom talk can be seen as serving two major functions: the coordination and control of what we do and when, and the control and development of our use of the *thematic systems* of science. Lemke (1982:264)

While the notion of talk in a science classroom has attracted many educators and researchers, it is important to note that talk within a classroom can take different forms and thus lead to different outputs. van Zee and Minstrell (1997) analysed reflective discourses and categorised discussions into three areas:

- where students express their thoughts through questions and comments
- where the teacher and individual students are engaged in a series of questioning exchanges
- where students exchange their thoughts as they try to understand each other's thinking

These different approaches certainly should give different products. The third type, in which students exchange their thoughts, is recognised as possessing enormous potential. Such exchanges crucially have potential of positive impact on identity. Scott and

Mortimer (2003) categorised communication between students and their teacher into four groups:

- Interactive/dialogic communicative approach: the teacher seeks to elicit and explore students ideas about a particular issue
- Interactive/authoritative communicative approach: the teacher leads students through a sequence of instructional questions and answers
- Non-interactive/dialogic communicative approach: the teacher is pulling together and presenting students ideas and also drawing attention to the differences between everyday and scientific points of view
- Non-interactive/authoritative communicative approach: the teacher is presenting a specific point of view.

These different opportunities suggest different ways that teachers can employ in their science classrooms. However, some writers implicate the choice of these categories to be affected by other considerations (e.g. Carlsen, 1993; Wilson, 1999). Carlsen (1993) found that the teachers' subject-matter knowledge affected opportunities given to students to talk. Despite this though, encouraging talk in a classroom should remain a priority. Setati *et al.* (2002) emphasise the importance of talk as a social thinking tool and further argue that teachers need to understand that learning comprises teaching exploratory talk as well as discourse – specific talk. The Scott and Mortimer's (2003) categories fall short of describing the interaction between students. The interpretation of situated cognition is that learning involves talk between students. This interpretation makes van Zee and Mintrell (1997)'s third category an important tool.

The process of enculturation therefore comprises identity formation. It is important to note that enculturation, advocated in this study, will be implemented within a second language situation. This necessitates discussion of language issues. The next section discusses the language debate.

3.6 LANGUAGE DEBATE

The two theories of learning, the Vygotskian sociocultural theory and situated cognition, discussed above consider language as a central psychological tool within a social activity.

Language must however be put into context more so when the debate of a second language or in some cases foreign language in science education, especially in developing countries, is a critical issue. The operational definition of language assumed in this study concurs with Setati *et al.* (2002) and Granville *et al.* (1998). In the view of this research, language is foreign when within ones' neighbourhood it is hardly used and there are hardly any materials that can be used to support it. On the other hand it is a second language if after mother tongue it is mostly used within ones neighbourhood. Lesotho's situation is complicated by commonly available use of technological devises such as radios. However, English is hardly a second language for students except in urban areas. It is the researcher's view that in the rural areas the technological devices such as radios are mainly used not for learning purposes but rather for notices and entertainment.

The role of language in science education has raised concerns related to learning and teaching. Both concerns are important in Lesotho's situation. Teaching at tertiary level in Lesotho is done in English. Students are therefore faced with double challenges. They learn the language of learning and teaching and the scientific concepts at the same time. Several science and mathematics educators have alluded to language being a barrier towards scientific concept learning (Mortimer, 1998; Moje, 1995; Moje *et al.,* 2001). Rollnick (2000) identifies two categories of difficulties which cause use of a second language, in Lesotho's case English, to be a barrier towards students' learning. These are problems caused by English as a language system not familiar to students and problems caused by English as a social institution; that is, in the case of this study, language of science. As Khati (2001) noted, proficiency of English as a language system in Lesotho is not satisfactory. Inevitably the language debates in science education, in Lesotho, are unavoidable.

The language of science, on the other hand, and the problems encountered in classrooms, needs to be defined. Gee (1999) has distinguished between social languages and Discourses (with an upper case D). He defines Discourses as

> ...socially accepted associations among ways of using language, thinking, valuing, acting and interacting, in the 'right' places and at the 'right' times with the 'right' objects. (Gee, 1999:17)

There is therefore a way of talking, thinking, writing, doing and reading which is accepted within a community and thus within the community of scientists (Lemke, 1990). Discourses of science, then, are ways of talking, doing, reading, writing accepted within the community of scientists. The language of science, therefore, refers to certain ways of expressing Discourses of science and is peculiar to the community of scientists. Gee (1999) goes on to define a social language in terms of the role of language in Discourse. A peculiar feature of social language is that one can express the same thing to different people using different tones depending on who these people are (Gee, 1999; Gee & Green, 2005).

The language of science causes difficulties for students to learn science (Curtis and Millar, 1988; Rollnick, 2000). This problem has been researched enormously in the recent past. Studies done within the cognitivist paradigm have observed effects of words on scientific learning. Rutherford (1993), in trying to understand why students have problems in following scientific language, classifies scientific words into three groups; namely everyday words, portmanteau words and scientific specific words. Everyday words are those used in simple day-to-day language and thus bear a threat of misinterpretation. Bell and Freyberg (1985) argue that the problem of language in learning does not only lie in the complex word used but also in the underlying words, which in many cases are everyday words. The problem of everyday words is even made worse when the same word has different meanings, depending on the field of study. For instance, the word 'power' as used in Physics has a different meaning from the word 'power' as used in Mathematics. Sanders (1988) has noted that scientific words can cause confusion because one word, for instance 'motor', has different meanings depending on the field of study.

Similar observations are made within the situated cognition paradigm. Gee (1999) argues the situatedness of meaning of a word and maintains that such a meaning is assembled

through use of tiny theories he calls cultural models within a society. He defines situated meaning as

> ... an image or pattern that we assemble "on the spot" as we communicate in a given context, based on our construal of that context and on our past experience. (Gee, 1999:47)

A word such as field for example will have many meanings. The correct meaning according to Gee (1999) is assembled by people involved in a discussion depending on the context and past experience. Context and experience define these theories or cultural models which help the listener to construct meaning. For a student living in Lesotho, for example, a common theory he/she can use to define a field would be "a small arable land ploughed and bounded by small patches of unploughed strip" or "a land where maize is harvested". These cultural models, therefore, explain why one word, like field, can be represented in different ways.

The sociocultural perspective and situated cognition have been construed, as argued earlier, to lead to a concept of enculturation of students into the scientific community. Enculturation, in turn, is construed to lead to the concept of encouraging students to use the language of science. The contention is that encouraging the use of the language of science should promote better understanding of scientific concepts. Moje (1995) argues that it is of utmost importance that students learn to talk in the language of science to promote their understanding of concepts. If learning is viewed to be enculturation into a community of scientists, then science classrooms, as part of that community, must be such that the language of science is encouraged.

Rollnick (2000) observes that teaching approaches practised by teachers in developing countries originated from first world and first language teaching countries and are then transferred to developing and economically less advantaged countries. Crucial to note is the fact that teachers bring to their classrooms styles and perceptions influenced by their culture (Koballa and Crawler, 1995; Yore, 1991; Cronin-Jones, 1991). Inevitably, the problem of teaching approaches favouring a different culture from that of the teacher is bound to occur. A worse scenario is when the teacher and students do not share the same

culture. Critical to note is the fact the methods Rollnick refers to assume a certain level of accessibility of teaching material which, in developing countries has proved to be a problem. They also assume a certain level of teachers' and students' proficiency of a language of learning and teaching. In most cases both students' and teachers' proficiency of second language in developing countries is low.

Various studies have addressed the question of the role played by the second language in science and mathematics education in developing countries (e.g. Bamgbose, 1992, Bird and Weford, 1995; Rollnick and Rutherford, 1996). Kaunda *et al.* (1998) have investigated students' ability to communicate science investigations by analysing the effects of presentational methods and the nature of the task on the quality of the students' laboratory reports. Among their conclusions, they argue that a relationship exists between presentational method and the quality of what the student will report in terms of both the conceptual change and the language used. Like Duran *et al.* (1998), they suggest that the main contributions are support of presentation by non-linguistic means such as demonstrations and explicit guidelines.

The main issue emerging is that language can impact negatively on the learning of science concepts. From both the situated cognition and sociocultural perspective, language should not be viewed as an obstacle. The observations put a challenge on teaching strategies that teachers employ. It is argued in this study that the solution lies in enculturating students to learn to talk in the language of science so as to increase their potential for understanding the conceptual themes (Moje, 1995). The claims that Gee (2005) makes about language and learning of scientific concepts are worth noting though. Gee (2005) claims that

- success in school is primarily contingent on willingness and ability to cope with academic language,
- to acquire an academic social language, students must be willing to accept certain losses and see the acquisition of the academic social language as a gain,

- one does not know what a social language means in any sense useful for action unless one can situate the meaning of the social language, words and phrases in terms of embodied experiences,
- language acquisition crucially involves access to and simulations of the perspectives of more advanced users of the language in the midst of practice,
- lifeworld language is problematic for science, and
- a face-to-face conversational framework is problematic for the acquisition of scientific academic language

Taking note of these claims informs the process of enculturation. Most importantly, the claims define some responsibility between the student to be enculturated and the teacher responsible of pushing the enculturation agenda.

3.7 Alternative Conceptions in Electromagnetism

The notion of students' unscientific ideas, referred to in this thesis as alternative conceptions, is informative in understanding meaning – making. Research within cognitivist paradigm have shown that students, regardless of nationality, sex, race, colour or creed, hold, even after formal learning/teaching process, alternative conceptions in all science subjects (Shipstone, 1984; Driver *et al.*, 1994; Thijs, 1992; Kuiper, 1994). These researchers further indicate that alternative conceptions are world wide and resistant to change. Some of these studies argue that, among the causes, language is one of the major contributors to the problem of acquisition of alternative conceptions (Driver *et al.*, 1994; Head, 1986; Thijs and Berg, 1995).

A few studies reported students' alternative conceptions in electromagnetism. Erickson (1994) reported students' views on magnetism, and categorised them into three groups, namely pulling, emanating and enclosing models. In pulling model students understand a magnet as something whose main function is to "pull" objects. In emanating model students believe that there is somewhat a ray or a fluid emanating from the magnet and that interacts with the object and attraction results. In enclosing model students think that there is an area of influence where objects are attracted towards the magnet.

Borges and Gilbert (1998) propose the existence of five models, namely magnetism as pulling, cloud, electricity, electric polarization and field model. The pulling and cloud models are similar to Erickson's pulling and enclosing models respectively. In magnetism as electricity model, students think of magnetism as attraction between unlike charges and that at the end of a magnet there is either an "excess" or "lack" of electricity. In magnetism as electric polarization model students think that positive and negative electric charges are separated in a magnet so that there are different poles. In field model magnetism is understood to exist at microscopic level because of electrically charged particles' motion in the atoms.

Qhobela and Stanton (1998) reported that most students do not differentiate between electric and magnetic field and that some students correctly see the field around a magnet as magnetic field while the field around a current carrying conductor is erroneously called electric field. Andersson (1986) reported that students think of magnetic field existing around a wire only if it is not insulated.

The critical issue here is that access students might have ideas in electromagnetism that can be viewed as alternative conceptions. The cognitivist concept of alternative conceptions can be understood within the Vygotskian sociocultural perspective. Vygotsky's (1986) classified children's views into two categories, namely spontaneous and non-spontaneous. Spontaneous concepts, equivalent to alternative conceptions, are perceived to mainly develop as a result of students' meeting with concrete situations while non-spontaneous concepts, equivalent to scientific concepts, mainly develop as a result of mediation. The lesson that must be noted from the cognitivist view, though, is that spontaneous concepts can result also from mediation.

Analysis of Vygotsky on how these concepts develop is pertinent. Spontaneous concepts are said to develop upward while scientific concepts develop downward. Vygotsky (1986) views the way spontaneous and scientific concepts grow as an advantage in that spontaneous concepts can serve as a foundation for scientific concepts. The notion therefore of students' alternative conceptions becomes important in teaching and/or

learning, particularly where LoLT is an issue. It suggests that teaching has to acknowledge students' alternative conceptions as prior knowledge that a student may be having. The analysis of alternative conceptions by Klaassen and Lijnse (1996) must be noted. Their analysis of a discourse between the teacher and his students suggests that some reported alternative conceptions might have not been genuine but were rather misunderstandings on the side of the teacher and/or the researchers.

3.8 THEORETICAL FRAMEWORK

The theoretical framework of this study is drawn from the literature reviewed above. Perhaps it is important to observe that recently there have been a number of studies adopting sociocultural theory and situated cognition as their basic tenet conducted in various countries around the world. These studies were inevitably characterised by the situation and time which dictated research problems. Some of these studies specifically addressed issues of second language learning in developing countries and access to meaning – making resources (Adler, 1997, 1998, 1999; Setati and Adler, 2001; Moje *et al.*, 2001). Some of these studies have subscribed to the notion that language is a carrier of culture and that knowledge construction is social. This argument draws its base from the work of Vygotsky, discussed above; namely internalisation and ZPD.

Three studies, Duran *et al.* (1998), Christie (1998) and Scott (1998) have followed this trend, and are of interest to this study. Because of this interest, these studies have been used to draw the theoretical framework of this study.

3.8.1 The Duran, Dugan and Weffer (1998) study

Duran, Dugan and Weffer designed a study whose theoretical framework was the sociocultural theory. Their study was a twofold study whose aim was to describe the cognitive and linguistic tools that second language minority students, Mexican–Americans, use during science instruction, and secondly, to modify instructional practices to address the use of learning tools and suggest alternative techniques which would increase conceptual learning. Their concern was that there is need to re-examine the role of language proficiency in teaching/learning for two reasons.

> Firstly, it would contribute to a description of the learner characteristics of a distinct student population *during* learning … Secondly, it would provide information about how low English proficiency influences teaching/learning science in high school science. (Duran *et al.*, 1998:312).

Duran *et al.* (1998) were informed by Vygotskian theory, and their core thesis was that the Vygotskian sociocultural theory characterises learning as a type of enculturation in which learning occurs through adopting the social and cultural practices, particularly language, of a social group. Any social group is characterised by a distinct culture and distinct ways of thinking, talking and doing things. This raised a need and influenced Duran *et al.* (1998) to address issues related to language in the learning of second language minority students. Having identified cognitive and linguistic tools that students used, Duran *et al.* designed a three stage teaching intervention. The stages were called **receptive understanding and expression**, **conceptual understanding and expression** and **interpretive understanding and expression**. The purpose of these activities was to create progression from teacher-dominated learning to student-centred learning in which the teacher's authority decreased in favour of students' independent learning. Table 3.1 below presents the Duran *et al.* (1998) study stages.

Duran *et. al.* 1998	
Stage	Characteristics
1.Receptive understanding and Expression	- learners are made to understand actions and talk of the teacher - learners associate verbal labels with biology referents - learners 'ventriloquate' the talk of the teacher
2. Conceptual understanding and Expression	- learners use learning tools to construct science meaning - teacher withdraws from supplying science meaning
3. Interpretive understanding and Expression	- learners interpret their everyday experiences through scientific reasoning - learners view real world events as scientific problems with scientific solution

Table 3.1: Characteristics of Duran *et al.,* 1998

The *first stage* involves students being made to understand the actions and talk of the biology teacher. The intention was to make students find relationships between

characteristics so that it becomes easy for them to appreciate concepts. At this stage students, to a greater extent, depended on their teacher's direction on what is to be learned and on information from textbooks. In the *second stage,* conceptual understanding and expression, students are engaged in understanding complex concepts. Whereas in the first stage students relied on the teacher, in this stage they were expected to reduce that dependency and start to use learning tools provided to construct meaning. This, according to Duran *et al.* (1998:338), meant that students

> ...reconstruct relational patterns in a way that was compatible with their linguistic resources for expressing their understanding.

and engaging them

> ...in making their own inferences of the connections between the biological relationships they understood and changed social context. (Duran *et al.*, 1998:338)

In the *last stage* students were expected to interpret their everyday experience through reasoning of biology.

The manner in which students are made to participate positively towards their learning and are introduced to the way of talking about the biological concepts, concurs with Leach and Scott's (2003) way of representing a sociocultural study. Leach and Scott (2003) argue that the Vygotskian concept of internalisation suggests a number of things that must be seen as characteristics of a Vygotskian study. They suggest that

> …individual learners must make sense of the talk that surrounds them, relate that talk to their existing ideas and ways of thinking. Learners must reorganise and reconstruct the talk and activities of the social plane. (Leach and Scott, 2003:101).

The notion of ventriloquation advocated in Duran *et al.* (1998) study appears to be an important aspect towards achieving the Vygotskian concept of the ZPD in which an adult guides the child. However, in this study, Duran *et al.* (1998) do not make their students realise the potential and/or the deficit in what students knew before they that were guided.

3.8.2 The Scott (1998) study

The Scott's (1998) study adopted, as its theoretical framework, the Vygotskian sociocultural theory. The purpose of the study was to develop an instrument that addresses how meanings are developed on the interpsychological plane of the classroom in the institutional setting of Western schools. The study, whose sample was a class of 13 to 14 year olds, concentrated on the concept of air pressure. The review specifically addresses three issues, the teaching narrative, communicative approaches and the functions of the discourse and teacher talk and scaffolding. Of interest to this study is the discussion of the teaching narrative.

The teaching narrative comprised of three major strands which in turn break into five forms of pedagogical interventions as shown in diagram 3.1 below.

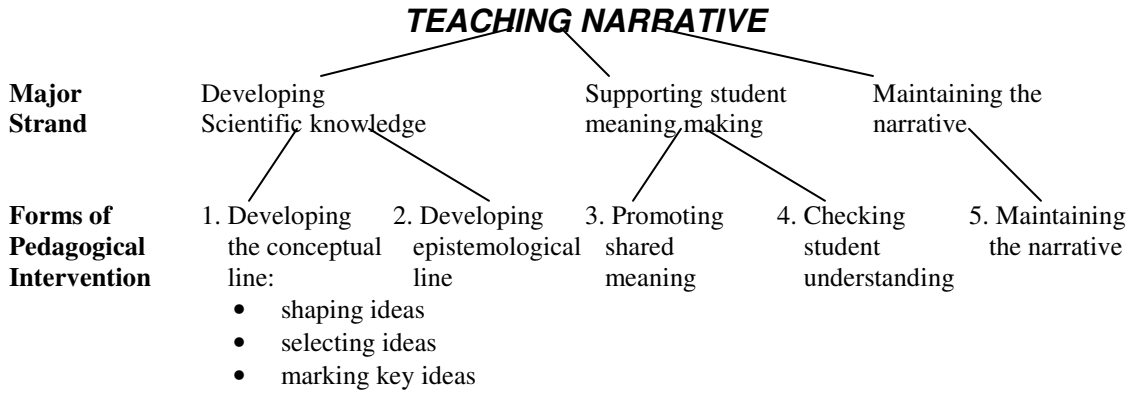


Diagram 3.1: Scott's teaching narrative

The main idea of the teaching narrative was to present to students scientific concepts and let them gradually develop scientific meaning starting from a teacher guided situation to a situation where the student attains some degree of independence. Scott (1998:56) argues that

> The concept of the Teaching Narrative is intended to provide an overarching theoretical structure which acknowledges the fact that teaching and learning science in the classroom occur over an extended time line with beginning and end point, and involves the teacher in laying a 'language trail' from students' cognitive starting point towards the learning goal of the scientific view.

In the first strand, the teacher is leading the learning process by introducing the concepts and involving students in discussion. The teacher does this by shaping students' ideas, selecting and redirecting those ideas. Then, the teacher introduces aspects of the nature of scientific knowledge. In the second strand, the meaning of scientific concepts was being developed and the teacher would be making sure that all students understand. The teacher does this by sharing ideas, whether coming from him or from a student or a group of students, and then asks questions of clarity and discussions. In the final strand, the teacher comments on the talk of students and refocuses their discussions.

The role of the teacher in Scott's study is worth noting. Scott (1998) describes the features of the intervention as follows

> A significant feature of the interventions identified is the way in which they contribute to, and constitute, a coherent 'performance' as the teacher is engaged in guiding the development of discourse on the interpsychological plane so that the scientific view is made available to all students. (Scott, 1998:58)

In the ZPD a teacher, acting as an expert, must guide students through a process of internalising discourses of the social setting. The process must end when the ZPD has become an actual developmental level of students. The measure of attainment of actual developmental level in this Scott's (1998) study has been the ability of students to use the discourses of chemistry.

3.8.3 The Christie (1998) Study

The Christie (1998) study conducted in Australia is based on a theoretical concept of genres and in particular curriculum macrogenres. A genre, according to Christie (1998), refers to a staged purposeful activity in which set goals are achieved. Christie develops this concept further to what he calls curriculum macrogenres. According to Christie (1998:154), the term curriculum macrogenres refers to

> … a cycle of teaching – learning activity in which a teacher and students engage with some 'content area', progressing from some introductory stage through a series of stages until a conclusion is reached.

The concept of macrogenre therefore encourages students to slowly acquire some independence and accountability of their learning as the teacher purposely and timely

shifts it towards them. The idea of working as a social group supported initially by the teacher is another strength of the macrogenre concept. The teacher's main responsibility is to introduce the "content area" and to guide students towards independence.

Students involved in Christie's (1998) study were 11 to 12 year olds at the upper primary level. The content area was machines in Physics. The purpose and design of Christie (1998)'s study was influenced by what, in his opinion, was lacking in earlier research studies. Christie was concerned that research did not study deliberately the manner in which contents of different school subjects are constructed in classroom talk. That is, Christie was concerned that research had not given enough attention to talk in science classrooms. He also found that research tended to focus on particular teaching episodes rather than on overall sequence in treatment of a particular topic. Finally he observed that research has not generally addressed the relationship of talk to the literacy students must learn to use in different subjects. Thus, Christie (1998) addressed these concerns.
Christie (1998) had three main stages, curriculum initiation, curriculum collaboration and curriculum closure. The study allows progression from an initial stage, Curriculum initiation, where the learning is teacher dominated, to the last stage, Curriculum closure, where students have taken control of their learning process. The curriculum initiation stage comprises of three sub-stages: *Firstly*, the teacher defines the goals of the topic and establishes common understanding of the purpose. *Secondly*, the teacher outlines possible activities that students can do and underlines the desired activity. *Lastly*, students begin to find their way into the work expected out of them. In curriculum initiation stage therefore, the teacher takes up the responsibility of introducing concepts that students will learn and allows them to negotiate how they will carry out their work. The next stage, curriculum collaboration, is characterised by students performing tasks and documenting procedures they followed. Unlike in curriculum initiation, students in this second stage are directing their own learning process in terms of deciding on what to be done. The last stage consists of two important practices, namely students reporting their work both orally and in writing.

Table 3.2 below summarises the Christie (1998) study.

Christie (1998) Study	
Stage	Characteristics
1. Curriculum Initiation	- teacher sets direction and sets purpose of activity - learners tasks are established - learners and teacher confer over the distribution of the tasks
2. Curriculum collaboration	- learners work together on their scientific task - learners direct their behaviour, demonstrate co-operative activity
3. Curriculum closure	- learners give oral recounts and demonstration of the scientific concepts - learners display written reports of their assignments

Table 3.2: Christie (1998) study

It is crucial to observe similarities that have made the three studies above attractive. Table 3.3 below compares their main characteristics.

Duran *et al.*(1998) Study	Christie (1998) Study	Scott (1998) study
Stage	Stage	Strands
1. Receptive understanding and Expression	1. Curriculum Initiation	1. Developing Scientific knowledge
2. Conceptual understanding and Expression	2. Curriculum collaboration	2. Supporting students in meaning making
3. Interpretive understanding and Expression	3. Curriculum closure	3. Maintaining the narrative

Table 3.3: The three studies

Two features of these studies, relating to how they are designed, are pertinent.

- Introduction of the Discourses of science: The striking feature of these studies is their focus on introduction and practising of the Discourses of science and their approach towards meaning – making processes in science classrooms. In applying Vygotskian approach, these studies concentrate on students being introduced to the way of talking, doing, writing and thinking about scientific concepts.
- Progression aspect: The three studies have, in their respective ways, introduced a progression aspect as a pertinent component of their design. Not only are Discourses of science introduced by the teachers but they are also engaged progressively by students. This is a Vygotskian ZPD approach in which learning starts from a level in which students need assistance and progress to another in which they are able to work

alone. It must be observed though that the ZPD does not necessarily imply a linear progression.

3.8.4 This Study

The theoretical framework of this study is informed by the three studies above. In particular the following concepts, as demonstrated in these studies and discussed in the literature above, have been instrumental. The understanding of the process of meaning making is conceived to comprise the following components.

- *The social nature of learning*. This component suggests that learning is patterned by social and cultural environment. The individualistic nature of learning is therefore challenged and a socially and culturally inclined learning is advocated. In this study students are engaged in activities where, in groups and with assistance from their teacher, they formulate solutions of a problem and engage in putting their solution into practice.
- *The situated nature of cognition*. The argument advocated in this study is that cognition is situated in physical and social context, it is social and distributed over people and artifacts. This is realised by providing students with resources to access the knowledge they are expected to learn.
- *Enculturation into a Discourse community*. The idea that adaptation of social and cultural practices of a community of practice leads to learning is advocated. In this study students were encouraged to use Discourses of science, with particular interest on engaging scientific talk. It was noted though, and importantly, that this adaptation of social and cultural practices is a process of give and take.

Table 3.4 below presents the framework of this study. It also compares this study to the Duran *et al.* (1998), Christie (1998), and Scott (1998) studies. This study is designed to comprise four predetermined stages, Conceptual Foundation, Conceptual Initiation, Conceptual Formulation, and Conceptual Application.

Duran *et al.*(1998) Study		Christie (1998) Study		Scott (1998) study		This Study	
Stage	Characteristics	Stage	Characteristics	Stage	Characteristics	Stage	Characteristics
						1. Conceptual Foundation	- students talk about their prior knowledge, - students study concept maps and/or form improved maps
1. Receptive understanding and Expression	- learners are made to understand actions and talk of the teacher - learners associate verbal labels with biology referents -learners 'ventriloquate' the talk of the teacher	1. Curriculum Initiation	- teacher sets direction and sets purpose of activity - learners tasks are established - learners and teacher confer over the distribution of the tasks	1. Developing Scientific knowledge	- making scientific knowledge available to students by developing conceptual and epistemological lines	2. Conceptual Initiation	- understanding the teacher's talk and information from other sources, - associating the talk with scientific concepts,
2. Conceptual understanding and Expression	- learners use learning tools to construct science meaning - teacher withdraws from supplying science meaning	2. Curriculum collaboration	- learners work together on their scientific task - learners direct their behaviour, demonstrate co-operative activity	2. Supporting students meaning making	- making science point of view available to all students - checking meaning and understanding are developed	3. Conceptual Formulation	- working together to construct scientific meaning, - access meaning making sources, - telling scientific story
3. Interpretive understanding and Expression	- learners interpret their everyday experiences through scientific reasoning - learners view real world events as scientific problems with scientific solution	3. Curriculum closure	- learners give oral recounts and demonstration of the scientific concepts - learners display written reports of their assignments	3. Maintaining the narrative	- teacher provides a commentary to help students follow development of scientific story.	4. Conceptual Application	- studying application of scientific concept in artifacts, - reporting work done orally and in writing

Table 3.4: The theoretical framework

The theoretical framework, as presented in Table 3.4 above, comprises the following predetermined stages with the following characteristics.

- Conceptual Foundation: The idea in Conceptual Foundation is to provide students an opportunity to talk about their prior knowledge.
- Conceptual Initiation: During Conceptual Initiation students will be introduced to Discourses of science and to associate these Discourses with the phenomenon.
- Conceptual Formulation: During Conceptual Formulation students will be given opportunity to start practising Discourses of science introduced during Conceptual Initiation.
- Conceptual Application: During Conceptual Application students are given further opportunity to use Discourses of science. In particular students study application of a phenomenon in artifacts.

This framework adopts the two characteristics noted in the discussion of the Duran *et al.* (1998), Christie (1998), and Scott (1998) above. That is, this study maintains the notions of practising of Discourses of science and progression aspect in practising these Discourses. The literature reviewed above is perceived to advocate the concept of enculturation which requires students to be given an opportunity to practise using Discourses of science. In adopting this framework it is hoped that students can be encouraged to use Discourses of science. Inevitably, the initial stage will see the teacher supporting the process until the final stage where students can use these Discourses on their own. The Vygotskian understanding of the process suggests that the support that the teacher gives must decline as students assume the responsibility of the learning process.

On the other hand, two aspects introduced in this study do not surface as strong characteristics in the three studies. Firstly, it is the introduction of the first stage where students talk about their prior situation definitions of electromagnetism concepts. It will be argued in Chapter 5 that this design is necessary in situations where the LoLT is a second language. It is also necessary in situations where problems associated with the use of LoLT are compounded by a background of chalk and talk teaching methods. Secondly, in this study students will, at the Conceptual Application stage, further practise

using Discourses of science. They will make use of artifacts provided by the teacher and they will have used those artifacts one way or the other. This is an important difference in that this study subscribes to the idea of offering students further opportunities of practising Discourses of science.

This theoretical framework can be further understood through understanding different aspects of Discourses that students practised. Chapter 4 introduces the analytical tools that will be employed to analyse data from this study.

CHAPTER 4

ANALYTICAL TOOLS

4.1 Introduction

Chapter 4 discusses three major analytical tools that will be employed to analyse data collected in this study. The chapter introduces the three analytical tools that will be employed when analysing data. These are the SAMPS system, Communicative approaches and discourse patterns, and Toulmin's Framework.

4.2 The analytical Tool

Data collected in this study is analysed using three lenses; the SAMPS system, students' Discourses approaches, and the Toulmin's framework. These tools are discussed below.

4.2.1 The SAMPS system

The primary analytical tool employed in this study is a model suggested by Gee (1999). The model is abbreviated in this study as the SAMPS system of discourse analysis. It has five components of any situation, *S*emiotic aspect, *A*ctivity aspect, *M*aterial aspects, *P*olitical aspect, and *S*ociocultural aspect (Hall, 2002; Gee, 1999; Gee and Green, 1998). Analysing of Discourses in the intervention briefly outlined in section 3.2 above starts with the contention that any Discourse activity has more to it than what appears on the surface. That is, for example, any talk between two or more people is influenced by a variety of issues such as relationships, gender, history, age, and purpose. It is pertinent therefore to note that words used in any communication carry deeper meaning than just what is on the surface. This concurs with the assumption that meaningful Discourse analysis is done within its specific social context (Luke, 1995). The SAMPS system therefore takes care of this contention in that it suggests the analysis strategy in which a variety of aspects of a situation are considered and attention is paid to social context of the situation. However, the following advice by Gee and Green (1998) is worth noting

> …since it is not possible during analysis to consider all of these aspects simultaneously, it is necessary for an analyst to foreground particular aspects while backgrounding others. (Gee and Green, 1998:135)

The choice regarding which aspect of analysis to be foregrounded or backgrounded should be influenced by the goals of a study. Since the main goal of this study is to understand how and what meanings are constructed by access students, the semiotic and activity aspect of this system will be foregrounded while all other aspects will be backgrounded. In order to apply the SAMPS system Table 4.1 shows a set of questions that will be asked about any situation.

The *Semiotic aspect* of analysis refers to studying of situated meanings and cultural models in place and understood significant as communicators engage in the discussion (Gee, 1999; Gee and Green, 1998). The contributions of Kress (1996) and Gee (1999) are pertinent in order to construe the semiotic aspect of analysis of a situation. Kress (1996;6) defines *semiotic* as "…the study of the meaning of systems of signs." while Gee (1999:17) defines Discourses in the following way " "Big D" Discourses are always language *plus* "other stuff"." Sign systems include talk, and "other stuff" Discourses such as writing, reading, gestures, symbols, and values (Gee, 1999; Kress, 1996). The semiotic aspect of analysis therefore refers to studying constructed meanings embodied in Discourses in a situation. Such meaning can be understood for example from a careful and purposeful understanding of a text or gestures. The semiotic aspect therefore challenges an analyst to go beyond mere studying of meanings embodied in a talk and to identify and study meaning embodied in "other stuff" Discourses in a situation. Thus, analysing semiotic aspects of a Discourse implies studying meanings of different elements of a Discourse. Gee and Green (1998) add that studying semiotic aspects may encompass critical studying of institutions, communities of practice, and/or discourses that are being produced in the situation and how they are transformed in the act.

The *Activity aspect* of Discourse analysis refers to studying of specific social activity or interconnected chains of activities in which participants are engaged (Gee, 1999; Gee and Green, 1998). According to Gee and Green (1998), activity aspect of analysis calls for

consideration of how time is being spent in a given situation and what sub-activities and sequences compose a given activity. How time is spent introduces notions of the multi-voicedness principle of activity theory (Engestrom, 2001). According to Engestrom (2001) activity can be viewed as a community of multiple points of view, tradition, and interests. In addition to multiple views, activity theorists argue that any activity highlights not only the historical development of an idea but also the active and constructive role of participants (Jonassen and Rohrer-Murphy, 1999). In this study it will be found imperative that the actual activities and sub-activities that define any of the stages are identified and discussed. In order to classify activities and sub-activities in any of the stages of the intervention the following core question is asked: What kind(s) of Discourse enabling activity is practised by actors in this stage?

The *Material aspect* of analysis refers to identification of actors, place (space), time, and objects present when the discussion takes place. Material aspect focuses on questions of when, where, with whom, and under what conditions members are interacting and on consideration of objects and artifacts present during the interaction (Gee and Green, 1998; Hall, 2002).

The *Political aspect* of analysis refers to studying of the distribution of social goods in the interaction (Gee, 1999). Political considerations of a Discourse will include issues such as intelligence, possessions, race, gender, and which school one comes from. Political aspects should normally result in a one way discussion.

The *Sociocultural aspect* of analysis refers to studying of personal, social, and cultural knowledge, feelings, identities identified as being relevant during a discussion (Gee, 1999; Gee and Green, 1998; Hall, 2002). According to this therefore, an analyst should identify all social and cultural aspects in a situation. Gee and Green (1998) argue that studying sociocultural aspects of a Discourse include defining identities signalled by members and/or constructed in the interactions among members and how they are transformed in and through the actions, responses, and collective activity in the situation.

Semiotic	Activity	Material	Political	Sociocultural
▪ Which sign systems did communicators use in this situation? Is it ▪ Talk? ▪ Writing? ▪ Drawing? ▪ What meanings are constructed and/or signalled in this situation? ▪ When statements are made do communicators justify them and what justifications are made? ▪ In events of agreement and/or disagreement what justifications are given?	▪ On what is time being spent in this situation? ▪ What sub-activities compose the main activity in this situation? ▪ What actions compose these sub-activities in this situation?	▪ When, where, with whom, and under what conditions are members interacting in this situation? ▪ What objects and artefacts are present in this situation? ▪ What meanings are attached to objects and artefacts in this situation? ▪ Do the communicators give names to event/activity in this situation?	▪ What social goods are there in this situation? ▪ How are the social goods expressed and made relevant in this situation? ▪ How are the social goods related to the actors in this situation?	▪ What expectations, roles and relationships are constructed by actors in this situation? ▪ What personal, social, and cultural knowledge and identities seem to be relevant in this situation? ▪ How are these identities signalled by actor in this situation? ▪ What sorts of connections are made in this situation?

Table 4.1: The SAMPS system questions

4.2.2 Understanding Discourses

The semiotic aspect, and to some extent the activity aspect, of SAMPS system of analysis have shortcomings insofar as they do not indicate how communicators contribute to the construction of a meaning. That is, the analyst also has to say whether communicators share a particular meaning or whether the one communicator was convinced by the other. This necessitated supplementary analytical tools, which study the contribution of communicators towards construction of meaning reached. Two approaches were identified, namely communicative approaches and discourse patterns and Toulmin's framework.

4.2.2.1 Discourse Pattern and Communicative approaches

The notions of discourse pattern and communicative approaches supplement the SAMPS system discussed above insofar as defining how communicators took turns in communication. Addressing the question of how communicators took turns in communication is important in highlighting how intersubjectivity was reached. Mortimer and Scott (2003) have elaborated on the use of the term communicative approaches as referring to a consideration of whether the interaction between the teacher and students takes account of students' ideas. In the present study, the concept of communicative approaches is used to consider whether students engaging a talk take account of others' ideas and whether they mutually participate by contributing ideas. A basic question addressed therefore is whether the meaning is shared by the communicators. In order to define communicative approaches that LP students engaged, discourse patterns also have to be analysed. Discourse patterns refer to communication interactions that occur as students discuss a view. Table 4.2 below introduces the concept of discourse patterns between two communicators

	Statement (S)	Explanation (E)
Accept (A)	S – A	E – A
Question (Q)	S – Q	E – Q

Table 4.2: The discourse patterns

If a person talks he/she could be making a statement or an explanation. When there are two communicators the first person could be making a *statement(s)* about a particular object of discussion. A statement refers to any utterance that simply states what a communicator considers factual. For instance, a statement can be in a form of an observation, writing an equation, or a remark. Statement 1 below is a typical example of a statement that a student in a physics classroom can utter.

Statement 1: A magnet has two parts; a north pole and a south pole.

Statement 1 claims what the communicator understands as a fact about magnets. If s/he does not make a statement s/he could make an *explanation*. An explanation refers to any utterance that is aimed at making one's point of view comprehensible by offering a description of relevant circumstances. Statement 1 above could have been accompanied by an addition that turns it to statement 2 below.

Statement 2: A magnet has two parts; a north pole and a south pole because particles in a magnet are aligned in a particular direction.

Statement 2 is viewed as an explanation because the communicator offers a reason that justifies his/her claim about existence of two parts of a magnet.

In response to either a statement or an explanation the second person could utter one of the following responses; *accept* or *question*. S/he could *accept* either the statement or the explanation that the first person makes. Accepting one's statement or explanation could be in the form of passing a positive or affirmative remark such as "yes" or repeating what the first person said. An *accept* therefore will be any utterance that does not require the first communicator to offer any more justification. Otherwise s/he could *question* the first person's utterance. Questioning the utterance includes demanding a further explanation or passing a negative remark such as "no". A *question* on the other hand will be an utterance that requires the other communicator to justify his/her opinion.

Table 4.2 shows four possible discourse patterns that can be drawn from these four discourse roles. We can have Statement-Accept (S–A), Explanation-Accept (E–A), Statement-Question (S–Q), and Explanation-Question (E–Q). In *Statement – Accept*

pattern, one of the communicators offers a statement and the other, in response, just accepts the statement as suggested. In *Explanation – Accept* pattern one of the communicators offers an explanation and the other in response just accepts the statement as suggested. In *Statement – Question* pattern, one of the communicators offers a statement and the other in response poses a question. In *Explanation – Question* pattern, one of the communicators offers an explanation and the other in response poses a question.

Mortimer and Scott (2003) further propose four fundamental classes of communicative approaches, interactive/dialogic, non-interactive/dialogic, interactive/authoritative, and non-interactive/authoritative. The communicative approaches that Mortimer and Scott (2003) propose refer to how the teacher interacts with students. In the present study the emphasis is put on the interaction between students. A critical consideration, given the discourse patterns discussed above, is whether communication between students can be *authoritative*. Mortimer and Scott (2003:35) have defined an authoritative approach as an interaction

> …where attention is focused on just one point of view, only one voice is heard and there is no exploration of different ideas.

Any combination of discourse patterns in Table 4.2 above hardly fits into this definition. In terms of the discourse patterns mentioned above the Mortimer and Scott (2003)'s definition of authoritative approach implies that the first person ignores the responses of the second person. It has to be noted though that, as Gee (1999) argues, there can be political aspects of the communication. That is, communication between students can hardly be labelled *authoritative*. Communicative approaches between students will therefore be classified according to how extensive they discuss a suggested idea. They will be classified as *deep* or *surface* dialogue. A communicative approach in which students follow *statement – accept* or *explanation – accept* patterns will be referred to as *surface dialogue*. Similarly, a communicative approach in which students follow discourse patterns *statement – question* or *explanation – question* will be referred to as *deep dialogue.*

Communicative approaches, according to Mortimer and Scott (2003), refer to patterns of interaction that emerge between communicators. A pertinent point about communicative approaches is their contribution towards understanding how intersubjectivity between communicators was reached and therefore how meaning was constructed by communicators. This is critical because this study assumed that interaction of students can lead to construction of meaning. Generally speaking, intersubjectivity reached after surface dialogue, implies a meaning that was not necessarily negotiated while intersubjectivity reached after deep dialogue implies a negotiated meaning.

4.2.2.2 Toulmin's Framework

To completely appreciate the constructed meaning between communicators, an understanding of how an actor in the communication argues that his/her view point is pertinent. Toulmin's framework is helpful in achieving this understanding. Toulmin's framework is employed to consider how one communicator convinces the other. Diagram 4.1, adapted from Toulmin (1958:104), summarises the basic structure of Toulmin's framework of argumentation.

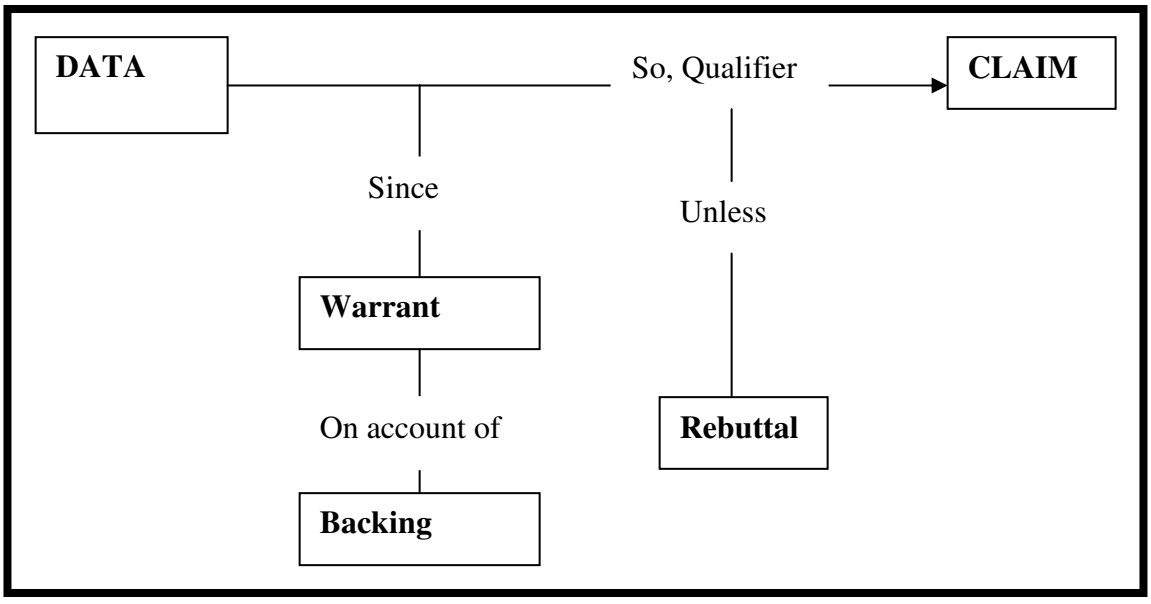


Diagram 4.1: Toulmin's Framework

The diagram highlights five major elements (Data, claim, warrants, backing, and rebuttal) of a well constructed argument (Driver *et al.*, 2000; Yerrick, 2000; Jimenez-Aleixandre *et al*., 2000). Driver *et al.* (2000: 293) elaborate on four of these:

- *Data*: these are the facts those involved in the argument appeal to in support of their claim
- *Claim*: this is the conclusion whose merits are to be established.
- *Warrants*: these are the reasons (rules, principles, etc) that are proposed to justify the connections between the data and the knowledge claim, or conclusion.
- *Backing*: these are the basic assumptions, usually taken to be commonly agreed that provide the justification for particular warrants.

Driver *et al.* (2000:293) defines the two other features of an argument as follows:

- *Qualifiers:* these specify the conditions under which the claim can be taken as true; they represent limitations on the claim.
- *Rebuttals:* these specify the conditions when the claim will not be true.

Toulmin's framework therefore assumes that arguing starts with some *data* and the communicator's role becomes that of convincing his/her audience that the data leads to a claim. Toulmin (1958) argues that the primary task in any communication is to draw the relationship between the *data* and the *claim*. The audience, at the end of an argument, need to be convinced that

> 'Data such as D entitle one to draw conclusions, or make claims, such as C' or alternatively 'Given data D, one may take it that C' (Toulmin, 1958:98)

Thus, the "warrants" and "backing" are important elements in order to build this relationship. It is important, as can be observed from Diagram 4.1, that communicators may need to show conditions under which claims may be rejected. Inevitably, Toulmin's framework has enormous power in explaining the intersubjectivity that communicators, involved in a process of making a scientific mean, reach. Jimenez-Aleixandre *et al.* (2000:760) note that

> Toulmin was committed to a procedural interpretation of argumentation form as opposed to the rigid idea that all arguments have the form "premises to conclusions.

Methodological problems have been noticed about the framework. Erduran *et al.* (2004: 919) noted that

> …organizing student discourse into Toulmin's argument components required careful attention to the contextualized use of language. According to Kelly and his colleagues, while the Toulmin model makes distinctions among statements of data, claim, warrant, and backing, the scheme is restricted to relatively short argument structures and the argument components pose ambiguities. Statements of claims can serve as a new assertion to be proven or can be in service to another claim, thus acting as a warrant.

Toulmins's framework will be used in these "...relatively short argument structures..." and the position is taken that students making an argument may not always make rebutting statements. Thus, the rebuttal in the framework above should be backgrounded where relevant. In fact it was noticed that analysis of arguments, students made in this study, revealed no evidence of rubuttals.

Employing Toulmin's framework to analyse students' Discourses, in particular talk and text, informs the researcher on the justification that a communicator makes in order to convince his/her audience. The analysis therefore will cast some light on the constructed meaning.

4.4 Result chapters

The foregoing discussion presented analytical tools to be used in this study. Two tools have been identified as being important in helping to answer the research questions stated in chapter 1. These are activity and semiotic aspects. The assumption is that, through these two aspects of Discourse analysis, meaning implied and/or constructed by students can be understood. The activity aspect will highlight critical meaning making actions that took place. The semiotic aspect will highlight meanings that were constructed. Further, meanings that students construct will be reinforced by analysing communicative approaches and discourse patterns. These two notions, particularly discourse patterns, highlight how students took turns to construct meaning. Discourse patterns will further be analysed, using the Toulmin's framework of argumentation. Toulmin's framework will highlight how students justified claims that they made.

The analytic tool discussed above resulted in two categories of result chapters. Firstly, it is chapter 6 which presents the results of the activity aspect of the SAMPS systems. The chapter basically discusses the activities that students engaged to make meaning at different levels of the intervention. Then, follows the category of chapters 7, 8, and 9, that presents the results of the semiotic aspect of the SAMPS system. The core of these chapters is the meaning made by students at different levels of the intervention.

CHAPTER 5

METHODOLOGY

5.1 Introduction

This chapter deals with how and why data was collected the way in which it was collected. Discussion of the actual study is broken into two broad categories. The first category comprises theoretical issues. This is done by describing a fundamentally qualitative study, data collection methods, validity and reliability within qualitative paradigm and the limitations of this study. To define the study, the design and justification of why a generic qualitative paradigm was chosen, are discussed. The second category is a discussion of what actually happened. The first thing was to explain the context of the study, and then the intervention and the data collection methods used. The chapter ends by discussing the pilot study.

5.2 The Actual Study

5.2.1 Design of the Study

In chapter 1 the research questions that guided the study were stated as follows:

- What strategies can be employed to enable access students to construct meaning through discourse of science when learning about electromagnetism?
- Which elements of the strategies enable or constrain the students' use of the language of science?
- What is the effect of mediation strategies on the students' learning?

The research questions, coupled with the aims of the study, are instrumental in deciding upon the nature of a research design. The research questions above are, by and large, asking 'what' questions (Creswell, 1998), a characteristic which is conceptualised to mandate a qualitative paradigm. When designing, and implementing, this study there was a strong opinion that to answer these research questions there is no need to employ statistical techniques and thus no need to mix with a quantitative design. The reasons for choosing qualitative research for this study concur with Creswell (1998)'s advocacy of

reasons for qualitative research. According to Creswell (1998) a researcher may choose a qualitative paradigm because of

- the nature of the research questions: The research questions of this study are asking the "what" questions which, according to Creswell (1998), are best answered with a qualitative research.
- the intention to study individuals in their *natural setting*: This study investigates an impact of an intervention in an access programme classroom. Of special interest is the students' meaning making process; how and when it occurs and what factors influence its occurrence.
- the intention to be an active learner: Since the researcher was a Physics lecturer at the access programme, the intention to be an active learner was clear.

Various scholars have defined qualitative studies and shown when and where they best answer the research questions and help the researcher to meet his/her aims. A famous definition of qualitative research is made by Denzin and Lincoln (1994:2) who define it as

> … multi-methods in focus, involving an interpretive, naturalistic approach to subject matter. This means that qualitative researchers study things in their natural setting, attempting to make sense of or interpret phenomenon in terms of the meanings people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials case study, personal experience, introspective, life story interview, observational, historical, interactional, and visual texts-that describe routine and problematic moments and meaning in individuals' lives.

According to Denzin and Lincoln (1994) this interpretive approach studies a phenomenon in natural setting. The intention of this study is to understand the impact of an intervention in the natural setting of a classroom. Creswell (1998:15) defines qualitative study as

> …an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting.

A phenomenon that a qualitative researcher seeks to investigate, therefore, according to Creswell (1998) must be a social problem investigated in a natural setting. Because of the emphasis on natural setting or use of non-interfering approaches, qualitative research

is understood as a naturalistic inquiry (McMillan and Schumacher, 1994). The main purpose of this study is to interpret the meanings which students bring to, and construct in, an access classroom. According to Denzin and Lincoln (1994) understanding the social phenomena, such as meaning making, has to be perceived as a pertinent action that a qualitative researcher can engage in. Berg (1995:7) explains a qualitative approach with the following

> …qualitative research properly seeks answers to questions by examining various social settings and the individuals who inhabit these settings. Qualitative researchers, then, are most interested in how humans arrange themselves and their setting and how inhabitants of these settings make sense of their surroundings through symbols, rituals, social structures, social roles and so forth.

Not only does a qualitative researcher study a phenomenon in its natural setting but also studies the individuals who inhabit the setting. One important assumption that a qualitative researcher makes is that meaning is embedded in people's experiences and influenced by the social setting. The qualitative researcher takes it therefore, from the onset, that experience and social a setting cannot be divorced from each other. In simple terms qualitative research must be seen to have capacity to reveal how all the parts in social setting work together to form a whole (Merriam, 1995; 1998).

From these three definitions the main characteristics of a qualitative study, which makes the paradigm ideal for answering the research questions, can be drawn. Merriam (1995) suggests the following characteristics:

- qualitative researchers are more interested on the *process* rather than on the products. Understanding a phenomenon in its natural setting will make more sense when the observer had studied the whole behaviour from when it starts up to its end than if observed at different stages. That is, qualitative researchers want to know what has happened and what is happening and what factors influence such behaviour at all stages.

- qualitative researchers want to understand *meaning* with a clear understanding that this meaning is embedded in people's experiences and mediated through the researcher's own perceptions. Since the researcher is interpreting every stage of the

research, he/she is in a position to draw different meanings suggested at every stage. He/she is also in a position to draw a coherent meaning of the process.

- qualitative researcher is the *primary instrument* for data collection and analysis. Thus, the qualitative researcher is called upon to become a participant and the observer at the same time. However the participant – observer has a wide spectrum and the exact role is determined by the questions that are answered.

- Qualitative research usually involves *fieldwork*. The qualitative researcher must physically go to the people, setting site, institution ("the field") in order to observe behaviour in its natural setting. The understanding is that no data collection tool can give a holistic picture of the field and thus a qualitative researcher needs to be there to feel it for himself.

It thus makes sense to conclude that a qualitative study has the potential to cater for a study whose research questions are stated above. Because this study traces development of the language of science and the anticipated impact on learning, it is pertinent to look at the process at its totality something that is a characteristic of a qualitative study. The fact that a qualitative study places the researcher as a primary instrument fits well with the intention of this study in that the researcher is the lecturer at the polytechnic.

5.2.2 Generic Qualitative Study

Qualitative research, as indicated earlier, is multi-methods in nature (Merriam, 1998). That is, there are traditional research designs characteristic of qualitative research. The five traditions of qualitative research designs are basic or generic, ethnography, phenomenology, grounded theory and case study (Merriam, 1998). These traditions are briefly compared below in table 5.1, adapted from Merriam (1998:12).

Type	Characteristic
Basic or Generic	▪ Includes description, interpretation, and understanding ▪ Identifies recurrent patterns in the form of themes or categories ▪ May delineate a process
Ethnography	▪ Focuses on society and culture ▪ Uncovers and describes beliefs, values, and attitudes that structure behaviour of a group
Phenomenology	▪ Is concerned with essence or basic structure of a phenomenon ▪ Uses data that are the participant's and the investigator's firsthand experience of the phenomenon
Grounded Theory	▪ Is designed to inductively build a substantive theory regarding some aspect of practice ▪ Is "grounded" in the real world
Case study	▪ Is intensive, holistic description and analysis of a single unit or bounded system ▪ Can be combined with any of the above types

Table 5.1: Qualitative research methods

Because of the aims and the research questions pursued, this study was conceptualised as a generic method of qualitative research. Commending on the nature of generic qualitative studies Merriam (1998:11) noted

> …the researchers who conduct these studies, which are probably the most common form of qualitative research in education, simply seek to discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved.

In order to realise the stated research questions and aims, the researcher must seek to understand a process of learning to talk the language of science. Further, the process must not be isolated from the natural learning setting in Lerotholi Polytechnic (LP)'s access programme. In its effort to encourage the talk of the language of science the study also aims at challenging the culture of silence of students in Lesotho, and in particular at LP. The operational definition of what is cultural is given by D'Andrade (1992:230) as

> To say something is cultural is – at a minimum – to say that it is shared by a significant number of members of a social group; shared in the sense of being behaviourally enacted, physically possessed, or internally thought.

In chapter 1 it was argued that due to factors such as teachers' authority, students in Lesotho tend to sit back and watch as the teacher demonstrates how things are done and why they are like that. In other words most of the teaching/learning in the Lesotho's

secondary education level is teacher centred. As a matter of principle then students are used to sitting quietly and listening to the teacher during the whole lesson.

In order to achieve these, the study will be identifying patterns and themes at different stages of the intervention. Inevitably, descriptions and interpretations will be made. Thus, considerations such as this make this study a generic qualitative study.

5.3 Qualitative Data Collection Methods

The definitions of qualitative research above imply that individuals' phrases, words and actions are critical to the qualitative researcher. Thus a qualitative researcher wants to capture language and behaviour of the participants. When a qualitative researcher is out in the field he/she can follow a variety of different strategies to collect data. Being in the field involves, as Creswell (1998:60) explains,

> …gathering information through observations, interviews, and materials helpful in developing a portrait and establishing 'cultural rules' of the culture-sharing group.

A researcher, in the field therefore, wants to systematically participate and observe, interview people, or collect documents and other artefacts that may help him/her to answer the research questions that are being pursued. Qualitative researchers therefore can use any, or combination, of the following methods to collect data.

Participant Observation: Participant observation refers to becoming part of the situation that is being observed (Leedy, 1997) and systematically observing the phenomenon as it unfolds. There are several issues to note when participant observation is used as a data collection method. Firstly, as Merriam (1998) notes, participant observation becomes an ideal data collection method when

- the research purpose is clearly defined and formulated
- it is planned deliberately
- recording is done systematically
- it adheres to validity and reliability issues

Secondly, participant observation as a data collection method has a spectrum of possible stances in the form of the relationship between the observer and the observed (Leedy, 1997; Babbie & Mouton, 2001; McMillan and Schumacher, 1994). Table 5.1 adapted from McMillan and Schumacher (1994), summarises the roles that the researcher can adopt.

Role	Description
Observer	Researcher is physically and psychologically hidden from the group
Participant	Researcher ▪ is a member of the group studied ▪ avoids disrupting the natural activity of the group
Observer - participant	Researcher ▪ creates role for purpose of study ▪ participation is secondary ▪ observer activities are known to the group
Participant - observer	Researcher ▪ has a formal position in organization ▪ observer activities are subordinate to the role as participant

Table 5.2: Participant Observer possible roles

Lastly, the researcher will, or must, commit to extensive time in the field observing participants within their natural setting.

Interviews: The other strategy that a researcher can follow while in the field is to have systematic talks and discussions with participants in the form of interviews. McMillan and Schumacher (1994) describe interviews as

> …open-response questions to obtain data of *participant meaning* – how individuals conceive of their world and how they explain or "make sense" of the important events in their lives.

Interviews are often used to serve as the primary sources of data. According to Merriam (1998:91)

> In qualitative research, interviewing is often the major source of the qualitative data needed for understanding the phenomenon under study. Interview can range in structure from those in which questions and the order in which they are asked are predetermined to totally unstructured interviews in which nothing is set ahead of time.

Thus, as a primary data source, the researcher has to decide on what kind of data is crucial for the study. According to Berg (1995), interviews can be

- structured: the researcher uses a structured schedule of interview questions
- unstructured: the researcher does not follow any structured schedule of questions
- semi-standardised: the researcher probes beyond the answers to their prepared and standardised questions.

An interviewer therefore, guided by his/her aims and in realisation of the difficulty to observe feelings, intentions and thoughts, decides on the interview structure that is most appropriate.

Document collection: The qualitative researcher can also decide to collect documents which may inform him/her in answering the stated research questions of the study. Merriam (1998) uses the term documents in a broad sense to include written, visual and physical material. Documents include public records, personal documents, physical material and researcher – generated documents.

The data collection methods employed in this study are participant observation and researcher – generated documents. In section 5.9 a description of what exactly happened and the reasons why those methods were employed is given.

5.4 Validity and Reliability

Although constructs of validity and reliability are often associated with a quantitative paradigm Merriam (1995:165) holds the following opinion

> …regardless of the type of research, validity and reliability are concerns that can be approached through careful attention to a study's conceptualization and the way in which the data were collected, analyzed, and interpreted.

The two constructs, in a way, respond to the question of why a recipient of a study should believe a researcher reporting his/her findings. Answering these broad questions, of validity and reliability, gives the reader some element of quality assurance. It is therefore of utmost importance that pertinent questions, raised by the two constructs, are answered even in a qualitative study. Merriam (1998:201) recommends that

> …qualitative researchers need to respond to the concerns of outsiders, many of whom may be unfamiliar with or blatantly challenging of the credibility of qualitative research.

It is for this reason that these constructs are briefly discussed below. Perhaps it is also important to observe that the two constructs are inextricably linked.

Reliability refers to the extent to which independent researchers could discover the same phenomena and to which there is an agreement on the description of the phenomena between the researcher and participants. Defining reliability this way should not hide the view that to a qualitative researcher experience and perception are presumed to be personal and thus may not be replicable. This observation to some degree complicates this notion of reliability. However, viewed from the view of qualitative research, reliability addresses questions of dependability or consistency of the researcher's interactive style, data collection and analysis (McMillan and Schumacher, 1994; Leedy 1993; Merriam, 1995; 1998).

To address the questions of dependability, consistency and repeatability McMillan and Schumacher (1994) suggest measures that a qualitative researcher can undertake. These measures include:

- *Research role*: The research role refers to the social relationship of the researcher and the participants. The identity and the status of the researcher have to be clear to participants. Until June 2003 the researcher was a Physics lecturer at the institution's access programme. This means in 2002 students knew the researcher as their Physics lecturer. In 2003 the researcher moved to the access programme of the National University of Lesotho (Pre Entry Science programme (PESP)) as a Physics lecturer. The researcher joined the Lesotho Polytechnic's 2003 programme for the last 5 weeks and the actual data collection was done during the second and third weeks of his stay. When the course started students were made that the first 5 weeks would be taken by one lecturer and the last 5 weeks by another.

- *Social context*: Social contexts are described physically, socially, interpersonally, and

functionally. McMillan and Schumacher (1994) argue that all these contexts must be described because they assist in data analysis and thus help in determining the consistency of the study. These issues were taken into account when writing journal and field notes.

- *Data collection strategies*: This calls for a precise description of data collection techniques. The researcher must explain varieties of observational (and interviewing) methods, and how data was recorded and under what circumstances. The strategies used in this study are explained in section 5.3 and 5.9. Section 5.3 addresses the theoretical aspect and section 5.9 addresses what exactly happened.

- *Data analysis strategies*: The researcher must provide retrospective accounts of how data were synthesised and identify the *general* strategies of data analysis and interpretations. In chapter 4 the analytical tool is discussed. In addition analysis strategies are described in full in the result chapters that follow.

When questions of reliability are answered, a qualitative researcher has two more validity questions to answer; one deals with truth value (internal validity) and the other deals with transferability (external validity). *Internal Validity* refers to the degree in which the research findings must match with reality (McMillan and Schumacher, 1994; Merriam, 1998). Matching the findings and reality can be made challenging by the fact that the notion of reality itself is complex. Merriam (1998) uses Lincoln and Guba (1985)'s definition of reality as "a multiple set of mental constructions … made by humans; their constructions are on their minds, and they are, in the main, accessible to the humans who make them". The complexity, of reality, is introduced by the individualistic undertone. Not only that matching findings and reality have implications on data collection strategies but also requires careful analysis methods. The qualitative researcher must think of whether the observation claims actually represent the observed phenomena as he/she analyses his/her data. Representation of observed phenomenon introduces a challenge. Merriam (1998) suggests that to address internal validity of a study the following strategies are helpful:

- *Triangulation*: Triangulation refers to using multiple and different data sources, data collection methods, investigators and multiple methods to confirm the findings.
- *Member checks*: Member check refers to taking the data back to people where it was collected. This is done with the purpose of asking the sample to confirm the results.
- *Long – term observation*: This refers to being in the field over a long period of time to gather data.
- *Peer examination*: This refers to asking a colleague to comment on the findings that the researcher purports.
- *Participatory or collaborative modes of research*: This refers to involving the participants at all levels of the study.
- *Researcher's biases*: This involves clarifying assumptions, views and theoretical constructs that the researcher employs.

It is important to note that in one study it may not really be necessary to address all these strategies (Glesne, 1999; McMillan and Schumacher, 1994). Hence in this study triangulation, long – term observation and researcher's biases were particularly addressed.

External Validity refers to the extent to which the findings can be applied to another study (Merriam, 1998). This refers to the generalisability of the findings of a study. The notion of generalisability of a study centres on whether it is possible to generalise from a qualitative inquiry. However, McMillan and Schumacher (1994) point out that the aim of a qualitative researcher is not necessarily generalisation but rather the extension of understanding. According to McMillan and Schumacher (1994) the extension of understanding includes a critical look at the notion of comparability and translatability. *Comparability* refers to the degree to which the research is adequately described so that researchers may use the study to extend the findings to other studies. *Translatability* refers to the degree to which the researcher uses theoretical frameworks and research strategies that are understood by other researchers. Effort is made to tell the story in such a manner that it is possible for other researchers to try the design in their own respective environments. The theoretical framework informing this study is discussed in chapter 3 and the analytical tool is discussed in chapter 4.

5.5 Limitations

Any research process in which human beings are investigated is bound to have limitations. Firstly, the researcher as a human being brings, with him biases and assumptions. Merriam (1998: 20) noting that in a qualitative research the researcher is the primary instrument, argues

> …the investigator as human instrument is limited by being human – that is, mistakes are made, opportunities are missed, personal biases interfere. Human instruments are as fallible as any other research instrument.

This implies that the researcher must be aware of the biases that may interfere, especially during data collection and analysis. One way of addressing these biases is to state them upfront. In section 5.8 a subjective statement is made as a way of stating the biases. Secondly, students have been told about the process and consequently may also bring such biases and their own assumptions.

Another limitation is the fact that qualitative studies lack properties of a generalisable study. As stated earlier, the researcher role is one factor that sometimes impacts negatively on the generalisability of a qualitative study. McMillan and Schumacher (1994) argue

> The preferred research role is that of a person who is unknown at the site or to the participants, in other words, an "outsider". A researcher who is a participant or already has status within the social group being observed limits reliability.

Therefore even though the study is expected to substantially contribute to the body of knowledge, it may not be used to claim generalisability.

5.6 Context of the Study

This study was conducted in Maseru, Lesotho, at Lerotholi Polytechnic (LP) and data collection spanned two years. Traditionally the topic dealt with in the intervention, interaction of magnetic field patterns, is taught towards the end of the programme. In both years of data collection, 2002 and 2003, the topic was taught in September. The researcher was a Physics lecturer in the polytechnic's access programme, Technician Induction Programme (TIP), up to 2002. In 2003 the researcher was on unpaid leave,

which gave him the status of a visiting lecturer. As briefly described in chapter 2, the TIP was an access programme which LP had embarked on since the phasing out of LESPEC in 1993 and was broadly charged with the responsibility of preparing students admitted into first year of diploma programmes.

At the time of this study LP, through Schools of Technology and Built & Environment, was offering diploma programmes in only four engineering fields; Construction Studies (which was later named Construction Engineering & Architecture), Civil Engineering, Mechanical Engineering and Electrical & Electronic Engineering. The practice was that twenty students would be admitted into the first year of each course every year. Thus ideally in any academic year there would be a maximum of 80 first year diploma students in the polytechnic. However, because of high competition between institutions of higher learning, due to low pass rate at secondary level, the numbers of students would always be less than 80. These students had to attend a 10 week access programme that is discussed in chapter 3. The material taught during these 10 weeks covered most of the Physics content that should have been done in the last two years of secondary school education.

The LP is divided into three schools: the school of Commerce & Applied studies, the school of Technology and the school of Built & Environment. The three schools offered certification at certificate and diploma levels. The schools of Technology and Built & Environment are predominantly populated by males while on the other hand the school of Commerce & Applied studies is predominantly populated by females. The reason for this is historical and cultural. There was a notion that in the schools of Technology and Built & Environment studies are coupled with physical activity not recommendable for females. It is because of this that in both years there were more males than females in the programme.

5.7 The Intervention

The intervention, designed by the researcher and aimed at introducing the concept of interaction of magnetic field patterns in electromagnetism, was designed to address basic

tenet outlines in the theoretical framework discussed in chapter 2, thus enculturating students into the scientific community. The topic was allocated two weeks and each week had nine hours contact time. Appendix 9 shows the weekly timetable. The activities are shown in Appendix 1 and 2 for the years 2002 and 2003 respectively. Though the 2002 data is discussed in section 5.11 it is important to note here that there were minor differences in 2002 and 2003 activities.

The intervention had four stages

- Conceptual Foundation: The primary aim in this first stage, Conceptual Foundation, was to encourage students to talk about their prior knowledge. Such talk would influence students to share initial situation definitions and to serve as an ice breaking activity. In 2002 there were two activities, Activity 1 and 2. Students had to recall words, and their scientific meanings, that they met in studying electromagnetism. Then they discussed and noted these meanings. During their discussions they were asked to note newly recalled concept words on the board for every body to know which words were being discussed. Having done that, they were asked to draw concept maps showing the relationships between those concept words. In 2003 one activity, activity 1, was done at this stage. Students were given a concept map to study and improve if they find a need to do so. As they were studying the concept map they were asked to write on the board other concept words they find missing.

- Conceptual Initiation: The Conceptual Initiation stage was the second stage of the intervention in which students were encouraged to understand how to talk about the phenomena. Two sources were important in introducing the phenomenon. Firstly, students had to draw diagrams of magnetic field patterns displayed with the assistance of iron filings. Then, the teacher moved from one group to another, studying their diagrams and demonstrating how to talk about the magnetic field patterns and the interaction between the fields lines. Secondly, students used their textbook to pick out information and to associate the talk with scientific concepts. Activities 3 and 2 in appendix 1 and 2 respectively show these activities.

- Conceptual Formulation: Conceptual Formulation was the third stage in which students were encouraged to start using the talk, and/or Discourses, learnt in the Conceptual Initiation stage. Students were given a story to analyse and either to agree or disagree with the proposed phenomenon. The story was of an electric bell model that was based on application of electromagnetism. Activities 4 and 3 in appendices 1 and 2 respectively show this activity.

- Conceptual Application: Conceptual Application is the last stage of the intervention (see activity 5 and 4 of appendix 1 and 2 respectively). The stage gives students opportunity to study an application of interaction of magnetic fields. Students either had to study operation of a speaker or of an ammeter and prepare a written and oral report.

Table 5.3 below summarises the main activities and the intended meanings students had to construct in 2003.

Date	Hour	Topic	Meaning making activity	What to do	Report
9/9/03	1 & 2	Concept Mapping	Students ➢ discussed concept maps, and ➢ drew improved concept maps	i) Discuss given concept maps ii) Agree on relationships iii) Draw improved concept maps	Submitted an improved concept map
	3 & 4	Magnetic field	Students ➢ Drew magnetic field around bar magnets ➢ Studied magnetic field interactions around bar magnets ➢ Read & summarised text on magnetic field around a current carrying conductor	i) draw magnetic field lines around ➢ a bar magnet ➢ two bar magnets ii) extract important points from textbook on magnet field around a current carrying conductor	➢ Submitted diagrams of magnetic fields ➢ Oral summary of text
10/09/03	5	Magnetic field interaction	Students ➢ Studied magnetic field interaction between magnetic fields due to bar magnets and current carrying conductor	i) study diagram ii) fill missing words	➢ Oral presentation
11/09/03	6	Magnetic field interaction	Students ➢ Studied electric bell model ➢ Formed opinion on whether to agree with designer or not	i) study proposed design of electric bell ii) agree or disagree with designer	➢ Submitted improved design
12/09/03	7	Electric Bell Model	Students ➢ reported their views and were asked questions ➢ given a speaker or ammeter to study	i) report views about design ii) start analysing appliance	➢ submitted written report
16/09/03	8 & 9	Induction	Students ➢ Studied a given passage ➢ Filled missing words in a paragraph	i) read the given passage ii) Fill missing words	➢ Oral presentation
17/09/03	13	Operation of speaker/ammeter	Students ➢ Reported how they operate ➢ Asked questions and debated		

Table 5.3: The 2003 intervention

In designing this intervention some assumptions were made

- The majority of students have met the concepts of magnetic field lines in their

secondary education, and

- Some students have not had a chance to do basic experimental activities such as drawing magnetic field lines around bar magnets at secondary school level.

Perhaps it is important to note what is crucial about this intervention. Two basic fundamentals about its design are addressed:

- It gradually shifts learning responsibility to students: In the background section in chapter 1 a note is made that students in this access programme come from a chalk and talk tradition in which they were hardly active.
- It addresses issues of LoLT: It has also been noted that students in this access programme were facing challenges of learning in a second language. The activities reduce this load by providing environment in which language barrier was less of a problem between students and the teacher.

5.8 Who Are You To Think? My Subjective Statement

This section acknowledges the fact that any researcher brings with him/her some biases and assumptions to a study he/she undertakes (Merriam, 1998). It is advisable therefore, as a meaningful way to address these biases, for the researcher to state such biases and his/her background (Merriam, 1998).

I first became interested in physics education during my higher secondary education level (COSC). I still remember the incident when a fellow student was asked a question by our physics teacher and in his reply he used the phrase 'I think...'. The teacher, angrily, responded 'Who are you to think?...' The impression I got in particular was that science is like a "bundle" of facts lying somewhere and our responsibility, as students, was to access it. Thus, there is no need for "thinking". I also remember that I was confident that I knew the answer that my teacher was looking for and I wanted to become a teacher to help students access this "bundle". Inevitably, when I completed higher secondary education I wanted to go to university, or teacher training institution, to train as a physics or science teacher. In 1986 I enrolled at National University of Lesotho (NUL) for BSc Ed. with special interest in becoming a physics teacher graduate. I majored in Physics, Mathematics and Education. After a brief spell at LTC (see below) I joined the

University of the Witwatersrand (WITS) in 1993 where I enrolled for BSc (Hons) followed by MSc two years later. These experiences made me realise that physics education is nothing like the impression I had from secondary education. After completion of these studies I went back to LP to teach. I subscribed passionately to constructivism and this passion lead to two conference presentations; Qhobela and Stanton (1998a & 1998b). Even then I felt that something is not working well. This changed my perception of a student from an individual to a group in a classroom. I was aware of a paper written by Solomon (1994) entitled "*the rise and fall of constructivism"*.

My experience as a teacher has mainly been working with access programmes. After my initial degree in 1990 I joined the Lesotho Telecommunications Corporation (LTC)'s Training school, which was offering an access programme to young Basotho who wanted to become technicians at LTC. The school offered training to young Basotho in Mathematics, Science, English and Communications, and basic Telecommunications. The programme ran for 6 weeks and at the end of it students would be offered employment based on their performance. In 1992 I joined LESPEC as a physics demonstrator and once again worked with access students hoping to join tertiary institution at the end of the programme. In 1996 when I went back to Lesotho, from WITS, I joined LESPEC's daughter programme TIP.

My experience with these access programmes was that majority of students leaving secondary education in Lesotho are not ready to study at higher levels. Looking back at my secondary education and recalling that we were not allowed to think in our physics classroom also influenced me to believe that much is lacking in our students as they leave secondary level education. Even though I taught at secondary education level for one year as a part time physics teacher, it remains my opinion that teaching at this level is mainly chalk – and – board type and that, as a result, learning is affected negatively (Qhobela, 1996). It is also my opinion that because of this, students are used to keeping quiet in classrooms and accepting whatever the teacher tells them. When I conducted this study I believed that I need to reduce the distance between me and students coming from

this background. I noticed that they may not be used to the style and therefore might not be free.

5.9 The 2003 Data Collection Strategies

The process of data collection for the actual study was done in September 2003 and lasted for two weeks, as reflected in Table 5.3 above. In order to meet the basic requirements of triangulation, and for purposes of increasing richness of data, multiple sources of data collection strategies were used. In section 5.3 above, data collection methods applicable in a generic qualitative study are discussed. It is shown that two of the three methods, participant observation and documents collection methods were used in this study. Confidence was built through pilot study that, through the use of these two approaches, enough data to answer the research questions, would be collected.

5.9.1 Participant Observation

The participant observation method of collecting data was chosen for the following reasons. Firstly, since I was the physics lecturer at the institution's access programme, the participant observation method becomes a convenient way of collecting data. As the Vygotskian concept of ZPD suggested, I had to accept and to be seen performing my duty of an adult leading the learning process. Thus two duties were simultaneously done, that is, participating in the teaching/learning process and observing a phenomenon. In particular the participant-observer role was found to be suitable since my status was known to the students.

Two ways of collecting data by participant observation method, Journal notes, and Video and Audio tapes were used.

- *Journal Notes*. Journal notes refer to the notes that I produced every evening following each lecture. They were produced for all the lectures in 2003. They reflect all things I could remember happened in the lecture. Journal notes were important because they reflect, specifically, observations made by the researcher. In a way they reflect opinions of the researcher. They reflect successes and disappointments of the day I could remember. The reason why this approach was adopted was that the

researcher was able to reflect on the proceedings of the day and could make appropriate decisions where necessary. The motivating factor was that social research can be planned to a certain degree, but room has to be left for the unforeseen. In addition the researcher did not have to sit down during the lecture and be seen to have abandoned his responsibility as the teacher, to take notes. There were drawbacks though. Most of the details of the lecture are missed by the time notes were written. The method allowed for the researcher to move around, but every time he approached a group, the students in that group kept quiet, waiting for him to leave. This was so especially at the beginning of the intervention. The sample of journal notes is appended as appendix 3.

- *Video Tapes and Audio Tapes*. Merriam (1998) suggested that amongst the many ways of observing a phenomenon, a researcher can watch films or video tapes. Video tapes have the potential of capturing rich data. It is for this reason that video taping, supplemented by audio taping, was chosen as one of the data collection methods for this study. Video tapes were recorded although experience from 2002 was that talk is sometimes missed. They provided a critical data related to activity. One factor could be the noticed problem of students who lower their voices when the lecturer approaches. In 2003 all lectures were captured. Other than low voices, only one problem was experienced. The assistant, by mistake, deleted some information from an earlier lecture. Initially video tapes were preferred as one of the critical data collection method for two reasons. Firstly, it was hoped that it was going to capture more talk without much interference. Secondly, it was hoped that it would capture more actions.

  Audio tapes were introduced in 2003 and were optional in the sense that students were asked to voluntarily record their proceedings. All tapes recorded in 2003 were reasonably audible and were therefore transcribed. Audio tapes, as a supplementary method, were used in order to open more chances of capturing talk. The sample of audio transcript is appended as appendix 4.

5.9.2 Researcher – Generated Documents

Some data collected in this study falls under the category that Merriam (1998) calls Researcher-Generated documents. Merriam (1998) defines Researcher-Generated documents as

> …documents prepared by the researcher or for the researcher by participants after the study has begun.

In this study the documents were prepared for the researcher. Data prepared for the researcher were Students' reports and the field notes prepared by a colleague during the lecture.

- *Students' reports*. Activities discussed above required students to produce reports. In both years all students produced these reports. Table 5.3 above also reflects the stage at which these reports were produced. These were to be handed in as group reports, not individual reports. However, there were cases where individuals handed in their reports, which were identical to group report.

  Students' reports were chosen as one of the data collection methods for various reasons. Namely,

  - To capture more "talk": Though other data collection strategies were used students' reports were viewed to have the potential of supplementing what might be missing in the other data collection methods. Most importantly these reports increase the students' "talk'.
  - Triangulation reasons: The students' reports added value to the reliability and validity of the study.

This kind of data was certainly going to help in answering research questions. A sample of students' reports is appended as Appendix 5.

- *Field Notes*. Field notes refer to the notes prepared by a colleague who was invited to take notes of everything they could observe. The decision to have field notes as a data collection strategy was taken after realisation that students do not talk when the researcher approached them and that they also lower their voices when the video

camera was brought closer to them. Because of short notice, the note taker had no proper training.

The colleague who could help was the English lecturer at the institution. Other lecturers could not help because

- of competence reasons; they felt that they could not produce meaningful notes even if it was in Sesotho
- of time table reasons; they had lectures/laboratory sessions at the same time as Physics.

Having the English lecturer as an observer had its own problems

- Students did not feel free to talk, especially because she taught them English
- She had her own biases. For example she did not like the idea of letting students use any language they find comfortable to use. She would have preferred the use of English only.
- In 2003 she was joined by another colleague who was doing her Masters degree at UOFS. Their arrangements sometimes led to confusion of who had come and when.

The sample of field notes is appended as Appendix 6.

5.10 Ethical Issues

The policy of the University of the Witwatersrand is that questions of ethics for a study dealing with human beings be addressed. Ethical issues were identified to be implied at two stages, during data collection and data analysis. The methods of data collection were mainly observational. Merriam (1998: 215) argues

> Observations conducted without the awareness of those being observed raise ethical issues of privacy and informed consent.

The same comment is made by Soltis (1990:254) that

> …in intervention one tries to bring about a good and document it. This brings up the ticklish ethical issue of treating people as means to out ends rather than as autonomous human beings who should be free to choose their own ends.

This ethical issue makes a researcher, who is also a participant, to face a dichotomy. To address this, students were asked to fill in a consent form indicating voluntary participation (see appendix 7). It was made clear to them that they could withdraw any time they felt the need to do so. It was also made clear that in the event that there are students who are not willing to participate in the study special, arrangements would be made for them to be taught separately.

5.11 The Pilot Study

The piloting of the intervention of the study discussed above took place in 2002. It is worth noting that initially the plan was to conduct an action research study but because of the uncertainty surrounding the continuity of the Lerotholi Polytechnic's access programme, TIP, in 2003 and beyond 2002 data, was finally treated as the pilot study data. This decision, to consider the 2002 data as a pilot study, was based on the fact that any study, regardless of whether qualitative or quantitative, battles with addressing the constructs of reliability and validity of an instrument (Cohen *et al.,* 2000; Merriam, 1998). The following considerations were thought to be critical about these constructs:

- How suitable are the intervention's activities as Discourse generating mechanisms?
- How suitable are the data collection methods?
- Are the research questions answerable given the type of data collectable using the activities?
- Are the envisaged analysis methods implementable given the collected data?

It is on the basis of these considerations that some activities were changed and data collection methods improved.

5.11.1 Data collection methods; the problems and solutions

Data collection methods used in 2002 were similar to the ones described above, with the exception of audio tapes. Consideration of problems of the data collection methods employed in 2002 and their solutions contributes significantly to consideration of dependability and consistency of the study in general. That consideration reflected numerous problems experienced during data collection. Outstanding problems were;

- *The audibility of video tapes*: Much of data captured through video tapes was hardly audible. Since the purpose of the study was to offer opportunity of, and therefore to analyse, practising of Discourses of science engaged in by access students, inaudibility of video tapes was considered a major shortcoming that necessitated consideration of other data collection and analysis strategies. Audibility seems to have been affected by the level of noise in the classrooms and lowering of voices as the recorder approached. At the core was the need to capture students' talk at group level.

- *The irregular attendance of research assistant*: An arrangement was made in time with a laboratory technician from one of the institution's departments to assist as a research assistant. The research assistant's main responsibility was video taping of students' activities. However, at the time of data collection the assistant did not attend regularly. As a result, temporary arrangements had to be made with different colleagues depending on their availability.

- *Lack of details in field notes*: During the first lesson it became obvious that students were lowering their voices when the researcher, and of course their teacher, approached. It became difficult therefore to follow group discussions. The direct implication was that journal notes would capture little students' talk. Since the video tape recorder had the same problem, the data was not captured at all. This necessitated an observer whose responsibility would be the taking of field notes. A colleague, Lecturer in English and Study Skills, was therefore asked to offer this help. While she did a much appreciated job, most of the notes were not clear in some incidences. Clarity was measured in terms of explanations, and inclusion of talk, at certain incidences of interest. This was associated with her lack of preparation and, therefore, of understanding of the exact purpose of the field notes in this study.

The 2002 experiences above made it imperative that in 2003 some corrective measures are implemented. These measures were:

- *Introduction of audio recording*: Since students in 2002 did not feel free to talk in the presence of their teacher it was decided that audio recording be introduced. As a way of addressing what can be fear of speaking in the presence of the teacher, audio taping was made voluntary. That is, students were asked to voluntarily tape record their discussions. This strategy became successful in the sense that there were groups in all the lessons although they sometimes had to be reminded.

- *A research assistant was engaged and given prior training*. Because of the 2002 experience it became clear that it was necessary to have an outsider as a research assistant. Thus, somebody was engaged as a full time research assistant for three weeks. As part of the training, the assistant was asked to video tape a session in which students were asked to sign a consent form. The video tape was then discussed.

- *Preparation of a colleague to take field notes*: As a way of preparation for taking field notes that better answers questions coming from the 2002 data a colleague, who would be taking these notes, was allowed to listen to the comments that were made during the PhD weekend regarding her 2002 field notes. An explanation of what was required in terms of what to note and include in the notes was also emphasised.

Table 5.4 below summarises, and compares, the data collected in both 2002 and 2003.

Data	2002	2003
1. Journal Notes	Yes	Yes
2. Field Notes	Some lectures	Yes
3. Student reports	Yes	Yes
4. Video tapes	Some lectures	Yes
5. Audio tapes	No	Yes

Table 5.4: The 2002 and 2003 data

The important message in the table is the fact that more data, in particular talk, was collected in 2003. The most likely explanation is obviously the measures put in place in 2003 as a result of the experiences of 2002.

5.11.2 The Intervention

The critical and necessary consideration was to establish unforeseen problems in the designing of the intervention. This was done at piloting stage. Each of the four stages of the intervention were analysed with the aim of

- ascertaining that the activities of each stage really generate talking and have a potential of generating data that can inform the act of answering the research questions, and
- forming general impressions of the lessons that maybe learned from this type of data.

The following were initial observations concerning each stage and which informed the implementation of the intervention in 2003.

- Conceptual Foundation Stage: As implied above, two areas of observation were pertinent to this stage. These areas are
  - *The suitability of Conceptual Foundation Activities*: Two activities, Activities 1 and 2 (see appendix 1), were designed to generate talk in this stage. Two observations influenced the decision regarding what to be done in 2003. Firstly, concept maps could be categorised into three broad categories depending on the clarity of meaning of concept pairs. This had implications on concept mapping as an activity. Secondly, students tended to use the concepts "magnetic flux" instead of "magnetic field". On the basis of this, one activity was designed for 2003 with the aim of maintaining the idea of generating talk between students but also addressing the two issues. Thus the two activities were combined in one activity (see appendix 2) where students were asked to discuss and suggest alteration of a concept map that was considered to have unclear concept pairs and used the concept word "magnetic flux".

  - *Students' conceptual understandings*. Data collected through activities 1 and 2 were found to have a potential of informing response to the research questions. The response to the research questions encompasses two issues. Firstly, it encompasses defining situation definitions that students had prior to teaching and whether they were able to share these definitions. Secondly, it encompasses defining Discourses which students engaged and the process of sharing these

Discourses. The extract below highlight the potential in the data that was collected from these activities

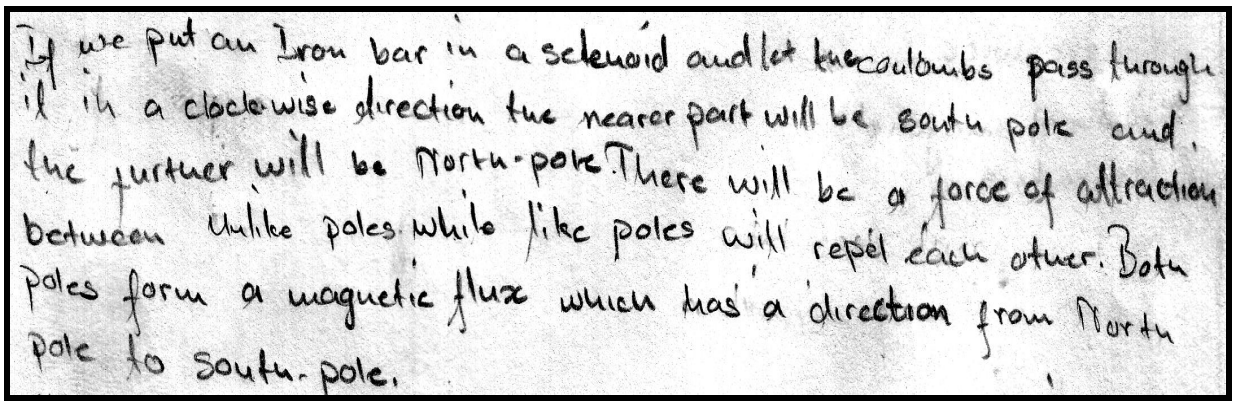


Diagram 5.1: Students' use of concept words

In this extract the students had discussed a list of concept words in activity 1 (see appendix 1) and were summarising their conclusions. Reflected in this extract are general ideas that students have as they leave secondary education. The ideas include

i. understanding of phrases such as "unlike poles attract" and "like poles repel",
ii. formation of poles of a magnet, and
iii. magnetic flux vs magnetic field.

The extract gives an impression, on the surface, that students who wrote this extract had an understanding of these ideas. However, what was of critical importance was the nature of this understanding. They refer to application of force and neither in their explanation nor the concept map do they refer to the interaction of magnetic field lines. The observation was therefore that talk at this stage is rather vague and lacks scientific meaning. Another observation was that the situation definitions of concepts at this stage reflect everyday understanding of scientific concepts. However, and crucially, the data collected in this stage shows that it is possible to answer the set research question.

- Conceptual Initiation Stage: The Conceptual Initiation stage is assumed to be the first stage in which Discourses of science are introduced. Minor observations were made

about Conceptual Initiation at the time.

- *The suitability of Conceptual Initiation Activities*: Two activities, Activities 3 and 4 (see appendix 1) were planned for this stage. In both cases no major concerns were identified and therefore no indication of need to alter them was observed.

- *Understanding the phenomenon*: The key question about the process was whether it does what is claimed to do. That is, does the process introduce students to ways of talking about scientific phenomena and thus generating some understanding of the concepts? At the time of this review it was clear that, if collection of data could be improved, there would be enough evidence to show that the process is taking place. Consideration of the following extract highlights this process.

  > Most of them were drawing patterns in the books…I was asking them to repeat the experiment and showed them the difference between their drawings and what they had to draw. After a number of trials they would understand the difference. The language I was emphasising included sentences like "Here lines <u>are joining</u>" and "Here lines are <u>not joining</u> but <u>compressed</u> together". (2002 Journal notes)

  The extract refers to situations when students were drawing magnetic field patterns around bar magnets and the teacher was helping them to draw and talk about the phenomenon. The types of diagrams which students finally drew are indicated in Diagram 5.2 below.

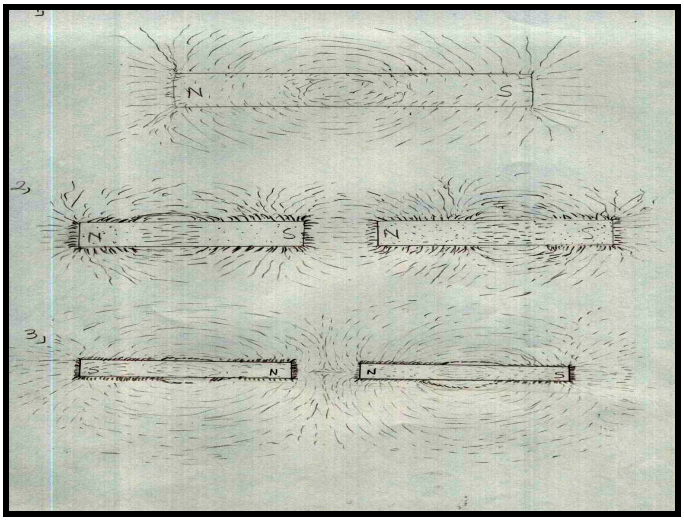


Diagram 5.2: Students magnetic field diagrams

The drawings in Diagram 5.2 were drawn by two students and submitted as a report of their work. The critical point about the diagrams and the extract above is an indication that a process is taking place in which students are encouraged to talk about a scientific concept. It must be emphasised that students start with diagrams such as Diagram 1.1 (see page 6). There is therefore convincing indication that, through Activities 3 and 4, the purpose at this stage can be achieved and that data from this stage was going to be helpful in answering the research questions.

- Conceptual Formulation Stage: The main activity in Conceptual Formulation was giving students opportunity to start ventriloquating Discourses that are learnt in Conceptual Initiation. That is, the aim of the stage was to have an activity which allowed students to, among other things, talk about a phenomenon. The following were initial observations about the stage.
  - *The suitability of Conceptual Formulation activity*: Activity 5 (Appendix 1) was planned for this stage. No major problems were observed about the potential of the activity as a talk generating tool. Therefore no alterations were thought to be necessary.

  - *The process of ventriloquation*: Data collected during activity 5 gave the impression that students were beginning to use ways of talking about the scientific phenomenon. Diagram 5.3 shows the diagram one pair submitted. In this diagram students were analysing magnetic field patterns between the bar magnets and the current carrying conductor.

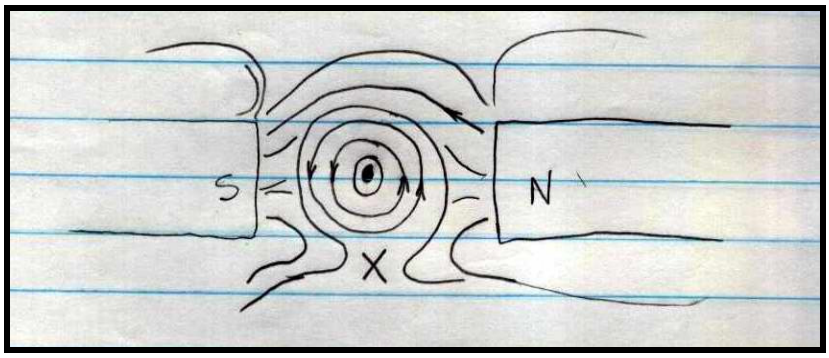


Diagram 5.3: Students' Electric bell Analysis

The following extract, from students' reports, highlights the nature of talk at this stage.

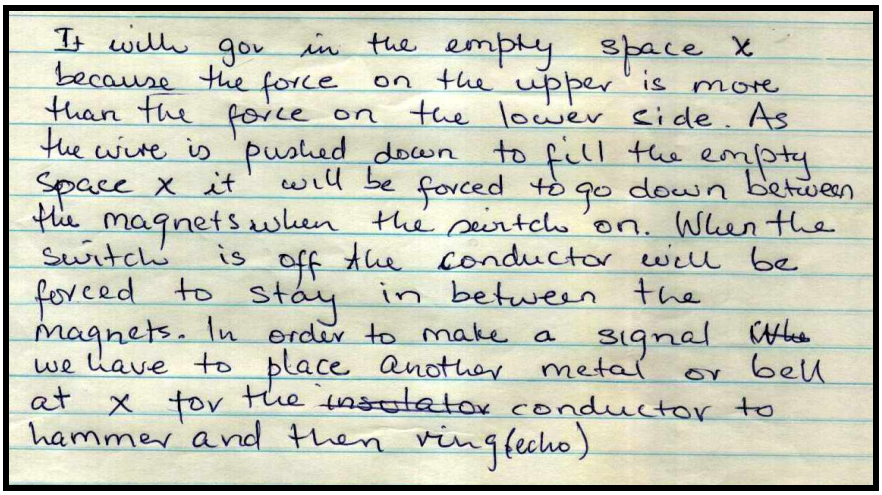

It will go in the empty space X because the force on the upper is more than the force on the lower side. As the wire is pushed down to fill the empty space X it will be forced to go down between the magnets when the switch on. When the switch is off the conductor will be forced to stay in between the magnets. In order to make a signal ~~the~~ we have to place another metal or bell at X for the ~~insulator~~ conductor to hammer and then ring(echo)

Diagram 5.4: Students' description of Diagram 5.3

The extract above explains the motion of the conductor in Diagram 5.3. There is little indication that students agree with the designers of the bell model but they have considered issues such as

i. the force on the upper is more than the force on the lower side, and

ii. In order to make a signal we have to place another metal or bell at x

The extract and the diagram reflect clear cases of a student ventriloquating ways of talking about a phenomenon that is just learned. Diagram 5.3 shows some understanding of interaction of magnetic field patterns but falls short of explaining how the "empty space x" is formed. The impression at the time

therefore was that the activity allowed students to ventriloquate Discourses of science.

- Conceptual Application Stage: The critical activity in Conceptual Application stage was to allow students to study the application of magnetic field interaction within an artifact. The following were observations made from the pilot data.
  - *The suitability of Conceptual Application Activity*: Both the oral presentations and students' reports suggested that students, to some degree, accessed meaning of concepts through activity 6. It was noted however that accessing meaning in the ammeter was affected by complexity of the instrument. However the activity was not altered. Rather, it was noted that students studying this artifact will need extra support and should be encouraged to study both artifacts.

    .
  - *Studying the artifacts*: Data collected during activity 6 also proved to have the potential of informing the process of answering the research questions. Diagram 5.5 below analyses an ammeter.

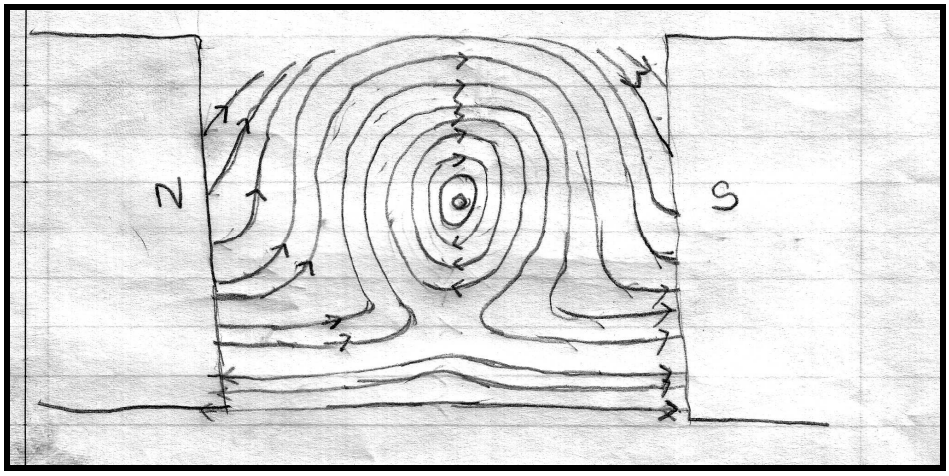


Diagram 5.5: Students' analysis of ammeter

The extract in Diagram 5.6 reflects the talk accompanying Diagram 5.5.

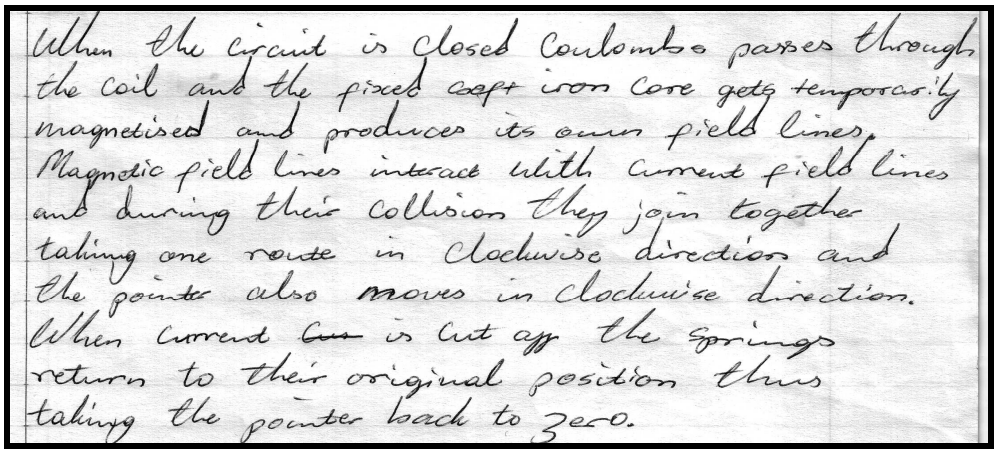


Diagram 5.6: Students' description of Diagram 5.5

The extract above discusses Diagram 5.5. The following observations can be drawn from this extract.

i) students considered interaction of magnetic field patterns. However, both conceptual problems, indicated by "magnetic field lines interact with current field lines" and language problems, indicated by "…thus taking the pointer back to zero", can be observed.

ii) the extract shows engagement of Discourses of science and thus a clear potential of data collected during activity 6.

From this analysis it was concluded that there was need to improve methods of the collection of data and that except in the Conceptual Foundation stage, activities have a potential of doing what is intended of them and therefore it is not necessary to alter them.

5.11.3 Analysis Methods

The problems associated with data collection methods discussed above became informative to evaluation of the feasibility of the intended analysis method. The two particularly critical problems were the inaudibility of video tapes and lack of detail in both journal and field notes. The initial plan was to analyse the collected data through studying meanings implied in a talk and then apply Toulmin's framework to understand the process of arguing engaged by students. The idea was that understanding meaning of talk at any stage would reflect the nature of talk with emphasis on reflecting whether such

talk is scientific or everyday. The hope was that talk would be noticed to improve from mainly everyday to scientific. However, talk, critical as it was, was limited for any meaningful analysis. The work of Gee (1999) was revisited. The 2002 data analysis made it clear that in the absence (and/or presence) of talk, activity was also important. The SAMPS system of Discourse analysis, discussed in chapter 4, was therefore influenced by this consideration. The inaudibility of talk therefore shaped the understanding that talk must be accompanied by understanding "other stuff" Discourses (Gee, 1999). This leads to the conclusion that analysis of data should be done in a manner that two aspects, activity and semiotic, are foregrounded. The results of activity aspects are reported in chapter 6 and those of semiotic aspects are reported in chapters 7, 8, and 9.

CHAPTER 6

ACTIVITIES: THE EMERGENT CATEGORIES

Any theory of learning must answer at least four central questions: (1) Who are the subjects of learning, how are they defined and located?; (2) Why do they learn, what makes them make the effort?; (3) What do they learn, what are the contents and outcomes of learning?; (4) How do they learn, what are the key actions or processes of learning? (Engenstrom, 2001)

6.1 Introduction

This Chapter presents the first results of the SAMPS (Semiotic, Activity, Material, Power, Sociocultural) system of Discourse analysis discussed in Chapter 4. The SAMPS system introduces a procedure to be followed when analysing qualitative data. As argued in Chapter 4, it is advisable to foreground other aspects of discourse analysis while backgrounding others. Accordingly, in this chapter the activity aspect is foregrounded. The foregrounding of activity in this chapter is influenced by Gee's (1999) definition of Discourses in particular the contention that "other stuff" Discourses are as important as talk. Most of "other stuff" Discourses are generally active in nature. The argument that Wells (1995; 237) makes underlines this importance:

> The making of meaning is always part of a larger activity, and it is the purpose of this activity that provides the motivation for the meaning-making and the framework of relevance within which the meanings made can be evaluated for their validity and utility…

Understanding the constructed meaning is dependent on understanding the activity and context under which the meaning is constructed (Gallego and Finkelstein, 2005). The critical consideration, about this analysis therefore, is that it brings to the fore and explains the process of learning that occurred. Thus, the activity aspect becomes critical in a study of Discourses. The activity aspect of this SAMPS system responds to the following core questions about any given piece of data, extract or episode:

- On what is time being spent in this extract or episode?
- What sub-activities compose the main activity in this extract or episode?
- What actions compose these sub-activities in this extract or episode?

The core question that is asked and responded to in this chapter about any of the four stages is: What kind(s) of Discourse enabling activity is practised in this stage? When responding to this question, emergent categories, i.e. categories emerging as a result of data analysis, are identified in the four stages of the intervention. The chapter therefore aims at explaining emergent categories of activities that enabled learning of scientific Discourses throughout the intervention. It has to be noted that some emergent categories can also be viewed as pre-determined categories. After describing data analysed in this chapter and showing how these data are analysed, the chapter discusses

- Emergent categories of the Conceptual Foundation stage and the concept of Conceptual Foundation,
- Emergent categories of the Conceptual Initiation stage and the concept of Conceptual initiation,
- Emergent categories of the Conceptual Formulation stage and the concept of Conceptual Formulation, and
- Emergent categories of the Conceptual Application stage and the concept of Conceptual Application.

6.2 Description of data analysed in this chapter

Data collection methods adopted in this study have been described in Chapter 5. In this Chapter data from the following sources will be used.

- *Field Notes*. Field notes, produced by the researcher's English Lecturer colleague at LP, were used as the main data reflecting activity at any stage of the intervention. Skimming through these Field Notes it is clear that their producer intended to describe activity more than other aspects of the SAMPS system.

- *Journal Notes*. The Journal Notes were another source of data used to identify activity. They were produced by the researcher every evening following each lesson. These notes are therefore the researcher's recollection of the proceedings of the day. These recollections too were mostly dominated by activity more than other aspects of the SAMPS system.

- *Video Transcript*. The video transcripts in this chapter are other sources of data that was used. Though most of the videos are inaudible, video transcripts provided rich support for the Field Notes and Journal Notes in the sense of reflecting deeper characteristics of the activity aspect.

6.3 Data Analysis

The following procedure was followed to analyse documented data. Two core sets of data were available as described above. These were field notes and journal notes. The analyses of these two sets of data were initially parallel and the results were later synchronised. The parallel analysis strategy followed steps recommended by McMillan and Schumacher (1994). According to McMillan and Schumacher (1994) analysing qualitative data is primarily inductive and involves organising data into categories and identifying patterns among the categories. Diagram 6.1 below adapted from McMillan and Schumacher (1994) summarises how data from the two sources was grouped.

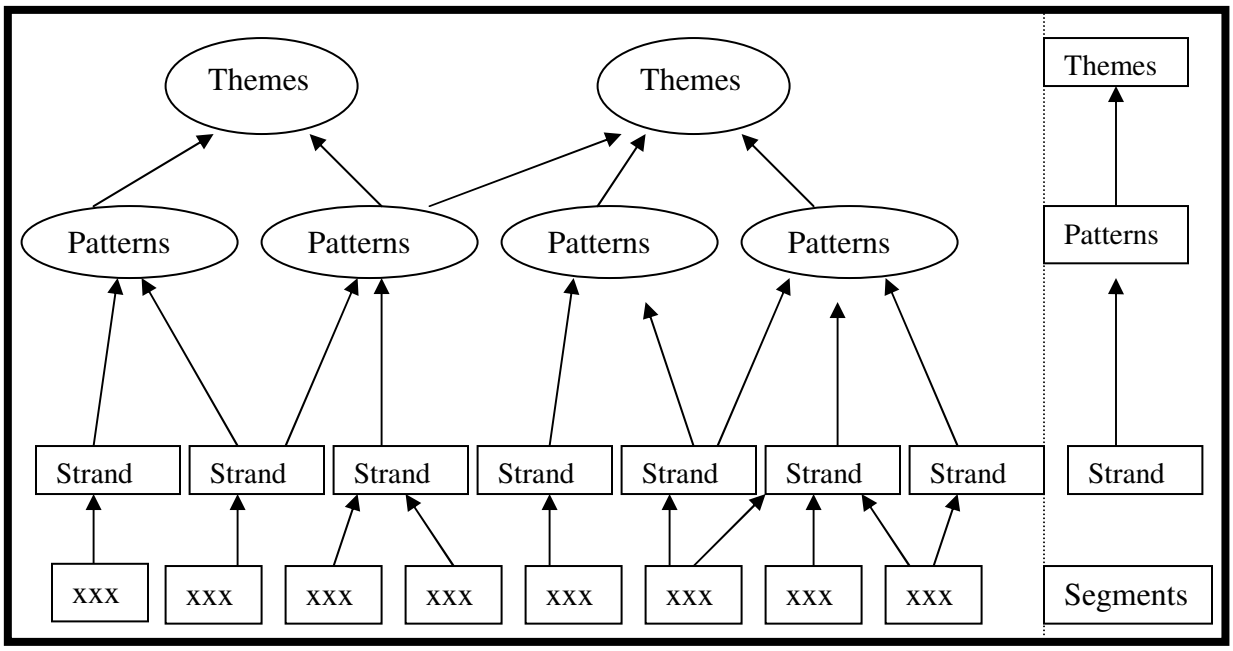


Diagram 6.1: Analysing qualitative data

McMillan and Schumacher (1994)'s strategy was applied in the following order

- Organising data into segments: Both sets of notes were read and divided into segments depending on the meaning in the sentence(s). A segment could be a

sentence or a number of sentences responding to the core questions stated above. The meaning of a segment describes how activity actors are engaging in a situation.

- Organising segments into strands: The segments with the same meaning were grouped together to form strands.
- Grouping strands into patterns: The strands with the same meaning were grouped together to form patterns.
- Themes: The patterns with the same message were grouped together to form themes.

Perhaps it is important to note that

- Segments, or any other part of the diagram, could be related to more than one strand, or more than one stage above it.
- In the chapter strands appear as extracts, patterns as sub-categories and themes as emergent categories.

As noted above, Field notes and Journal notes were supplemented by video transcripts. The following steps were followed.

- *Taking notes from the video tapes*: Data from video tapes were divided into 2 categories. There were portions of tapes where talk was inaudible. For these parts, clear action notes in the form of explanation of activities were made. The other portion was where talk was clear. Here transcription and translations were done.

- *Transcribing and Translating*: The audible data from video tapes were transcribed. Since some parts were in Sesotho, they had to be translated from Sesotho to English. In order to address validity issues, the translations were checked by a colleague at the National University of Lesotho and by an English and Study Skills lecturer at Lerotholi Polytechnic.

6.4 Pre-empting the results

The analysis above resulted in the activities summarised in Diagram 6.2 below

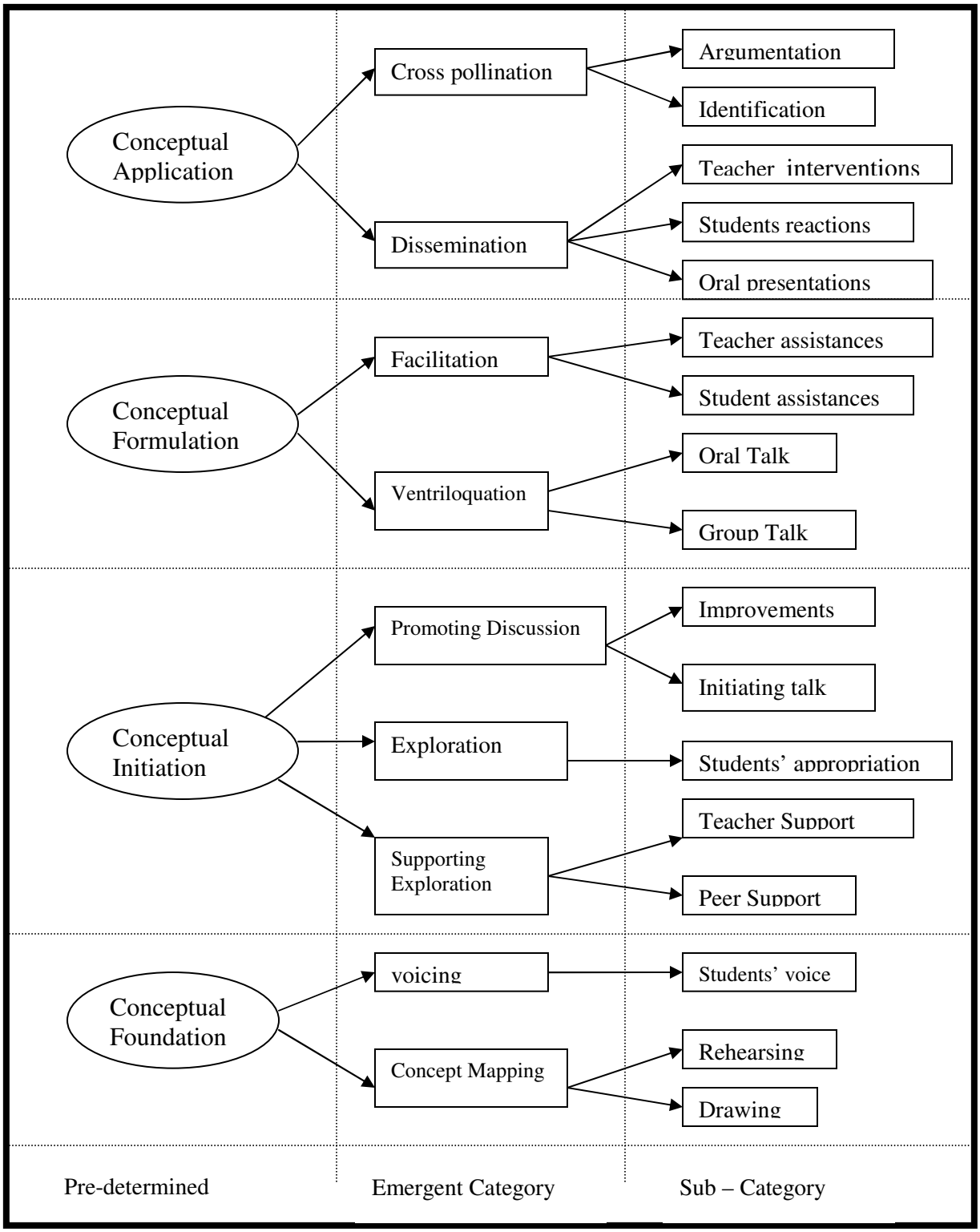


Diagram 6.2: Categories of activities

Diagram 6.2 presents the stages of the intervention with the emergent and sub-categories of each stage. Emergent categories represent themes observed about any one stage. For example, two emergent categories that are identified for the Conceptual Foundation stage are Voicing and Concept mapping. The concept mapping category is sub-divided into two sub-categories; rehearsing and drawing. The students' voice category however had no sub-categories. Detailed discussion follows.

6.5 The Conceptual Foundations Stage

Conceptual Foundation is the first of the four stages of the intervention discussed in Chapter 5. The focal characteristic defining the stage is encouragement and promotion of talk, both at group and classroom levels. Promotion of talk at an early stage of the intervention is viewed as being critical to this study for diverse reasons:

- Breaking the ice: Because most of the students in this programme come from different learning backgrounds which mostly consist of sitting back and watching the teacher as s/he "does science". They were not therefore familiar with talking in the classrooms. It is also possible that due to other factors, such as lack of proficiency in the language of learning and teaching, they are not ready to talk. The activities encouraged them to get started.
- Introduction of the new culture: In addition to breaking the ice students had to find talking in class as a convenient and fruitful mode of learning. The activities were therefore influencing students to accept talking as a way of learning.
- Sharing meaning: Students needed to share meaning of prior concepts and in particular their situation definitions of magnetic field.

Activities identified in the Conceptual Foundation stage are classified into two emergent categories, *Concept mapping* and *Voicing*.

6.5.1 Concept Mapping

The first emergent category of the Conceptual Foundation is named *concept mapping*. The main characteristic of this emergent category is the negotiation of meaning of concepts that students had prior to a formal teaching in the access programme and rehearsing of talking at interpsychological plane. Negotiation of meaning of concepts

incorporates redesigning and drawing of different, or altered, concept maps. The emergent category, concept mapping, is further divided into two sub-categories, **rehearsing** and **drawing**.

The second sub-category, **rehearsing**, comprises activities in which students were discussing, at group level. This was a suggested idea. Rehearsing, as can be deduced, refers to activities whose purpose was to give students opportunity to talk to each other, for the first time, about their thinking. The episode below demonstrates typical talk defining this sub-category.

Episode 6.1
[**bold = translation from Sesotho;** *italic = Talk in Sesotho;* **… = *inaudible***; Students' names = pseudonyms**]**

1. Thabiso: So, *Ha re*…let's explain this first, firstly discuss part where we do not agree and give explanation. So we don't agree that there is direct relationship between these two. (So, **let's**...let's explain this first; firstly discuss part where we do not agree and give explanation. So we don't agree that there is direct relationship between these two.)
2. Kabi: Magnet and power supply.
3. Thabiso: *Ee,* power supply and magnet. (**Yes***,* power supply and magnet.)
4. Kabi: *Ha re ka tlo e kenya moo,* power supply ee? (**What if we put it here, this** power supply?)
5. Thabiso: *Ee!* power supply. (**Yes**! power supply)
6. Kabi: *Hobane re itse* we can, by means of a power supply, *re ka magnetisa*. (**Since we said** we can, by means of a power supply, **we can magnetise**.)
7. Both A piece of, a piece of …. magnetic substance.
8. Thabiso: So! and we cannot, in this case use ac … ac generator to make…a magnet… carried out with the use of this ac generator, direct current.
9. Kabi: Ok!…*u batla pampiri moo u ngollang teng*? (Ok!… **are you looking for a paper to write on?)**

Episode 6.1 shows an activity in which Kabi and Thabiso are discussing the relationship between concept words "power supply", "ac generator", and "magnetisation". Although the semiotic aspects of episodes such as episode 6.1 are discussed in Chapter 7, this episode reflects the type of discussion that students engaged in before reaching an agreement on whether to leave a concept pair or to change it. In turn 6, for example,

Kabi gives a hint of what they think "power supply" meant and what its function can be. The situation definition of "power supply" in turn 6 is a device from which electrical energy can be drawn. This electrical energy can be used to magnetise a material. They also realise that ac generators cannot be used. Episode 6.1 therefore shows an activity in which communicators are sharing the meaning of a concept pair. Besides the fact that there are initial situation definitions reflected in this episode, the critical point is that students are talking to each other and thus getting used to communicating.

The central task in concept mapping activities was therefore, writing of concept words on small pieces of paper and re-arranging them according to how students thought they were related. As they re-arrange concept words, they discuss and share their situation definitions of the concept words. Activities in this category therefore mark an important aspect in sociocultural learning. That is, introduction of critical Discourses; *writing*, *drawing*, *discussing, agreeing and/or disagreeing* and *rearranging* of concept words. These are examples of Discourses that the study intended to emphasise as being necessary towards the learning of science concepts.

The second sub-category, **drawing**, comprises students that were engaged in arranging concept words and drawing concept maps. The following extract, extracted from the journal notes, reflects what some of the steps taken towards building a concept map were.

> Then I moved around checking what they were doing. Most groups were writing the concept words on small pieces of paper and arranging them while others were redrawing the map. (2003 Journal Notes)

This extract shows what students were doing when concept mapping; namely that some students were *writing* these concept words on small pieces of paper and *rearranging* them. Others were *redrawing* the concept maps. This activity comprised disassembling of concept pairs and drawing new arrangements that participants agreed on. It is fair to imagine that as students did this they were quiet. They should have been *discussing* and *reaching some common ground* for them to move a concept word. Hence the observation,

> I moved around checking what they were doing. Many of them were discussing their concept maps though they would lower their voices when I got closer. (2003 Journal notes)

According, to this extract talk was also a central activity. The extract however reflects another important phenomenon. That is, when the teacher approached students lowered their voices. The cause of this is not established by data in this study though a number of factors could be considered. For example

- It is possible that LoLT was inadequate, or
- It is possible that students feared to talk because of the tradition of not talking. These students came from a background of chalk and talk, or
- It is possible that students were influenced by their experience that the teachers' role is to correct their responses and not necessarily to assist learning.

6.5.2 Voicing

The second emergent category of Conceptual Foundation is named *voicing*. This category is extended to the sub – category level by considering **students' voice**. The sub–category is named student's voice to signify the beginning of listening to students, at class level, as they expressed their knowledge. The incidences show students reporting their group agreements orally.

Students were asked to present their views and, in particular, to show concept pairs that they agree with and the ones they do not agree with. Finally, they were expected to indicate the alterations that they implemented. The extract below shows the presenter indicating parts of the concept map where they agreed and/or disagreed with the designers.

> Sechaba: Yes sir! I would like to emphasize on that point. I also agree with the point that in magnetisation you will end up with a magnet but since we are using or we are dealing with electromagnetism which means we want to end up with a magnet using an electrical current and those magnets, this magnet is controlled by using current. That is, if there is current there is magnet and when there is no current there is no magnet. So when it says the power supply and then an a.c. generator that's where I don't agree because here we just want to, to, to make a magnet via electrical current, electric current and I don't think there is a

possibility that, that magnet can produce power. That we supply *inaudible* [2003 video Transcript]

This extract shows an incident in which Sechaba is orally critiquing concept pairs in the given concept map (refer to appendix 2, activity 2). After explaining their views other students ask them questions and more contributions were made.

Since they were free to express their ideas in a language they were comfortable with Mapetla reported in Sesotho. The extract below shows the report.

Mapetla: ke ne ke re, re ile ra khona ho nyalanya, ho ntsa magnete le power supply ka hore, power supply, magnete e sebelisoa ho generata alternating current. Bothata boo ke ileng ka bo fihlela feela ke ba hore hoba Thabo le Selloane bona eka re ba re, hore re tle re be le magnetic flux liunlike poles li tlameha ho attracta anthe on poles *inaudible* rona re ile ra nka magnetic flux ena eka fongoa from north pole and south pole. Ke hona moo re ileng ra e beha teng hobane ha re na le pole tse peli re ka ba le magnetic flux ho sa tsotelehe hore na lia attracta kapa ha li attracte hobane li south pole tse peli kapo re ka re lilike poles li ka khona ho etsa magnetic flux. (**I was saying, we managed to match, to separate a magnet and** power supply **because,** power supply, **magnet is used to generate** alternating current. **The problem I met though, is that** Thabo **and** Selloane **seem to be saying, so that we can have a** magnetic flux **unlike** poles **must attract yet** on poles *inaudible* **we took this** magnetic flux **as if it can be formed** from north pole and south pole. **This is where we placed it because when we have two** poles **we can have** magnetic flux **irrespective of whether they attract or not because two** south poles **or way like** poles **can manage to form** magnetic flux.)

As in Sechaba's case above, Mapetla is reporting the group views and the agreements they reached. It is difficult to draw any conclusive point on the advantages in Mapetla's act of using Sesotho over talking in English. For example, it will be shown that the situation definition relating to "magnetic flux" is also reflected in English discourse. It can only be assumed that the act made Mapetla to feel comfortable to express the group views.

In this sub-category, voicing, students are reporting their observations and corrections of concept pair they were suggesting. As a presenter reported the group conclusions, fellow students were expected to ask questions seeking clarification or even adding to what he/she was saying. The teacher also asked clarity-seeking questions. Critical, again, is

the fact that students in a science classroom are hearing their fellow student talking to them about scientific concepts. The emergent category therefore marks an important ice breaking activity for future activities.

6.5.3 The meaning of Conceptual Foundation

Discourse enabling activities identified during the Conceptual Foundation have been grouped into two emergent categories, concept mapping and voicing. Discourses that students portrayed include *writing*, *drawing*, *discussing, agreeing and/or disagreeing* and *rearranging*. Conceptual Foundation marks an important first step towards the process of enculturation (Roth, 2001; Hodson, 1999) which is viewed in this study as a pertinent constituent of membership into a community of practice (Lave and Wenger, 1991). Engagement of Discourses reflected above typically relates to the notion of identity. Identity constitutes a central issue of the enculturation process (Lave and Wenger, 1991; Nero, 2005; Roth, 2005; Wenger, 1998). The understanding of identity in this study is that it is related to self appraisal, relating to what one knows now and how community accepts and shapes it (Kozoll and Osborne, 2004). This self-assessment can only be completely achieved through a talk with members of the community (Roth, 2005; Wells, 1995). Wells (1995: 242) makes the following point.

> …the natural impulse of someone who has discovered something of interest is to share the discovery with others, both to celebrate the achievement and to receive feedback in the form of further questions and constructive criticism.

Students engaged in a talk at Conceptual Foundation that "discover", for example, how well they can communicate what they know. Arguably, "celebrating achievement" and "receiving feedback", relating to what one just discovered, contributes considerably to identity. The emergent categories and their sub-categories of Conceptual Foundation discussed above, show activities in which students shared initial situation definitions of concepts of electromagnetism. The discursive process first starts at group level between two or three students and ultimately progresses to a reporting stage, done in writing and orally. The feedback that presenters receive as they discuss and report, according to Wells (1995), contributes significantly towards identity within the class and on how one views him/herself in connection to the target community. The discussion above shows

the emergent stages of Conceptual Foundation to have dealt with (1) ice breaking, (2) introduction of new culture, and (3) sharing of initial situation definitions. In a situation where students come from classrooms that are dominated by minimal talking, these issues are pertinent insofar as they relate to identity within the classroom.

The second issue, which is also a constituent part of enculturation and thus of identity is the willingness to accept losing definitions that do not appear to merge well with those that are scientifically accepted. The issue of acceptability within a scientific community would be established by students as they talk. Gee (2005:21) claims that

> To acquire an academic social language, students must be willing to accept certain losses and see the acquisition of the academic social language as a gain.

At Conceptual Foundation, a student is helped, mostly by his/her peers, to identify potential "losses" that he/she must undergo. Perhaps it is worth noting that Gee's (2005) claim is not necessarily limited to definitions, as in discourses but to a broader issue, Discourses of science encompassed in "academic social language". The total rejection of a relationship between "magnet" and "power supply" by Thabiso and the alternative suggestion by Kabi in episode 6.1 accentuates the willingness that is needed between two communicators to accept the other's view. This willingness, a part of identity, is important in subsequent stages.

6.6 The Conceptual Initiation stages

The Conceptual Initiation stage is the second stage of the intervention. The primary purpose of this stage is to let students understand and start using the teacher's talk and information from other sources and then associate the talk and text with a scientific phenomenon. The main activities implied in starting to use these resources are talking about, and drawing diagrams of, interaction of magnetic field patterns. It is pertinent therefore to identify the major emergent activities and sub-activities that reflect implementation of these aims. The activity aspect of the SAMPS system of discourse analysis yields the following three emergent categories, *Exploration, Promoting Discussion, and Supporting exploration*.

6.6.1 Exploration

The first emergent category of Conceptual Initiation stage is named *exploration*. The incidents under this category refer to activities that students engaged to make meaning of the phenomenon. The extract below presents an activity in which students, Rethabile and Nthabeleng, were engaged in drawing magnetic field lines around bar magnets.

> Members of a group, two ladies, are looking at their patterns and admiring it. One lady, Rethabile, looks content with the diagram and is smiling. The second one, Nthabeleng, is trying to get an improved pattern. She is tapping and silently looking at the pattern. Rethabile is happy, she raises a thumb to indicate "ok". They want to draw but Nthabeleng reads instructions. Rethabile unintentionally pulls the paper on the magnet and disturbs the pattern.
> Nthabeleng: Oa bona na u se u entseng **(you see what you have done)** *inaudible*
> Rethabile: Ha re qale (**lets start**)
> Nthabeleng carefully picks up the paper and returns the iron filings to the container. She puts the paper back onto the magnet and starts sprinkling iron filings. Discussion continues as Nthabeleng sprinkles the iron filings.
> Nthabeleng stops sprinkling iron filings and leads a discussion on what the pattern looks like (*discussion inaudible*). She is pointing on the sides showing lines from the poles of a magnet. After that brief discussion they start drawing.
> Rethabile drew a diagram showing direction of magnetic field lines. Then she stopped and looked at Nthabeleng's diagram. They discussed and then took an eraser and erased her drawing and started afresh.
> Nthabeleng has divided her drawing of the magnet into two pieces and is still drawing. *(camera leaves 05:37:08)*. [2003 Video transcript]

The extract highlights what involved in *drawing* magnetic field line patterns. Firstly, it involved portraying magnetic field line patterns using iron filings, magnet and a plain paper. Inevitably, the activity involves two or more trials, due to differing factors, before obtaining what students were looking for. Secondly, after portraying magnetic field line patterns, students had to study the pattern. Thirdly, they had to draw the portrayed patterns. Rethabile and Nthabeleng are therefore engaged in an activity in which the core purpose is to form a mental picture of the interaction of magnetic field patterns. The activity however was not free of threats to the product. The following extract sheds some light on this process

> After some few minutes I started moving around to see what they were drawing. Some of them were drawing the usual diagrams students draw; that is similar to ones in the books, (rather than what they observed). (2003 Journal notes)

Two features of the "usual diagrams" are shown in the video transcript above.

- "Rethabile drew a diagram showing direction of magnetic field lines". Though after discussion Rethabile changes her diagram, which shows a positive point about group interaction, many students tended to draw these kinds of diagrams. The tendency of drawing magnetic field lines with direction shows the impact of prior learning on observation. Clearly Rethabile knows that magnetic field lines have direction.
- "Nthabeleng has divided her drawing of the magnet into two pieces …". This reflects the students' understanding of poles of magnet as two distinct parts of the magnet.

The earlier extract highlighted properties of the process of exploration. The activity shows Rethabile and Nthabeleng involved in a process of forming a mental picture of the scientific phenomenon through displaying, drawing, and talking about magnetic field patterns. This activity reflects a process of transformation of external actions into internal mental functions. In terms of Vygotskian language, exploration marks an important beginning of the process of internalisation. During this emergent category, the "other stuff" Discourses appearing in these activities are *identifying, matching, reading*, *agreeing, writing* and *drawing*. These Discourses appeared necessary at different stages of the intervention.

6.6.2 Supporting Exploration

The second emergent category of Conceptual Initiation stage is named *supporting exploration*. The sub-category above, exploration, reflects the need for concern if students could not get support. The circumstance therefore, necessitated activities in which exploration was supported. This category comprises two sub-categories, **peer support** and **teacher support**. Inevitably these sub-categories defining the emergent category, *supporting exploration*, refer to incidences when guidance is asked for and obtained by students from the teacher or fellow peers.

The first sub-category, **peer support**, reflects incidences when students are working on a specific activity and need help from fellow students. In the extract below one student seeks help from others.

> Teacher - takes clean papers and then distributes them to the groups, 1 per group. Student from one group asks another group about the arrows, and one student replies to say "there are no arrows, draw what you see" (2003 Field notes)

The extract has a similar message to the one under exploration above where:

> Rethabile drew a diagram showing direction of magnetic field lines. Then she stopped and looked at Nthabeleng's diagram. They discuss and then take an eraser and erased her drawing and starts afresh.

The intent in the first extract above is to highlight a scenario when students asked for help from one another. A number of aspects of a situation are reflected in this extract. A student approaches others about inclusion of arrows when drawing magnetic field lines. The essence of the reply is that there is no need to draw arrows. The extract highlights the social nature of a learning process in which students ascertain that what they are learning in their group is what others are also learning. The utterance "there are no arrows, draw what you see" resembles the teacher's instruction at the beginning of the class. The student uttering it must be responding to a question that needed to find out whether "arrows" must be included in the diagrams. It is important to note that the answer "there are no arrows" refers to a material thing that is not reflected in the displayed picture. Inevitably, seeing this material thing, about the nature of magnetic field lines, needed students to carefully study the portrayed picture. The second potion of the utterance refers again to a material thing "what you see". This answer is in line with what is emphasised in the first extract, namely *drawing what is seen.* While caution against generalising is important here, the extract shows the help that students gave each other to reflect what the teacher's instruction was.

Support was also sought and obtained from, or offered by, the teacher. The following extract highlights properties of the second sub-category, **teacher support**;

> The teacher arrives at a group and asks a question. He pulls a piece of paper away from one of the group member and reads. After some seconds he asks students questions and there is an exchange between them. Students are talking, to each other, and drawing. The teacher is watching. Then the teacher leaves. [2003 Video transcript]

In the extract above the teacher is offering support to students after realising the need to do so. When supporting exploration, according to the extract, the teacher (i) studies students' work and (ii) discusses their work. Students are then left to continue working.

From the Vygotskian sociocultural perspective, this role and those implied in the extract earlier, are crucial in the learning process within the Zone of Proximal Development. The category therefore refers to activities in which the students were seeking help. The support comes either from the fellow peers or from the teacher. Mortimer and Scott (2003) refer to similar activities as supporting students' internalisation.

6.6.3 Promoting Discussion

The last emergent category of Conceptual Initiation stage is referred to as *promoting discussion*. The category comprises interventions that the teacher implemented and whose primary objective was to promote talk. This category signifies the critical element of the study, helping students to begin to talk the language of science. The category is further divided into two sub-categories, initiating talk and improvements.

The first sub-category, **initiating talk**, refers to incidences when the teacher introduces ways of talking about a scientific phenomenon. That is, the interventions highlight what actually happened when the teacher introduced scientific Discourses. The extract below reflects some characteristics of the interventions.

> For example students would be shown "where lines are compressed and are in turn pushing away" and that be related to "repulsion". (2003 Journal Notes)

The first extract in section 6.5.1 above shows the teacher supporting students' exploration by visiting them and ascertaining that their diagrams conform to the expectation. When this is done then the teacher introduces ways of talking about the phenomenon. The extract above shows a teacher pointing at parts of such a diagram and giving meaning to what each part shows. Thus, the extract shows the teacher introducing ways of talking about magnetic field interaction.

The incidence portrayed by the extract is that the teacher makes connections between the observation "lines are compressed" and the concept "repulsion". The use of the phrase "where lines are compressed and are in turn pushing away" was intended to cover two inseparable scientific meanings and of course a scientific way of talking. Firstly, it demonstrates application of force due to interaction of magnetic fields. Secondly, it demonstrates the nature of interaction of magnetic field. According to the extract therefore students must first study the resulting interaction of magnetic fields, that is, identifying the type of interaction. Then, they can talk about the resulting force.

A similar activity took place towards the end of the lesson. This time the teacher was summarising major concepts learned and used a white board. The decision to use a board was influenced by the following considerations:

- To have one session during the lesson where main concepts are summarised and thus the purpose of the activity once more highlighted, and
- To deal with a "cultural shock" if it existed. It was imagined that most of the students are used to traditional methods in which the teacher is seen before the class, "teaching".

The following extract shows how the teacher talked about a similar diagram projected on the board.

> Teacher: … I am interested here, emm in between because when we say a repulsion we mean, sorry attraction, we mean that this second magnet is pulling this or this one is pulling the other. And so what activity emm is in between here. So I am looking at, at what happens there in between, here and say what kind of interaction do I have in between there. Now, you would notice then that *the lines join each other*, in other words these *lines of our magnets join each other* ok? (2003 Audio transcript)(*emphasis added)*

In this extract the teacher discusses a magnetic field line pattern portrayed by iron filings and projected onto the screen by a projector and is pointing at key features of the pattern. The teacher deals specifically with two issues:

- the interaction of magnetic field lines: He uses the phrase "lines join each other" to refer to interactions of magnetic field lines between these different poles.
- the observed application of force: The teacher emphasises the point and/or region of the pattern which he is interested on because of the concept of application of force.

There is a difference between the teacher's talk, in the above extract, and Bohlale and Tsebo, in episode 8.1 above. The intention of the teacher in this extract was to provide students with ways of referring to what happened to magnetic field lines from each magnet. Students have concentrated on material aspects of the situation and probably thought of "what does this look like". Hence, a comparison "…something like a circle…" Similarly Bohlale, in turn 5, is considering material aspect "straight lines". The teacher on the other hand considers activity and sociocultural aspects and says "what happened, or what do we know to have happened". Thus the utterance "…the lines join each other…"

The two extracts above however outline the importance and bringing together of talk as one element of Discourses and "other stuff" Discourses. That is, when introducing talk the teacher had to introduce other Discourses.

The second sub-category, **improvement**, refers to incidences when the teacher, on realisation of need for improvement, identifies issues that students need to discuss further. The extract below highlights the teacher moving from one group to another and identifying parts of students' work that need some improvements.

> Teacher moves among students. Tells them not to go up to no 3 yet.
> Teacher - "I'd like you to say why they match".
> They all seem to be busy following instructions. (2003 Field Notes)

While controlling the pace of the lesson, the teacher helps students to appreciate areas where they need to improve their responses. The comment that the teacher makes, "I'd like you to say why they match", is aimed at encouraging students to engage in Discourses, particularly that of talking about their decision "they match". The language that the teacher uses acknowledges this consensus, "they match", and the student further makes a personal appeal, "I'd like you to say why". The appeal therefore is asking students to "say why" the consensus hold. Inevitably students would discuss their reasons, agree, and write them down in preparation for another teacher's turn. The teacher is using personal language which signifies that students had done what is

expected but he, the teacher, is not satisfied and feels that there is room for improvement. In this incidence therefore the teacher is encouraging a deeper talk between students.

The critical thing that happened in this category was the introduction of the language of science and the appreciation of Discourses that are associated with it. The category also shows the teacher encouraging talk. Lastly, the category shows students engaged in "other stuff" Discourses.

6.6.4 The meaning of Conceptual Initiation

The Discourse enabling activities constituting Conceptual Initiation have been identified as exploration, supporting exploration and promoting discussion. Examples of Discourses engaged during these emergent categories include *identifying, matching, reading, agreeing, writing,* and *drawing.* Two issues are noted about the stage.

- Supporting exploration: Conceptual Initiation included the essential component of learning viewed within a sociocultural perspective. This component has been named supporting students' exploration. Exploration, as an activity, is a critical initial step of the Vygostkian concept of internalisation. Supporting internalisation at an early stage of the learning process is an important and necessary move. In discussing this notion of supporting students' internalisation Mortimer and Scott (2003:20) write,

  > …the teaching and learning performance therefore concerns the ways in which the teacher can act to support students as they gradually develop meanings for new scientific concept, and gains expertise and confidence in using them.

  As it emerges, support in Conceptual Initiation came from both the teacher and fellow students. The discussion above reflects the teacher visiting groups and offering the necessary support to students as they work. Other support is given by fellow students. When defining ZPD Vygotsky (1978) suggests that "…more capable peers" can offer support to fellow students. The peer support sub-category above conceptualises the issue within group work situation. The support is realised in two ways. The activity between Nthabeleng and Rethabile reflects the support that they gave to one another. The extract from the field notes suggests that some students moved to the other group to seek help. The "capability", as suggested in ZPD

definition, could only be determined by students. Inevitably there are questions about why a student chooses to go to one group and not the other.

- Promoting discussion: Promoting discussion is used in this study to refer to two issues; initiating talk and encouraging in-depth talk. Writers subscribing to Vygotskian sociocultural perspective agree that science learning is a discursive process (e.g. Duran *et al.,* 1998; Palincsar, 1998; Leach and Scott, 2003; Mortimer and Scott, 2003; Mercer *et al.,* 2004). Initiating talk draws its argument from the fact that talk and Discourses in general are a situated constructs. According to Gee (2005:23),

  > One does not know what a social language means in any sense useful for action unless one can situate the meanings of the social language's words and phrases in terms of embodied experiences.

  The claim that Gee is making sets the nature of activities that must initiate talk. The notion of "situating meanings" involves relating scientific phenomenon with talk and "other stuff" Discourses. Thus it was pertinent for students to understand meaning of concepts and to relate them to scientific context and/or phenomenon. In terms of interaction of magnetic field patterns the activity was important insofar as it attempts to situate the meaning of application of force. The teacher's responsibility, to initiate talk and encourage in-depth talking is further interpreted in Hodson's (1999:245) argument,

  > …it is the teacher's role to highlight important points and direct attention to what has to be learned, emphasize key vocabulary and introduce new terminology, function as a kind of "external memory" by providing appropriate information as it is required, assist the learner in analysing tasks and devising strategies for problem-solving, and furnish evaluating feedback on student performance.

  Hodson (1999) is discussing what he calls "second phase scaffolding" in the extract. The suggestion he is making clearly defines activities, and the teacher's responsibilities, in Conceptual Initiation stage as discussed above. Viewing the Conceptual Initiation through Hodson's (1999) lens, the stage comprised the following major activities

  - Introduction of talk, and

- Emphasising talking and relating it to a phenomenon.

6.7 Conceptual Formulation

The Conceptual Formulation stage, the third stage of the intervention, had activities whose primary aim was to allow students to start using the language that they learned independently. Activities in this stage are meant to allow students to start using the language they learned with reduced support from their teacher. The analysis of activity reveals two emergent categories, namely *facilitation* and *ventriloquating*. The categories are not discussed in chronological order because there are incidences of the categories that occur at different parts of the lesson.

6.7.1 Facilitation

The first emergent category of the Conceptual Formulation stage is named *facilitation*. Incidences classified under facilitation have been so classified due to support offered by the teacher or another student to students to make the progress or improvement of what was already achieved easier. The category is further sub-divided into two sub-categories; **Teacher assistance** and **student assistance**. Table 6.1 presents data, drawn from the 2003 video records, showing at least two activities that characterise the facilitation category. The activity involved students studying the electric bell design in groups of 2 or 3 members (see appendix 2, activity 4).

Time	Activity
14:08:00	The teacher comes to group 3, comprising of two girls, and watches as they work. The two students are drawing diagrams and discussing these drawings. After about 30 seconds the teacher asked a question and one of them answered (*the actual talk is inaudible*). Then the teacher pulls a seat and sits. He is heard saying "…activity 2). Students look for activity sheets and then the teacher points at something. (*Camera moves).*
19:48:05	Teacher is with group 2 and they discuss something Teacher: "is this your X?" (*Inaudible)* Student: Yes! (*inaudible. He is explaining something).* Teacher: *Inaudible.* Teacher says something and points at the paper and then leaves. Students are left discussing something.
20:49:30	Teacher is back to group 3. Students are drawing magnetic field line patterns and the teacher sprinkles iron filings and taps to make the drawing clearer (*camera does not capture the diagram).* Students are discussing the pattern as they draw and the teacher is listening. The teacher leaves after some time. (22:21:20)
25:42:00	Teacher visits group 3. He discusses the drawings and then leaves (25:46:09)
25:56:22	A lady from one group has moved to another group. She is asking them questions and the group members are explaining something.
26:34:00	Members of group 3 are discussing their magnetic field line drawings. Puleng: mona ke *inaudible* conductara. (*inaudible and points at another's diagram)* Re arohanye ntho tsena, ke magnetic field oa conductara (**Here is … conductor … lets differentiate between these things, this is the conductor's magnetic field**) Karabo: mm (**Yes**) Puleng: (*inaudible*) a nthoena, e leng south mona. Mona ke magnetic field oa conductara (*inaudible and camera leaves*) (…**of this thing, which is a** south **here. This is a conductor's** magnetic field.)
28:21:01	The lady visiting another group is still there. They, the three students, are demonstrating with fingers (Right hand). (*They are discussing the magnetic field pattern around a current carrying conductor. Though talk is inaudible they continue to use gestures).* Then they discuss a diagram on the sheet and the lady leaves.

Table 6.1: Video Transcript

The first sub-category, **teacher assistance**, refers to interventions, put into practice by the teacher, whose purpose is to assist students. Because the teacher is moving from one group to another, he is in a position to gauge when assistance is needed. The sub-

category is marked in the table above by resulting activities when the teacher visits group 3. These occasions show the teacher realising that the two students, Puleng and Karabo, need support. When realising this need, the teacher makes every effort to get them working like other students. The extract below further demonstrates the nature of these interventions.

> Teacher - still with group 3. It seemed they didn't know what they were supposed to do. He then directed them to take the equipment, i.e. pink paper, Magnet & iron filings to do the experiment that was done the other day.
> Teacher was now with group 4 but came back to group 3 after they had sprinkled the iron filings on paper. He then asked them to draw. But he helped them tap the iron filings to make a clear diagram. (2003 Field Notes)

A variety of aspects of a situation are reflected in the extract and the table above. However, a striking feature is the fact that students were left behind and as a result an effort to bring them on board was necessary. The data pieces in the table and the extract reflect a meaning making activity in which the teacher and the two students were involved. The teacher, as he moves from one group to another, identifies a group that is totally stuck "…they didn't know what they were supposed to do." The actions of the teacher "He then directed them to take the equipment" tells the story of how he thought he could help them. He asked them to re-do the earlier activity. It is important to observe that even though the pace was controlled students could move at their own pace when working at group level. The extract below highlights what the intention of the teacher was.

> I met one group which could not draw lines of magnetic field around both the magnet and current carrying conductors. I had the impression that they were totally lost. I asked then to go back and re-do activity 2 and asked them to draw the patterns. After drawing the diagrams and discussing them they seemed to follow what we are doing. I asked them to continue with the assignment. (2003 Journal Notes)

A broad purpose of this stage is the construct of ventriloquation. The picture left by the pieces of data above shows the criticality of the earlier activity as a component of ventriloquation. Students are expected to make a judgement of the feasibility of the electric bell design working as a bell. In order to do so they had to talk about the interaction of magnetic field and being able to "…draw lines of magnetic field around both the magnet and current carrying conductors." was crucial. The two data pieces

underline that for students to start "mimicking" the language of science the mental picture of the phenomena, ways of talking about the phenomena, and "other stuff" Discourses associated with talking are taken to be crucial. Thus, the activity in which the teacher makes sure that all students in the class are following, as reflected above, forms an important component of the definition of this category.

The second sub-category, **student assistance**, refers to incidences when students sought help from fellow students and/or from the teacher. That is, incidences in which assistance is sought by, and given to, the student by either the teacher or a fellow student. In the table above, the sub-category is characterised by incidences when a student visits another group (times = 25:56:22, and 28:21:01) and when the teacher is discussing with members of group 2 (time = 19:48:05). The sub-category comprises two groupings of incidences therefore. The first group is of incidents when students sought help from other students in the form of asking questions. Accordingly, such incidents comprise discussions between a student seeking help and those that are approached.

The second group is of incidents when students asked their teacher questions. The extract below characterises the discussions between the teacher and the students in group 2.

> Teacher moves to another group. Students are asking questions. He also asks the questions.... "why aren't they meeting (?) at point X?
> Students in this group respond, discussion continues with teacher asking and students looking at the diagram and responding. (2003 Field Notes)

A broad picture painted by the extract is that students asked their teacher a question and, in response, the teacher is asking them questions aimed at helping them to consider certain characteristics of a phenomenon. Part of this discussion is shown in the table above (time = 19:48:05). These pieces of data reflect different aspects of a situation. Actors, the teacher and students, in the situation are engaged in some kind of exchange of ideas. According to the extract students asked the teacher a question and in response the teacher asks a question "why aren't they meeting (?) at point X?". This question, and the one in the table above "is this your X", helps us to understand what the actors were discussing. The question refers to a material thing that can be expected to meet at some

point “X”. It is evident that they were talking about magnetic field lines. The point “X” is introduced in activity 3 (see appendix 2) as a neutral point in the pattern where there are no magnetic field lines. It is obvious from the phrases therefore that the actors are looking at a diagram, showing interaction of magnetic field lines. The activity they are involved in was to discuss a suggested design of electric bell. In the assignment sheet, appendix 2, there are no magnetic field lines drawn. This suggests that students had drawn these magnetic field lines. It can be concluded therefore that “other stuff” Discourses, particularly drawing, are reflected in these phrases. The diagrams, that students drew, are used to generate talk at interpersonal level.

It is pertinent to consider the purpose of the teachers’ utterances without necessarily doing semiotic aspect of analysis. The teacher is asking questions that require students to give some kind of an explanation. In other words the teacher is encouraging students to discuss something and agree on an explanation. The data pieces therefore highlight a characteristic of the facilitation category, namely that the teacher encourages talk between students and achievement of some level of intersubjectivity.

6.7.2 Ventriloquating

The second emergent category of Conceptual Formulation stage is called *ventriloquating*. Incidences classified in this category were so classified due to specific characteristic reflected in their talk. Students are beginning to use Discourses of science, learned in the Conceptual Initiation stage, on their own. This use of Discourses of science puts particular emphasis on talk as an important element of learning, which most students in Lesotho missed at secondary education level. The central assumption in the Conceptual Formulation stage is that although students begin to use these Discourses, they do not deeply understand what it means. They only use them because they are encouraged to so. The product of the process will be realised later. This emergent category, ventriloquating, primarily comprises of two sub-categories of interventions, **group talk,** and **oral talk**.

The first sub-category, **group talk**, refers to incidents in which students were discussing ideas that they raised as they tries to understand the story at group level. The extract below, extracted from Table 6.1 above, reveals some important characteristics of these interventions. In this episode Puleng is suggesting that the group should distinguish between magnetic field patterns.

1. Members of group 3 are discussing their magnetic field line drawings.
2. Puleng: *mona ke … conductara*. (inaudible and points at another's diagram) *Re arohanye ntho tsena, ke* magnetic field *oa conductara* (**here is** … **conductor … we should differentiate these things, this is the** magnetic field **of the conductor).**
3. Karabo: *mm* (**yes)**
4. Puleng: *… a nthoena, e leng* south *mona*. *Mona ke* magnetic field *a conductara* (inaudible and camera leaves) (…**of this thing, that is** south **here. Here is the** magnetic field **of the conductor)** [2003 video transcript]

The extract above illustrates a social activity in which actors were discussing their ideas after they got assistance from the teacher. The extract highlights an activity in which the two students are discussing the electric bell design and are considering magnetic field around the current carrying conductor and presumably around the bar magnets. The teacher had asked them to re-do an earlier activity in which magnetic field patterns were portrayed using iron filings. In this extract Puleng and Karabo had just finished portraying, discussing, and drawing those magnetic field patterns and were beginning to analyse the electric bell model (see appendix 2, activity 4). Perhaps it is necessary to underline what is ventriloquating about this extract. Puleng and Karabo had just been assisted by the teacher and are beginning to talk without assistance about their diagram. A holistic view of this talk and the activity potrayed in Table 6.1 is important. The assistance that they received followed a realisation, by the teacher, that they were lost. Their reference to magnetic field patterns suggests that they had a diagram since in the activity sheet magnetic field patterns are not drawn. The undertone in the extract is that of mimicking what the teacher had just been saying. In this way Puleng and Karabo do not necessarily understand what they are saying but simply mimicking and/or rehearsing the teacher's talk.

The field notes are also helpful in highlighting further characteristics of oral talk. They suggest that this talk was supported by the use of a textbook. The extract below illustrates how students made use of meaning making tools, diagrams and books.

> group 3 - she kept on drawing in order to illustrate something to her group member. Unlike other groups, group 3 was discussing something (magnetic drawings) from the physics text books. (2003 Field Notes)

Even though no actual talk is captured in this extract from the field notes, illustration using own drawings signifies a semiotic aspect which actors engaged in establishing meaning. According to this extract, actors supported their discussion of magnetic field patterns with the use of a text book. It is not clear from this extract which diagrams in the text book were being discussed. Members of group 3 are Puleng and Karabo and had just been assisted. Though the timing of the two extracts could not be established accurately, a critical point for consideration in the extract is the fact that students are beginning to use talk and "other stuff" Discourses to discuss text.

An important characteristic of mimicking is highlighted by the use of a text book by Puleng and Karabo. The act reflects a feature where knowledge, being constructed, is assumed to be external by actors. Thus, there was need to refer to an "authoritative" figure. However, the fact that they talk makes some element of that generated knowledge their own. This reflects therefore an important view of knowledge at this stage. Namely, that knowledge is half their own and half external. It is also important to note the general picture brought to the fore by these extracts. The extracts reflect talk accompanied by uncertainty in what the actor wants to say. That is, talk just as mimicking what actors think must be said.

The second sub-category of ventriloquating category, **oral talk**, refers to incidences where students were presenting their opinions about functioning of the suggested electric bell model to the whole class. Two issues had to be made clear by presenters. Firstly, they had to state whether they agreed or disagreed with the designer of the electric bell model. Secondly, they were expected to support their conclusion by showing interaction of magnetic field lines due to bar magnets and current carrying conductor. Tau presented

their conclusion. Before the presentation he drew a diagram on the board and then discussed it. The diagram looked like this.

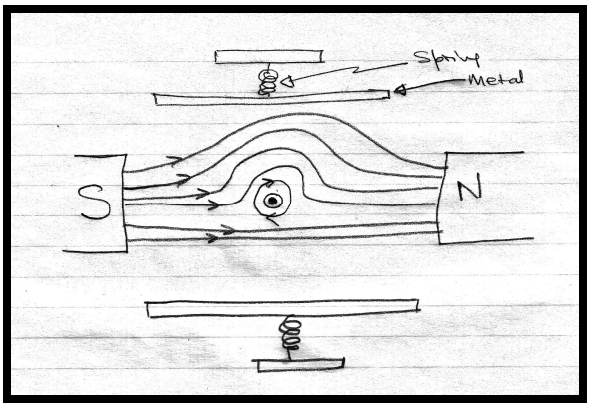


Diagram 6.3: Tau's analysis of electric bell model

[2003 Journal notes]

In the extract below, Tau is explaining Diagram 6.3 and thus presenting their conclusion.

> Tau: *Ehh Rona re ile ra etsa tjenana. Ka lebaka la* motion *oa* conductor *ona mona o keke oa tla mahlakoreng a limagnet mona ele hore* sound *ebe teng, re ile ra decida ho beha limetal* plates *mahlakoreng a limagnete mona ele hore motione oa conductora ona, conductora ena nako eo e movang e tle e tsebe ho thetsa* metal plate *ena e etse* sound*. Lispring tsena re ile ra etsa hore nakong eo nthoena e otlang mona, ka ha e tlabe e mova directioneng e ele ngoe, e tle e comprese ebe e khutlisetsa conductora ena ka saeteng lena, ena le eona e tla compresa ebe ea vibrata e etsa* sound*. Joale, ntho eo re ileng ra e hlokomela ke hore ka ha mohlomong* force *e bang conductareng mona e ka ba nyenyane hore e tle e fihle mona ka* force *e tla etsa hore lispring tsena li contracte, re ile ra decida hore mohlomong re tla sebelisa* spring *se* sensitive *haholo ho* force *ebe re eketsa* strength *sa limagnete le* power supply *ea rona hore lifield tsena li tle li be* strong*. Ka mantsoe a mang, e le hore li tle liproduse* force *e kholo e tle khone ho vibrata. Ke eona feela ntho eo re ileng ra e nahana.* (**Ehh we did the following. Because** motion **of this** conductor **here will not be sideways towards the magnets here so that** sound **can be produced, we decided to place the metal** plates **at the sides of the magnets so that the motion of this conductor, when the conductor moves it can be in contact with the** metal plates **and make** sound**. These springs we made them such that at the time when this thing hits, because it will be moving in one direction, it should compress and return this conductor to this side, this one also will compress and vibrate and make** sound**. Now, what we noticed was that the** force **on the conductor may be too small to allow it to get here with a** force **that can make these springs to contract, we decided that may be we can use a** spring **that is very** sensitive **to** force **and then increase the** strength **of the magnets and our** power supply **so that the** field**s are** strong**. In other words, so that they produce a bigger** force **that will vibrate. This is the only thing we considered)** [2003 video transcript]

The extract above shows an oral presentation of students who disagreed. It is perhaps important to note that the category of students disagreeing with the design was in the majority.

What is ventriloquation in this talk? The operational definition of ventriloquation above suggests talk without understanding. According to Tau's diagram and presentation the current carrying conductor will move downwards and will hit the metal plate. Then it will be pushed upwards, go through the magnetic field, and hit the upper metal plate. In this presentation he has disregarded interaction of magnetic field patterns when the conductor moves upwards. This is a case of a talk where understanding of the concept is minimal. The presenter merely claims the motion of the conductor but does not justify why the claim is correct. The diagram that he drew also does not justify why interaction of magnetic field patterns support the claim. The core of the presentation is about the alteration and feasibility of alteration achieving the desired goal. The talk and the diagram can only be viewed as mimicking or as the first step towards the use of, interaction of magnetic field patterns. It is worth noting that after this presentation other students concurred "…for they nodded their heads." This is shown in the extract below.

> Volunteer 1 now started describing his drawing on the board, he used gestures as he presented, student 1 disagreed in low voice.
> Volunteer 1 finished the description and it seemed most of students agreed, for they nodded their heads. (2003 Field Notes).

The extract however does not show exactly what students were agreeing on when earlier it was noted that "…student 1 disagreed in a low voice." Given that students did occasionally ask questions, it can be imagined that even though they agreed in principle with this particular presenter, there were other explanations they could give. The sub-category, oral talk, therefore shows conclusions that students made at group level about the activity when studying the electric bell model.

6.6.3 The meaning of Conceptual Formulation

The above discussion shows that Discourse enabling activities in Conceptual Formulation have been grouped into two emergent categories; facilitation, and ventriloquation. The main idea in the Conceptual Formulation, as reflected in the discussion above, is the use

of the language of science with minimal assistance from the teacher. At the centre of the activity is what Duran *et al.* (1998) called ventriloquation. According to them ventriloquation refers to when students are

> …consciously mimicking teacher talk for the purpose of learning to use biology terms appropriately.

Rephrased generally, ventriloquation refers to conscious mimicking of introduced Discourses of applicable in a community. This is the first step of independent use of the language of science by a student. The Conceptual Formulation discussion above shows the following observations about the way in which students talked:

- some students were mimicking the teacher's talk,
- some students initially insisted on using diagrams from the text book rather than drawing their own diagrams and discussing them,
- drawings which some students made lacked evidence of deeper understanding of the concept of interaction of magnetic field, and
- talk in which some students engaged does not refer to the supporting concept, interaction of magnetic field patterns.

All these observations show omissions of different types. These omissions, according to Duran *et al.* (1998), signify characteristics of a novice beginning to use a learned language. It is fair to conclude that there is more to these omissions. Firstly, these observations reflect different degrees of ventriloquating, depending on how far an individual is in terms of getting used to using the Discourses. Secondly, these different degrees of ventriloquation imply gradual Discourse acquisition. These are characteristic associated with learning a language which makes it prudent for a teacher to arrange a variety of opportunities for learners to practise using the language. Roth (2005:62) has noted that

> …to be familiar with a language, one has to have many opportunities to speak it with other native speakers.

Ideally native speakers of science language are scientists. But, and most importantly, the Discourses of learning science are practised in classrooms and school laboratories. Speakers of a language ought to be teachers, as experts, and students, as novices. Teachers are therefore directly responsible to offering the opportunities that Roth (2005)

refers to above. The emergent categories of activities offered students these opportunities in Conceptual Formulation.

6.8 Conceptual Application

The Conceptual Application stage, the last stage of the intervention, is characterised by activities directed towards understanding how a concept is applied and thus how an artifact functions. The Conceptual Application stage comprises two emergent categories. These emergent categories have been named *cross-pollination* and *dissemination*.

6.8.1 Cross Pollination

The first emergent category of Conceptual Application stage is named *cross pollination*. The term "cross pollination" is used to connote an activity in which there is an exchange of opinion or a "transfer" of understanding between two or more people. The category therefore refers to incidences when students were engaged in an exchange of ideas used by students to acquire understanding of the application of a phenomenon within an artifact. The category is further divided into two sub-categories, **identifying** and **argumentation.**

The first sub-category, **identifying**, refers to incidences where a communication between students concentrated on identifying components of an artifact and in turn assigning a meaning to their function. That is, students identify parts of the artifacts under study, an ammeter or speaker, where electromagnetism concepts are applied and an attempt is made to associate a certain meaning of how such components must function. The extract below reflects an incident where students were commencing to study a device allocated to them.

> All are busy opening the speakers and ammeters.
> ……..
> Group5 are looking at/reading the text book, it seems they are comparing the speaker with the one drawn in the text book. (2003 Field Notes).

In summary, the above extract illustrates an activity in which students start to identify some parts after opening their artifact. The text book is used in this activity as the major resource to help attach meaning to identified components. The episode below, extracted

from a group discussion between Kabi and Thabiso shows how they started discussing the ammeter.

Episode 6.2

1. Kabi: *Ehh rona re tsoere ntho eo ho thoeng ke* … ammeter. Ammeter *ena re bona ha re e bula ka hare, e e-na le* magnet *oo* in a u-shape, a u-shaped magnet. *Na o* u-shaped? Ok! *Ha se* u-shaped, *e ka re ke* two magnets. *Ee! li peli empa feela* (Ehh **we have this thing called** … ammeter. **This** ammeter **when we open it, we see a** magnet **that is** u-shaped**,** a u-shaped magnet. **Is it** u-shaped? Ok!, **It is not** u-shaped, **it looks like** two magnets. **Yes! They are two but)**
2. Thabiso: the appearance
3. Kabi: *ee* the appearance, it's a u-shaped magnet. *Pakeng tsa teng, holimo mona, re bona ho e-na le* soft iron *e beuoeng mononong* (**Yes** the appearance, it's a u-shaped magnet. **Between them, up here, we see a** soft iron **that is placed there**)
4. Thabiso in between
5. Kabi: in between. *Ha qeta, re bona ka hare ka mane ho na le* coil, some sort of a coil. *E re re bone*. Ok! coil *enana re lumela hore monana ho etsahala ntho e tjena. Oa bona hore na ho joang moo? Ke lumela hore nako e* current *e fetang, ha ke re ua bona hore ka nqee ho joang? Ere re bone. Nako ee* current *ena e fetang ka mona, ha ke re ua bona e kena ka mona, ere, nako ee fetang monana* (coughs) some current is induced, electricity is induced, *ha ke re*? (in between. **Again, we see** a coil **inside there,** some sort of a coil. **Let me see.** Ok!, **in this** coil **we believe this is taking place. Do you see how this thing is like? I believe that when this** current **passes, do you see how this side is like? Let me see. When** current **passes this side, do you see it goes in here, then, when it passes here,** *coughs* some current is induced, electricity is induced, **isn't it**? (2003 Audio Tape)

These two pieces of data above, the episode and the extract, extracted from activities of two different groups, illustrate what the activity was when students started to study their artifacts. Firstly, actors are involved in opening their artifacts. Secondly, once the devices were opened students engaged in identifying parts of the devices in which the phenomenon, interaction of magnetic field, is applied and in understanding this application. Though, in episode 6.2, Kabi is addressing a third party, the nature of the talk reveals that they are at the same time identifying the parts that he is talking about. It should be noted that the request to audio record the proceedings did not indicate what, and how it, should be said. The extract, on the other hand, reveals an important element of the activity. That is, students used textbooks to identify and give meaning to the

identified parts. The utterance in turn 5 highlights the cross pollinating nature of talk. In this utterance Kabi is attempting to give meaning to the observations of the group. Kabi says "**When** current **passes this side, do you see it goes in here, then, when it passes here,** *coughs* some current is induced, electricity is induced..." Though the actual meaning of this utterance may be problematic, it is noted that the core of the utterance is to give some meaning to an observation.

The second sub-category, **argumentation**, refers to interpersonal communication incidences when students exchanged views regarding how they perceived the application of the phenomenon in the artifact. The next extract reveals the sort of arguments that students engaged in.

> group 4 - there is a hot argument, "**Are you referring to this thing or this one. It can't be**" he can not agree with them so much that he gets hold of a text book and opens it. They are supporting their arguments with the help of diagrams (drawings).
> group 6 - one member reads out v. loudly to the members about the ammeter, "... and there is a soft iron ore ..." They are at the same time looking at the ammeter as they read. (2003 Field Notes)

The extract above highlights a typical social learning environment in which students are discussing their ideas. According to the extract, in group 4 the actors are disagreeing and one, vehemently opposes the other's view from what he says. It is worth noting that their disagreement is settled through the use of a textbook. It is possible that this student is hoping to find evidence that will support his argument in the textbook. The student's action gives a textbook some voice of authority over the discussion. The extract further shows that the students' discussion was reinforced by use of diagrams. Similarly, in group 6 actors use a text to make meaning of the identified component, soft iron.

The episode below adds some understanding of the argumentation sub-category.

Episode 6.3

1. Kabi: *Ha ke re mona ke ho* zero *mona, ha ke re*? *Nako eo* current *e fetang, ha ke re oa bona, mona li* parallel. No! *na li* parallel *le ntho*? (**It is at** zero **here, isn't it? When** current **passes, you see, they are** parallel **here.** No! **are they** parallel **with this thing**?
2. Thabiso: *e* parallel *joang*? (**How is it** parallel?)

3. Kabi: *li* field lines *tsee*? *Feela hantle ntle ene e tlamehile e be, e re re bone* (**These** field line **here? But it should be, let us see)**
4. Thabiso: *Na e tlamehile hore ebe* parallel? (**Should they be** parallel?)
5. Kabi: *Hobane ha ke re ha ele ntho, ha ele, ha ele at right angle ntho e ngata, ha ele at* right angle (silence) force force *e ngata, ha ele* at right *angele ha ke re*? (**Because if it is this thing, if it is, if it is** at right angle **this thing is greater, if it is** at right angle *silence,* force, force **is greater, if it is** at right **angle, isn't it?)**
6. Thabiso: force *eang? Ea li*-field lines *kapo eang*? (**which** force?, **of the** field lines **or which one?**)
7. Kabi: *E re ke bone,* force *ena ea li*-field lines *ena. Joale taba ke ena.* (Silence) *nthoe ke* north *kapa* south? *Ere re late nthoane uena monna, re late* magnet *re tlo bona hore* north *e hokae* south *e ho kae*, *ua bona*. (**Let me see, this** force **of** field lines**. Now here is the issue.** (Silence) **Is this thing a** north **or a** south? **Let me bring that thing man, bring a** magnet, **to confirm where** north **is and where** south **is, you see**.) (2003 Audio Tape)

Episode 6.3 portrayed an activity in which Kabi makes a suggestion and Thabiso always questions the suggestions. The undertone in the discussion suggests that Thabiso does not really agree with a suggestion and decides to demand an explanation. Answers that Kabi provides called for the next question until some agreement was reached. Other than in the above extract where some authority had to be called, in episode 6.3 students adopt a question and answer approach until there is some agreement. It is crucial to reiterate what is cross pollination in these data pieces. In the extract, Group 6 members for example, are trying to give meaning to an observed "...soft iron ore...". The extract shows a discussion whose aim is to make meaning of an observed phenomenon. In episode 6.3 Kabi is trying to make meaning between "force" and something that is either "parallel" or "at right angle". Because actors, in these data pieces, are trying to influence others to form certain meanings of observed phenomenon, the activities highlight characteristics of cross pollination.

Identifying and argumentation, as components of cross pollination, signify activities in which the students were making meaning of components of their artifacts. Students discuss different opinions until there is an agreement.

6.8.2 Dissemination

The last emergent category of Conceptual Application stage is called *dissemination*. In this category the incidences refer to activities in which students made oral presentations and to the reaction of other students and the teacher immediately after the presentation. Two features are important characteristics of dissemination. Firstly, the activities are meant to pass on what was learned at group level. Secondly, the activities offer the teacher and students an opportunity to contribute towards meaning that is constructed. The emergent category is sub-divided into three sub-categories, **oral presentation**, **students' reaction**, and the **teacher's intervention**.

In the first sub-category, **oral presentation**, students were explaining their findings regarding the application of interaction of magnetic field lines in speakers and/or ammeters. A number of students came forward to present their findings. The extract below reflects an incidence when Thabang volunteered to explain operation of the group's device. He drew the following diagram before the explanation,

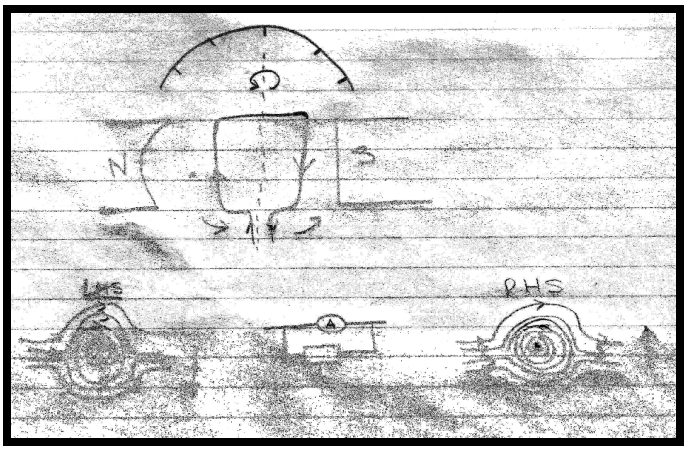


Diagram 6.4**:** Thabang's analysis of Ammeter

[2003 Journal notes]

Then he explained:

> Thabang: I have tried to show the two sides of the coil that is between the Ammeter and this is the left hand side of the coil, looking at it from this angle. The current around the wire would appear as if though it is going in the clockwise direction and therefore since the field of the magnet that is enclosed in this coil there will be a north and a south between that coils. This is the left hand side and the field from the north will appear like this and some of the fields will connect. And in this case there will be more force on the top and therefore the coil on this side will appear down and that might be a conflict to that what we see there and

> that intentional movement can be detected by a small needle there and because of the spring that we fixed here so that after detecting it can come back and this is the galvanometer principle that we applied there. And now for the ammeter for it to measure current we used the, we connect two resistors in parallel and as we have see when we have two resistors connected in parallel the resulting resistance in that situation will result in a lesser resistance than we started with. Because one of these resistors that we have here or resistance could be the ammeter itself we make it in such a way that the resistance here is less than we have here. We make this one the big one, maximum. The idea here is that this resistors that we put in here should not be too big so that they take all the current, it should be normal.

The extract highlights Discourses that emerged as Thabang presented the group findings on how the concept of interaction of magnetic field is applied in an ammeter. According to this extract, students' oral presentation included the following

- Drawing the diagram on the board, and
- Talking to the diagram:

The extract reflects what Thabang, and arguably his group mate, learned earlier. They have learned interaction of magnetic field patterns and the resulting motion of the current carrying conductor. It is this meaning that Thabang is presenting. Perhaps it is pertinent to show that the text book did not have this analysis.

The second sub-category, **students' reaction**, refers to incidences when students reacted to the oral presentation. The extract below shows the reaction of students immediately after a presentation

> " hona le ntho eo u e utloileng? 'Na che ha kea utloa letho. **Have you understood anything? I don't understand a thing**" student 2 to a neighbough. Student 3 asks a question. volunteer answered. (2003 Field Notes)

The extract highlights some characteristics of students' reactions immediately after the presentation. There were students, such as student 2, who did not understand what the presenter communicated. It is not clear from this extract whether student 2, in particular, ever asked or made his/her problem(s) known. Then, there was a group of students, such as student 3, who asked questions. Episode 6.4 below presents a discussion between Thabang, the presenter, and Toka. Thabang had just finished presenting how an ammeter operates.

Episode 6.4

1. Toka: Yes sir *inaudible* I am asking about the two springs *inaudible* that the ammeter *inaudible*
2. Thabang: The two?
3. Toka: springs
4. Thabang: The two springs (thinking). There is one spring that you that you attached to the coil. Just so that every time it marks your zero, the zero of this meter will be on the centre. So therefore half the deflection because the the current as it goes through there will be one deflection and therefore after that deflection it will come back to the original position. So the the spring that you are putting there is just to bring ehh to the original.
5. Toka: It will have another one at the bottom, so I would like to know how that one works *inaudible*.
6. Thabang: Another spring?*(slowly)*
7. Toka: **Yes!** You got two springs one at the bottom and the other up.
8. Thabang: Unless maybe the one that I have did not have two springs. *(moves to the trolley to pick up an ammeter)* Well even if this one is not so clear *inaudible*, but I think it was just one at the top *inaudible*.
9. Toka: *Inaudible*
10. Thabang: **Yes!** *inaudible and continue to inspect the ammeter. Finally puts it and goes back to his seat.*

Episode 6.4 reflects the two actors, Toka and Thabang, discussing the diagram that Thabang had just discussed (Diagram 6.4). Thabang and Toka disagree about the presence of the second spring in the ammeter. Incidentally, Toka had also studied an ammeter and therefore had some experience to share with the class. Toka's contention is that there are two springs while Thabang claims to have had an ammeter which had only one spring. An interesting thing is the manner in which Thabang perceived a solution to their disagreement. He chooses to take out another ammeter from the trolley to prove his point. This is critical in defining the product of the cross pollination stage. The act shows that Thabang owns the constructed meaning and only wants to make sure that the "source' of the meaning is consistent. Otherwise, he would have used the text book.

The activities in this sub-category comprise exchanges of ideas between students, after oral presentation, as a way of sharing their experiences and achieving some level of intersubjectivity.

The last sub-category of this category, **teacher intervention** comprises incidents where the teacher intervened to help the presenter. Episode 6.5 illustrates an activity in which the teacher intervenes immediately after the presenter was asked questions by fellow students.

Episode 6.5

Teacher: (*students have grouped into two large groups) inaudible [referring to a diagram]* on the board regarding the interactions might need to be corrected a little bit, how do we have ehmm end up having higher, you said high

Student: force

Teacher: forces this side? there? and then we could do that by referring back to, to ehm activity 3, part 3 of that activity. You remember when we were looking at the interaction of, of current carrying conductor and *inaudible (he is pointing at magnetic field lines of magnet and current carrying conductor drawn at the board).* I think, I think ehh if you go through *inaudible* again that interaction needs to be straightened out. *After this he introduced parts of the ammeter; the magnets, two poles, solenoid, coil, current carrying conductor, the springs and the needle. Finally drew two diagrams on the white board.* (2003 Video Tape)

This activity, highlighted in episode 6.5 above, is explained by the following extract

> *Still I was not sure whether every body understood. So I decided to come in and identity some parts.* I gave students ammeters again to look at the structure and identified the part. Then I asked them to think about the operation of the ammeter along the functioning of these parts. (2003 Journal Notes)

Episode 6.5 therefore highlights the steps that the teacher took when he realised that students might have not understood what the presenter said. The main activity, therefore, was to identify parts of the ammeter and compare them with the diagram drawn on board by the presenter.

Episode 6.5 characterises the teacher's intention, and therefore of the sub-category, into two elements.

- He is forming connections between what students wanted to explain "…higher … forces this side…" and what they learned "…activity 3, part 3 …". Forming this connection allows him to emphasise the importance of the interaction of magnetic field lines.

- He leads students into identifying the parts of the ammeter in which electromagnetism is applied.

In this sub-category the teacher identifies areas which need to be strengthened in students' presentations. The teacher then takes appropriate measures to help the presenter.

6.8.3 The meaning of Conceptual Application

The discussion above reflects Conceptual Application as another opportunity for students to further use Discourses of science (Driver *et al.,* 1998; Wells, 1995) to understand a concept. Special emphasis in this stage is grounded on talking about an application of a concept in an artifact. Discourse enabling activities in Conceptual Application emerge in two categories, **cross pollination** and **dissemination**. The following are observed about the two emergent categories:

- Cross Pollination: Activities grouped under this emergent category are discursive in nature. Students identify components and study application of a concept of interaction of magnetic field patterns. This comprises arguing ideas on how a concept is applied. The importance of arguing ideas on intermental plane has been reported in literature (e.g. Driver *et al.,* 1998; Mercer *et al*., 2004; Yerrick, 2000; Zohar and Nemet, 2002, Niaz *et al.,* 2002; Jimenez – Aleixandre *et al*., 2000). Cross Pollination activities bear testimony to the Driver *et al.* (1998:298) argument that

  > Students need opportunities not just to hear explanations being given to them by experts (teachers, books, film, computer programs), but they also need to practice using the ideas themselves to gain confidence in their use, and through this process develop a familiarity with, and understanding of, scientific practices and ways of thinking.

  The Conceptual Application therefore presents students further opportunity to "practice using the ideas…" The notion of using ideas is accomplished in two ways. Firstly the activity of identification of components of an artefact in applying a concept goes beyond just hearing about the application. The utterance that Kabi makes, in episode 6.3, reflects them focussing on, and/or beginning the talk from, a magnet and disregarding other components. Kabi and Thabiso's discussion reflects the use of ideas learnt earlier. The activity therefore calls for using what is already

learned on a new situation. Secondly students are further given opportunity to study the application of the concept. Studying the idea included talking about the idea and using Discourses learnt to understand meaning of the learnt concept. Leach and Scott (2003:100) argue that learning science

> …involves coming to understand and be able to use a new set of tools for talking and thinking about the world, which can be drawn upon when circumstances and context are appropriate.

Thus, activities classified under Cross Pollination go a long way towards Leach and Scott's (2003) understanding of learning science. The activities further offer opportunity to use "new set of tools for talking and thinking…" learned in earlier stages on the new situation. Cross Pollination has helped students to develop and share understanding, at group level, of how a concept is applied, thereby gaining a better understanding of the concept.

- Dissemination: Activities classified under the emergent category, communicating, refer to incidences where different groups were reporting their conclusions to the whole class. As sub-categories of this emergent category suggest feedback came from the presenter's audience, fellow students and the teacher after each presentation. Feedback from fellow students took the form of questions or comments. It is noted from episode 6.4 that in cases of disagreements between the presenter and a fellow student, a type of authority would be used. In this episode intersubjectivity is reached by referring back to the artifact. The second type of feedback came from the teacher. As Cross Pollination suggests, conclusions that students presented were reached after a discussion between themselves inevitably. It was prudent therefore, for the teacher to play a role in constructing the knowledge. The purpose in such a feedback activity is summarised by Hodson (1998:778),

  > …teachers have it in mind that students will arrive at particular understanding – the particular scientific knowledge specified in the curriculum plan. Consequently, they define and control classroom discourse in order to achieve it: they ask specific questions; direct attention to some things rather than others; introduce easy ways of arriving at preferred solution and acceptable views, and so on.

Episode 6.5 confirms Hodson's (1998) point that teachers exercising the role of leadership "direct attention to some things rather than others". This responsibility must also be viewed in realisation to the situation where students in this access programme came from. Since students, especially the presenter and his/her group mates, are used to the teacher's authority it is understandable for them to be expected to want the teacher's validation and/or feedback.

Perhaps in this stage it is pertinent to address development of talk as an activity and occurring through stages. Talk during both the Cross Pollination and Dissemination emergent categories shows improvement compared to earlier stages. It is argued above that the talk during Cross Pollination demanded more than just a talk. Thabang's presentation also shows a more confident person than was the case in earlier presentations where mimicking was dominant.

6.9 Concluding Remarks

The discussion above, summarised in Table 6.2 below, presents and analyzes the results of the activity aspect of SAMPS system of Discourse analysis introduced in Chapter 4. The questions set at the beginning of the Chapter required identification of activities, defining the intervention, with an underlying understanding that such analysis has the potential of highlighting the meaning making processes engaged in the intervention.

From this analysis the following conclusions are drawn:

- The discussion above reflects the Conceptual Foundation achieving valuable results as a foundation building component of the intervention. Firstly, the stage gave students opportunity to share their prior knowledge and reach intersubjectivities insofar as their situation definitions are concerned. The stage also acted as an identity building stage. It is argued that enculturation, as a sociocultural process, possesses a better chance of succeeding when the issue of identity within a social setting is established.

Pre-determined Stage	Emergent Category	Sub-category	Description
Conceptual Foundation	Concept mapping	Drawing	Activities included writing concept words on small pieces of paper, arranging concept words, and drawing concept maps
		Rehearsing	Discussing concept words and agreeing on meaning
	Voicing	Students' voice	Reporting views on concept maps in class
Conceptual Initiation	Exploration	Students appropriation	Forming mental picture of a scientific phenomenon
	Promoting Discussion	Initiating talk	Introduction of ways of talking about a scientific concept by the teacher
		Improvements	Teacher identifies issues students need to discuss further Students discuss
	Supporting Exploration	Peer Support	Students seeking help from fellow students
		Teacher Support	Teacher offers support individual groups
Conceptual Formulation	Facilitation	Teacher assistance	Teacher realises need to help students Offers help
		Student assistance	Students seek help, and obtain, from fellow students
	Ventriloquating	Group Talk	Students begin to discuss ideas Agree on a solution
		Oral talk	Reporting ideas in class
Conceptual Application	Cross Pollination	Identifying	Students identify components of artefacts by themselves?
		Argumentation	Students talk about application of concept with each other?
	Dissemination	Oral presentation	Students explain their findings
		Students reaction	Students react to the presentation
		Teacher intervention	Teacher helps presenters

Table 6.2: Emergent Categories

- The discussion shows the Conceptual Initiation stage introducing a scientific phenomenon and Discourses of science that students needed to understand scientific concepts. In the discussion above, the issue of supporting internalisation of a scientific concept as a basis for meaning making is underlined. Discourses engaged in this study included *talking, writing, drawing, reading, matching, identifying,* and

agreeing. The importance of these Discourses in the learning of science has been discussed in the literature (e.g. Lemke, 1990; Gee, 1999).

- The Conceptual Formulation stage allowed students to progressively ventriloquate Discourses of science. An important observation regarding ventriloquation has to be noted. Ventriloquation is a process rather than an event and therefore develops progressively until a person can talk with some understanding. The notion of progressive ventriloquating shows characteristics, and/or trajectories, of learning a language or Discourses (Setati and Adler, 2001).

- The Conceptual Application stage allowed students to situate knowledge of a concept within an artifact. The stage reflects, within a sociocultural learning, the importance of cross pollination as a mechanism through which students learn concepts within an environment controlled mostly by students.

Perhaps it is important to address questions of whether these activities reveal any success. It has to be re-iterated that the background of students in this study is important when making a judgement of this magnitude. Evidently the strategy employed in this intervention made an impact on the learning of students. The activities above reflect a development of Discourses from a lower demanding category to higher demanding categories. Data above shows talk, and/or Discourses of science, commencing from a level of talk dominated by prior knowledge recollection and therefore mostly dominated by recall. The next level shows talk as ventriloquation that develops through different stages. Talk as ventriloquation is of higher cognitive demand than talk as recollection of prior knowledge. Lastly, data show own talk used to understand application.

CHAPTER 7

Understanding Students' Initial Situation Definitions

> ***[T]he most effective learning takes place when the learner, faced with a question or problem arising from an inquiry to which he or she is committed, is helped to master the relevant cultural resources in order to construct a solution. Procedures and knowledge, which are thus initially co-constructed in interaction with others, are then internalized and reconstructed to become a unique personal resource that is used for further, and often creative, problem solving, both alone and in collaboration with others.*(Wells, 1995)**

7.1 Introduction

The activity aspect of the SAMPS system, discussed in Chapter 6, identifies two emergent categories constituting the first predetermined stage of the intervention, Conceptual Foundation. The Conceptual Foundation stage should be construed as an important first step in the process of enculturation into community of practice. The two emergent categories are named concept mapping and students' voice. Discussion of these emergent categories highlighted two pertinent elements of the process of enculturating Lerotholi Polytechnic's (LP) access students. The issue of identity in which a student seeks recognition in the form of feedback and self assessment is reflected. The process of talking, insofar as it relates to accepting possible losses, has also emerged as an important element of the process of enculturation. The significance of this stage has been identified as including

- ice breaking,
- introduction of new culture, and
- sharing of initial situation definitions.

This chapter discusses the results of the semiotic aspect of the SAMPS system of Discourse analysis. The analysis studied meanings constructed by students during the Conceptual Foundation stage. In particular, the chapter traces the initial situation definitions that LP's access students constructed on magnetic field prior to the learning of magnetic field interaction. The operational definition of situation definition refers to the

representations that students constructed and/or shared in discussing a concept such as magnetic field. These representations include their views on the existence of magnetic field and actions caused by the interaction of magnetic field due to two magnets or a magnet and a current carrying conductor. In order to discuss these definitions, analyses of concept maps that students drew and discourse patterns that unfold as they are engaged in concept mapping are made.

It is pertinent to note the use of the term situation definitions other than alternative conceptions. In chapter 3 a definition of situation definitions as suggested by Wertsch (1984; 1985) is discussed. Two issues, making an important distinction between alternative conceptions and situation definitions came to the fore. These are shared definitions and semiotic activity. Though there maybe a debate on whether the definitions referred to are alternative conceptions or not, a position is taken in this study that situation definitions is a better term. Alternative conceptions have been defined as unscientific ideas which students have about scientific concepts (Dykstra, Boyle and Monarch, 1992; Shipstone, 1984; Stanton, 1990).

As shown in Chapter 4, the semiotic aspect of Discourse analysis seeks to identify the meanings constructed by communicators. In discussing the initial situation definitions that access students have on magnetic field, this chapter will answer the following questions:

- What initial situation definitions did Lerotholi Polytechnic's access students have about magnetic field prior to their learning of magnetic field interaction?
- To what extent did access students share these situation definitions?
- How did the discussion of their situation definitions help them to achieve some level of intersubjectivity?
- What patterns of discourse emerge as students discuss their situation definitions?

The results of the analysis are presented under the following headings

- Concept maps,
- Students' magnetic field situation definitions, and

- Student – student communication and discourse patterns

Before presenting these results, however, the chapter describes the data and the analysis steps that was followed. Then a brief discussion of the stage and the core activity, concept mapping, are discussed.

7.2 Description of data analysed in this chapter

The data analysed in this chapter is drawn from Conceptual Foundation, the first stage of the intervention. In this stage the activity was mainly concept mapping and hence the data is about concept maps and concept mapping. The sources of these data are the students' written reports which included concept maps and explanations as well as video and audio transcripts. These data were described in Chapter 5 but are briefly described below.

- *Students' concept maps and explanations*. Students were required, after doing activity 1, to submit their improved concept maps with explanations, where possible, showing why they altered the given diagram, Diagram 7.1 below. They were expected to hand in their reports as a group work. These concept maps were labelled from A1 to A13 for analysis purposes.

- *Video Transcripts and Audio Transcripts*. Video and Audio transcripts are other sources of data to be analysed in this chapter. Audio taping was optional since students were asked to voluntarily record their proceedings. A pair of students, whose concept maps were labelled A1, volunteered to audio tape their proceedings and their discussions are analysed.

The practice at Lerotholi Polytechnic's access programme, Technician Induction Programme (TIP), was to group students into three streams; 1, 2 and 3. Although that the streaming implied here was based only on consideration of the first alphabet in the surname of each student, data analysed in this chapter are drawn from one of these streams, stream 1. The choice of which stream to analyse its data was influenced by the following considerations:

- Ethical issues: It was felt that if in any one stream there are students who do not like to be involved in the study in one way or the other data from that stream should not be analysed.
- Purposeful choice: It was felt that if students in a stream volunteer to audio tape their proceedings, data from such a stream should be analysed.

One student in the third stream indicated unwillingness to appear in the video tapes and because of this, data from the third stream could not be used. One pair of students in the first stream audio recorded its discussions and because of this the first stream was preferred over the second stream.

7.3 Conceptual Foundation

Concept mapping was the core meaning making activity in the Conceptual Foundation stage. The main purpose of the activity was to encourage students to talk about their prior knowledge and thus share situation definitions of concepts in electromagnetism. Data analysed in this chapter are drawn from the 2003 intervention. In this year students were provided with an incomplete and incorrect concept map, Diagram 7.1 shown below.

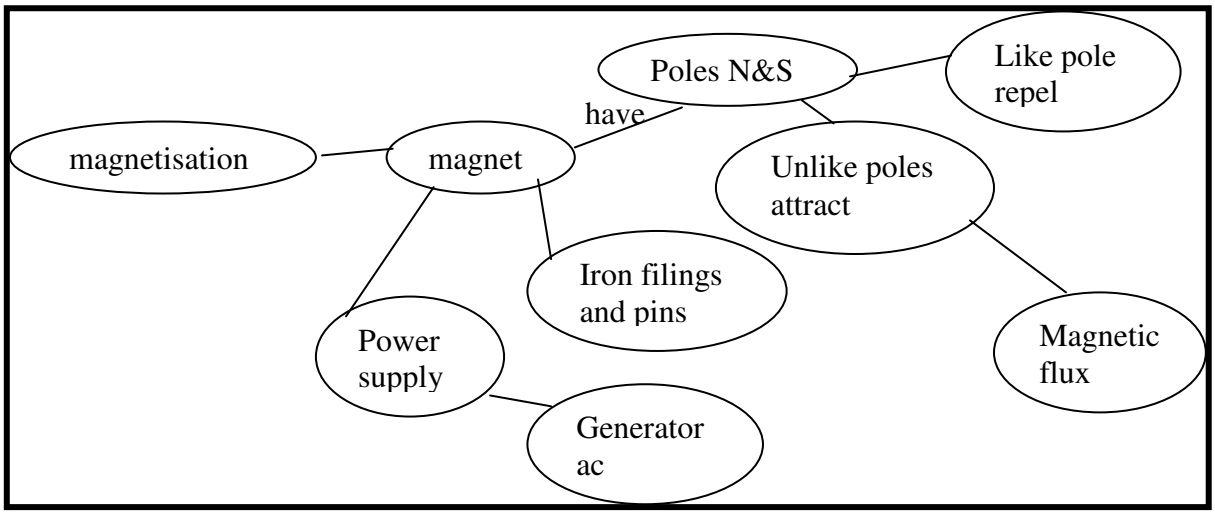


Diagram 7.1: Concept map

The complete activities carried out in 2003 by access students are shown in appendix 2. The appendix further shows the instructions that were given to students. These included:

- studying a given concept map with the purpose of understanding the relationships suggested in each concept pair,

- agreeing or disagreeing with the suggested relationships between the concept pairs, and finally
- constructing an improved concept map.

The concept map shown in Diagram 7.1 is part of student B11's concept map, taken from the 2002 pilot. Other than the fact that the concept map was meant to initiate talk, it was chosen because it had typical shortcomings found in the 2002 concept maps. At the macro level, for instance, the concept map has no linking words/phrases between the majority of concept pairs. The problem then is of understanding the suggested meaning between such concept pairs. The suggested meaning of most concept pairs is not clear at micro level either. For example, the intended meaning between the concept words "magnetic flux" and "unlike poles attract" is not clear. In particular it is not clear whether the suggested meaning implies that "magnetic flux" influences "attraction" between unlike poles or that there is magnetic field around unlike poles. Whatever the case, the suggested meaning excludes "unlike poles". The other factor which influenced the choice of this concept map was that when discussing it students would reflect their understanding of the concept of interaction of magnetic field. The concept map therefore would

- encourage students to talk about their understanding of the relationships between concepts, particularly the concept of interaction of magnetic fields,
- make them share the meaning of those concepts, and
- make them think of a better way of relating those concepts.

As students discussed and drew concept maps, they were encouraged to add new links or eliminate existing ones, add linking phrases and/or introduce or omit some of the concept words. They were expected to add new concept words and also write them on the board so that other students are aware of them.

Although many students did not change this concept map at both micro and macro levels, they were not unfamiliar with concept mapping. They were introduced to the process prior to studying electromagnetism. Concept mapping was introduced as a way of summarising the topic of electricity. Then students were asked to discuss concepts learnt in electricity, show their relationships, and draw concept maps. As they worked on this

activity in electricity, students showed reasonable understanding of what the activity involved. An explanation of the difference between students' ability to construct concept maps in electricity and in electromagnetism can be attributed to the stage at which the activity was done. That is, in electricity it was used as a way of summarising the topic while in electromagnetism it was used as a way of introducing the topic.

7.4 Analysis

Because of the nature of the data collected and the questions that are being answered in this chapter, different methods of analysis are employed. The results of the two analyses will be presented; namely, analysis of concept maps and of documented data.

7.4.1 Analysing Students' Concept Maps

Concept mapping has been used for some time in science education (Heinze-Fry, 1990; Wandersee, 1990; Novak, 1990). The fact that concept mapping has been used when choosing an appropriate analysis method for students' concept maps and analysed differently by researchers was found to be pertinent. For example, concept mapping has been used in assessment and evaluation (Rice *et al.*, 1998; Stoddart, *et al.* 2000, Markham *et al.*, 1994; McClure *et al.*, 1999) in classroom collaboration (Roth and Roychoudhury, 1993; Van Boxtel *et al.*, 2000) and as a research tool (Rye and Rubba, 1998; Wallace and Mintzel, 1990). Inevitably, the way these studies analysed concept maps has been influenced by the research orientations that informed them.

The analysis method adopted in this study is adapted from Mwakapenda and Adler (2003) who used concept mapping as a research tool. There were a number of features in Mwakapenda and Adler (2003) which influenced adoption of their analysis method. Firstly, Mwakapenda and Adler were informed by a qualitative paradigm and as a result do not use any formal scoring techniques. Secondly, they were analysing students' meaning of concepts as portrayed by a concept map. Thirdly, their subjects were mainly students enrolled in an access programme and/or in a Foundation mathematics course. Lastly, they analysed concept maps designed by students who were partly familiar with

the concept mapping. These features are issues that this study is dealing with, hence the reasons why their analysis approaches were found useful.

Mwakapenda and Adler (2003) did not use formal scoring procedures but simply counted the number of

- linked concept pairs formed,
- linking phrases/words,
- concept words used from the initial list, and
- extra concept words included.

The strategy above does not address the issue of the meaning of concepts which students used in constructing their concept maps. Thus an additional approach was necessary. In addition to the Mwakapenda and Adler's (2003) strategy, the meaning of concept pairs was studied. Two analysis stages were followed. The first stage was to give each concept pair a **possible phrase,** guided by the nature of linking that students suggested. The concept pairs had three categories of linking that students made. These linking categories are shown in Diagram 7.2 below.

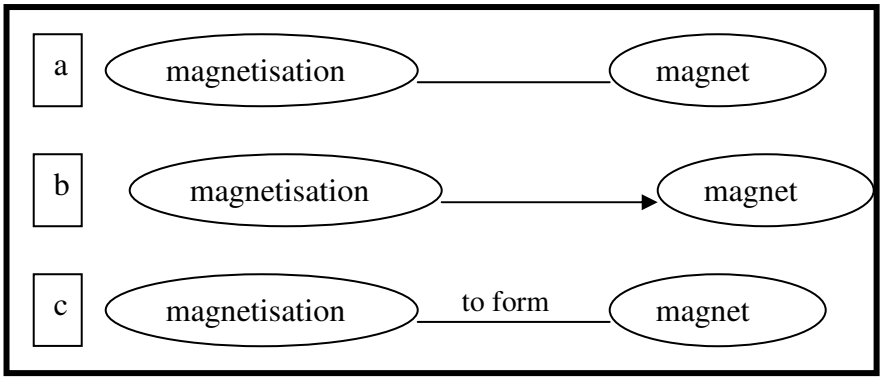


Diagram 7.2: Possible linking categories

- In Diagram 7.2 (a) there is no linking phrase/word. I gave this category of links the meaning **"is related to".** This meaning was influenced by acknowledgement that even though the designer is not indicating the intended meaning with the use of a linking phrase/word, s/he claims existence of a relationship between the two

concepts. The possible phrase of concepts in Diagram 7.2a would therefore be **magnetisation is related to magnet**.

- In Diagram 7.2 (b) the designer only uses an arrow. I gave this category of links the meaning **"leads to"**. The choice of this meaning was influenced by a simple interpretation of an arrow. The possible phrase given to this concept pair would therefore be **magnetisation leads to magnet**.
- In Diagram 7.2 (c) the designer uses a linking word. The possible phrase given to this concept pair would therefore be **magnetisation forms a magnet.**

The second stage was to give each possible phrase a **possible meaning**. The notion of possible meaning was driven by the fact that even after allocating the possible phrase, intended meaning between concepts remained unclear. A number of considerations were made in other to allocate a possible meaning to a phrase constructed in the first stage,

- **Intended meaning:** The intended meaning could be deduced in the cases where a linking phrase/word is used. For example in Diagram 7.2 (c) above the intended meaning is **magnetisation of magnetic materials results in formation of a magnet.**
- **line of argument:** Some phrases were interpreted based on how the earlier pairs were interpreted. In Diagram 7.3 below the pair "magnet – poles (N&S)"could be interpreted based on the earlier pair.

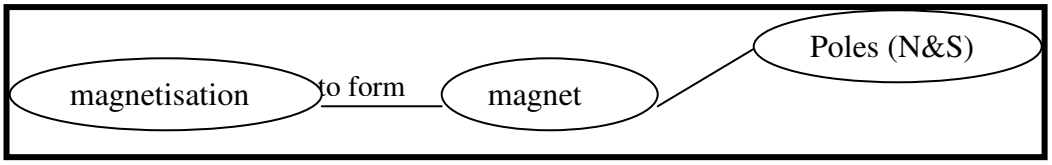


Diagram 7.3: Argument line

The possible phrase between magnet and poles (N&S) is **magnet is related to poles (N&S)**. The possible meaning of this phrase is **magnets have north and south poles.** In deciding on this meaning the process of magnetisation implied in the earlier phrase is noted.

- **class discussion:** During class discussion some of the meanings were made clear. These were:
    - **poles N&S** which means **north and south pole**

- **unlike poles attract** used as **unlike poles** when connected to other links and **like poles repel** which means **like poles**
- **iron filings and pins** which mean **iron filings**

- **students notes:** Some students have added notes to explain some of the concerns they had. These notes were therefore used to give them possible meanings. For example students in group A1 have added a note that says **"Magnetic flux is around the magnet".** This note is used to give their possible phrase **magnet leads to magnetic flux** the meaning **magnetic flux is around the magnet.**

7.4.2 Analysing Documented Data

The second set of data, from audio and video transcripts, represents talk. To analyse this talk the following strategy was employed

- Formation of episodes: Data was divided into small episodes depending on the idea being discussed by students. An episode would therefore be a small discussion of a certain concept.
- Classifying episodes: The episodes were then grouped depending on the nature of the contribution to the discussion between students.
- Applying Toulmin's framework to episodes: Toulmin's framework, as described in Chapter 4, is used to understand meaning of semiotic aspects of the episode formed above.

7.5 Concept Maps

Students' discussion of Diagram 7.1 above resulted in thirteen modified concept maps (see appendix 5 for samples). Analysis of these concept maps, employing Mwakapenda and Adler's (2003) strategy, resulted in Table 7.1 below. The table summarises characteristics of these concept maps.

Group	No of linked concept pairs	Linking phrases used	Initial concept words used	Additional concept words used
A1	13	2 + arrows + notes	9	4
A2	13	Arrows	9	4
A3	9	2	9	1
A4	7	Arrows	9	0
A5	10	1	9	1
A6	9	0	8	2
A7	8	arrow + notes	9	0
A8	8	2	9	0
A9	19	Arrows	8	9
A10	14	Arrows	9	4
A11	14	8 + notes	9	5
A12	8	2 + arrows	7	2
A13	9	6 + arrows	8	2

Table 7.1: Characteristics of Concept maps

Table 7.1 summarises the conclusions that students made, regarding how to improve Diagram 7.1. The table shows that students' alterations could be characterised as either and/or both qualitative and quantitative.

7.5.1 Qualitatively altered concept maps

Qualitatively altered concept maps refer to concept maps in which alterations were in the form of shifting concept words to form different concept pairs. Table 7.1 above shows that there are three such concept maps, namely A4, A7 and A8. This is made clear in the last column in which there are no extra words added. This type of alteration affected mainly two concept words; "magnetic flux" and "iron filings". Apparently, this alteration was influenced by the following comment,

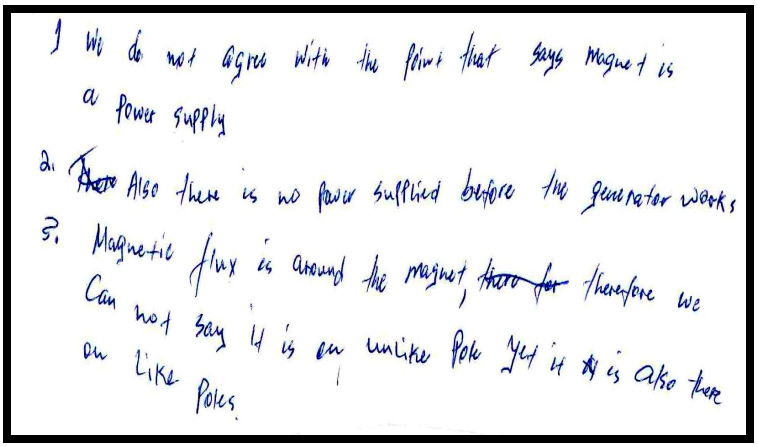


Diagram 7.4: A1's views

These are observations that group A1 made. Their third comment reflects dissatisfaction with omission of a concept pair. Group A8 made the following alteration in attending to this problem.

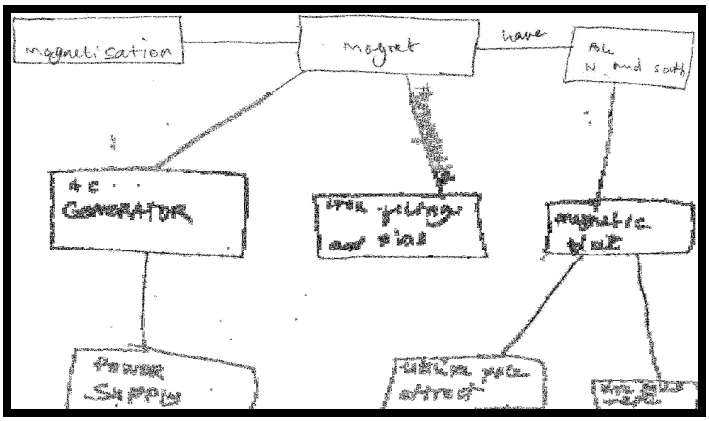


Diagram 7.5: A8's corrected concept map

In Diagram 7.5 the concept word "magnetic flux" has been moved so that it forms pairs with both "unlike pole attract" and "like poles repel". Thus, the intention with qualitative alterations is to improve the quality of concept pairs.

7.5.2 Quantitatively Altered concept maps

Quantitatively altered concept maps refer to concept maps in which the alterations that students made were mainly to introduce more concept words or to drop some of them. Table 7.1 suggests therefore that all concept maps show quantitative alterations except, A4, A7 and A8. The quantitative alterations shown in the table are either in the form of

increasing or decreasing the number of concept words other than increasing the number of already existing concept pairs. These quantitative alterations seem to be influenced by dissatisfaction with concept pairs, and in particular the pair between "magnet" and "power supply".

The essence of the first and second comments in the A1's observations above reflects discontent with concept pairs. During class discussion a member from group A1 reported

> Student1: This route between magnetization and magnets we said we can magnetize a magnetic substance with a magnet and this magnet can have a south pole and north pole. ehm *we said the route between magnet and power supply, we said, ehm, we think we don't need because in order to magnetize a magnetic substance we need to have a direct current.* Because a.c., no we need direct current so as to have north pole and south pole. The positive can group themselves to the other pole and the negative to the ehm to the other pole. (2003 video transcript)(emphasis added)

Student 1 is emphasising dissatisfaction in the concept pairing of power supply and magnet in this extract. Their way of solving the problem was to introduce more concept words. This is also exemplified in the concept map drawn by group A11 shown in Diagram 7.6 below.

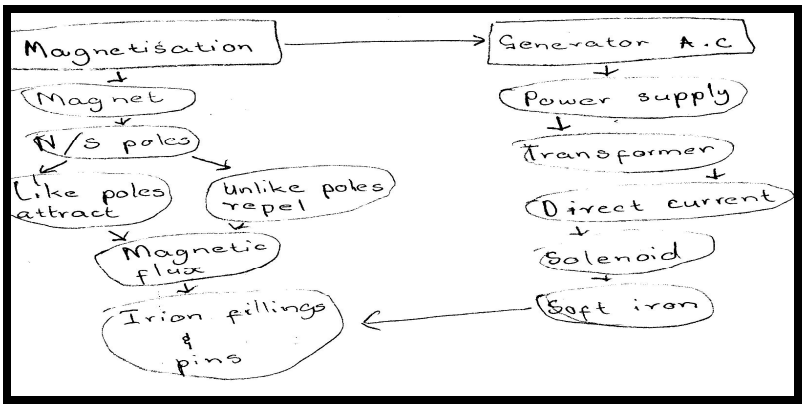


Diagram 7.6: A11's correct concept map

When comparing Diagrams 7.6 and 7.1, two major alterations have been implemented in Diagram 7.6. These are

- Addition of the concept words; transformer, direct current, solenoid, and soft iron.
- Introduction of a link between "unlike poles repel" and "magnetic flux" and moving of "iron fillings & pins".

Other concept maps show a reduced number of concept words. For example consider the A6 concept map shown in Diagram 7.7 below

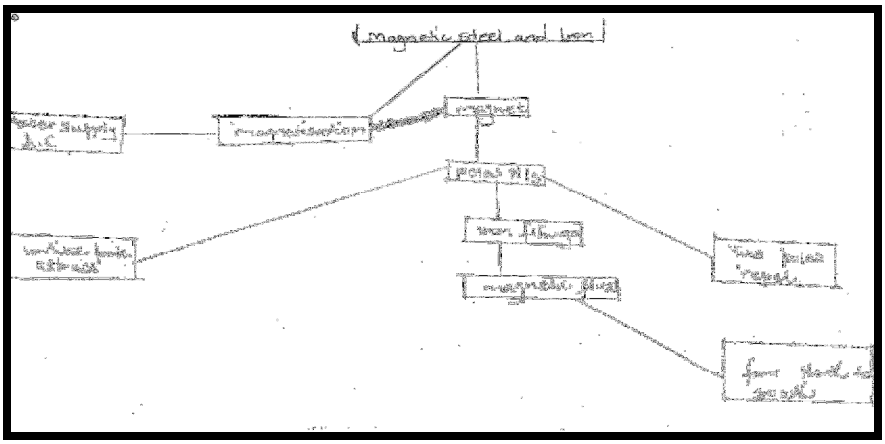


Diagram 7.7: A6's corrected concept map

In this concept map the designers have

- added two new concept words, "magnetic steel and iron" and "from north to south"
- they have left out the concept words "generator ac"
- they have shifted the concept words, "iron filings" and "magnetic flux".

The concept mapping activity was dominated by discussions around how to eliminate or increase some concept pairs. It has to be noted though that the majority of concept maps with quantitative alterations also had qualitative alterations.

7.6 Students' Magnetic Field Situation definitions

The discussion on concept mapping above identifies the main students' activity as talking about concepts. Inevitably embedded in a talk is the act of reaching conclusions about what the discussion is on. One of the concepts discussed, and a conclusion reached, was concerning the magnetic field. This is important because this term, magnetic field, is central in the intervention. To conceptualise talk about magnetic field, it is necessary to ask the following questions about these students' understanding of magnetic field:

- What initial situation definitions did these access students have about magnetic field?, and

- To what extent did the talk contribute to their sharing of these initial situation definitions?

The significance of the use of the term, magnetic field, by students in their concept maps is the reflection of the situation definitions that students have and agree on, about the concept. A critical study of the concept map, Diagram 7.1 above therefore raises pertinent questions. For example, in the diagram "magnetic field" is linked to "unlike poles attract" and not to "like poles repel". The question is whether students, studying this map, would agree with the designer and therefore find no reason to alter it. What meaning would be suggested if they change the link? In order to facilitate answering these questions, Table 7.2 summarises the concept pairs that the 2003 students suggested relating to magnetic field.

GROUP	LINK	HINT(S)	Possible Phrase	Possible Meaning
A1	Magnet – Magnetic flux	Arrow + note	Magnet has magnetic flux around it	Magnet has magnetic field around it
A2	Like poles repel – magnetic flux	Arrow	Like poles repel **leads to** magnetic flux	**Like poles also have magnetic field**
	Unlike poles attract – magnetic flux	Arrow	Unlike poles **leads to** magnetic flux	**Unlike poles have magnetic field**
	Magnetic flux – iron fillings & pins	Arrow	Magnetic flux **leads to** iron filings	**Iron filings determines direction of magnetic field around a magnet**
A3	Unlike poles attract – magnetic flux	Arrow	Unlike poles attract **leads to** magnetic flux	**Unlike poles have magnetic flux**
	Magnetic flux – strong & uniform	Arrow	Magnetic flux **leads to** strong & uniform	**Magnetic flux can be strong and uniform**
A4	N pole & S pole – magnetic flux	Arrow	N pole & S pole **leads to** magnetic flux	**Both south and north poles have magnetic flux**
A5	Like poles repel – magnetic flux	Linking words	Like poles repel **also produce** magnetic flux	Like poles also produce magnetic flux
	Unlike poles attract – magnetic flux	None	Unlike poles attract **is related to** magnetic flux	Unlike poles produce magnetic flux
A6	Iron fillings – magnetic flux	None	Iron fillings **is related to** magnetic flux	**Iron filings show direction of magnetic flux**
	Magnetic flux – from n to s	None	Magnetic flux **is related to** from n to s	**Magnetic flux starts from north to south**
A7	Iron filing & pins – magnetic flux	Arrow	Iron filing & pins **leads to** magnetic flux	**Iron filings show magnetic flux**
	Magnetic flux – N/S poles	Arrow	Magnetic flux **leads to** N/S poles	Magnetic flux are to check direction of north and south poles
A8	Poles N/S – magnetic flux	None	Poles N/S **is related to** magnetic flux	**Poles have magnetic flux**
	Magnetic flux – unlike poles attract	None	Magnetic flux **is related to** unlike poles attract	**Magnetic flux is there on unlike poles**
	Magnetic flux – like poles repel	None	Magnetic flux **is related to** like poles repel	**Magnetic flux is also there on like poles**
A9	Magnet – magnetic flux	Arrow	Magnet **leads to** magnetic flux	**Magnet has a magnetic flux**
	Magnetic flux – unlike poles	Arrow	Magnetic flux **leads to** unlike poles	**Magnetic flux is there on unlike poles**
	Magnetic flux – iron fillings & pins	Arrow	Magnetic flux **leads to** iron fillings & pins	**Magnetic flux is detected by iron filings**
A10	Unlike poles attract – magnetic flux	Arrow	Unlike poles attract **leads to** magnetic flux	**Unlike poles have magnetic flux**
	Like poles repel – magnetic flux	Arrow	Like poles repel **leads to** magnetic flux	**Like poles also have magnetic flux**
	Magnetic flux – iron fillings & pins	Arrow	Magnetic flux **leads to** iron fillings & pins	**Magnetic flux is detected by iron filings**
A11	Unlike poles attract – magnetic flux	Note	Unlike poles attract **produce** magnetic flux	Unlike poles produce magnetic flux
	Like poles repel – magnetic flux	Note	Like poles repel **also produce** magnetic flux	Like poles also produce magnetic flux
A12	iron fillings & pins – magnetic flux	Linking word	iron fillings & pins **making** magnetic flux	Iron filings shows magnetic flux
A13	N & S poles – magnetic flux	Linking word	N & S poles **form** magnetic flux	Poles form magnetic flux

Table 7.2: Use of the term Magnetic flux

It is worth noting that the 2003 students, like the 2002 students, used the concept word "magnetic flux" and did not introduce the concept word "magnetic field". Perhaps it is also important to ask what they mean by "magnetic flux". The discussion as summarised in Table 7.2 portrays two notions that appear to have been universal amongst the groups, namely, existence of magnetic field lines and direction of these lines.

Magnetic field or magnetic flux: The two concepts, magnetic field and magnetic flux, do not mean the same thing. Students are normally not expected to know the concept of magnetic flux at secondary education level. Most ordinary level books used in Lesotho's secondary schools do not use the term. This concept "magnetic flux" was suggested by the 2002 students and used in a manner that suggests magnetic field. For example the following notes from two groups suggest that magnetic flux is used to mean magnetic field.

> If we put an iron bar in a solenoid and let the coulombs pass through it in a clock-wise direction the nearer part will be south pole and the further will be north pole. There will be a force of attraction between unlike poles while like poles will repel each other. Both poles form a magnetic flux which has a direction from north pole to south pole (Students Notes – B1 2002)

> Magnet is the bar with two poles and can be north pole or south pole, bringing like poles together repelsion occures while bringing unlike poles together attraction occures as this two things occure is just because of force and it is on the field around the magnet and it is called magnetic flux. (Students Notes – B9 2002)

In these notes the context in which the term magnetic flux is used means magnetic field. The last sentence in B1's notes suggests two issues. Firstly, they are talking about magnetic field line patterns, originating from one end of the magnet to another. Secondly, they are referring to direction of magnetic field. Students in B9 use magnetic flux to refer to the magnetic field around a magnet. However, their definition of magnetic field is a force around a magnet. In 2002 therefore the magnetic flux is used to mean magnetic field.

Students in 2003 programme used the concept, magnetic flux, in the same way. That is, instead of magnetic field. The note that A1 makes suggest this.

> Magnetic flux is around the magnet, therefore we cannot say it is on unlike pole yet it is also there on like poles. (Students Notes – A1 2003)

It is evident from this extract that students are referring to magnetic field. The following episode from 2003 data reflects this meaning.

Episode 7.1

1. Sepetla: Ehh we we have our our ... Meaning we can observe ehh the magnetic flux flux when having the iron filings ehh sir and pins.
2. Teacher: Come again
3. Sepetla: We can observe the magnetic flux when we have iron filings on paper.
4. Teacher: So so what is your point? Do you agree with that?
5. Sepetla: We have iron filings being followed by magnetic flux.
   [2003 video transcript]

In episode 7.1 the discussion is on a correction that Sepetla's group is suggesting. The reference to iron filings shows that the students were thinking of the magnetic field line patterns.

It is not clear from these data how students met the concept magnetic flux. However, these students tend to use the word to mean magnetic field. Since the word does not appear in school text books or syllabi, it is suspected that the term must have been used by teachers to mean magnetic field. Hence in this study it was decided to leave the 2002 concept map as it was and to see what the 2003 students made of it. The fact that they seemed to have no problem with the term to mean magnetic field suggests that this understanding is quite widespread in the schools.

Origin of magnetic field: The idea of origin of magnetic field is crucial in making students understand the concept. Students later learn the concept of electric field and one of the distinguishing factors is their origin. In the concept maps discussed in this study reference is not made to magnetic field and current carrying conductor. There is no mention of origin of magnetic field either. However, students refer only to current when they talk about the process of magnetisation. For example, Sechaba reports on what his group agreed on

> Sechaba: Yes sir! I would like to emphasize on that point. I also agree with the point that in magnetisation you will end up with a magnet but since we are using or we are dealings with electromagnetism which means we want to end up with a magnet using an electrical current and those magnets this magnet is controlled by using current. That is if there is current there is magnet and when there is no current there is no magnets. So when it says the power supply and then an a.c. generator that's where I don't agree because here we just want to to to make a magnet via electrical current electric current and I don't think there is a possibility that that magnet can produce power. That we supply *inaudible* [2003 video transcript]

The report deals only with the process of magnetisation using the electric method but says nothing about the origin of magnetic field.

Existence of magnetic field: The concept maps that students drew reflect general awareness of the existence of magnetic field around a magnet. These concept maps show three popular alterations:

- introducing a link between "like poles repel" and "magnetic flux", or
- linking "magnetic flux" directly to "magnet", or
- linking "magnetic flux" to poles.

The alteration and the provided backing of the link between "unlike poles attract" and "magnetic field" reflects a general consensus between and amongst the groups on the appropriateness of the link. All qualitative and quantitative alterations, discussed above, have affected this link. Diagram 7.8 below is an example of alterations that are suggested.

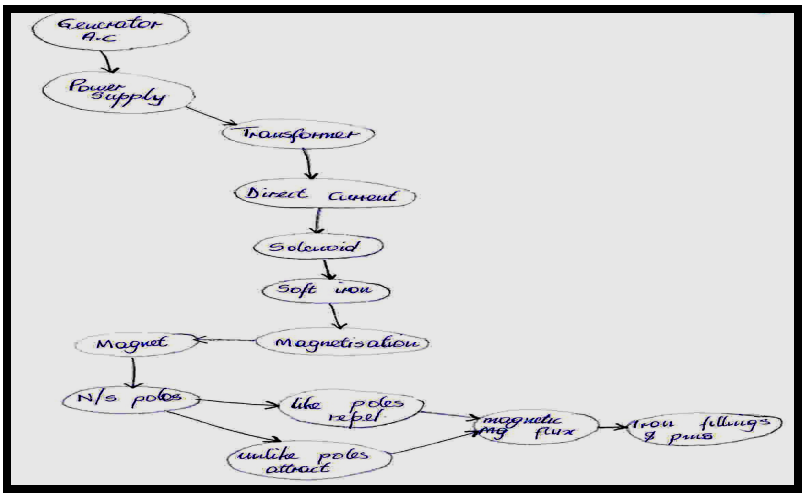


Diagram 7.8: 2003 A2 Concept Map

Group A2 has introduced a link between "magnetic field" and "like poles repel" that were missing in Diagram 7.1. These students are suggesting that like poles also have a relationship with magnetic field. This relationship is made clearer by A1 in the extract shown above. Group A1 wrote

> "Magnetic flux is around the magnet, therefore we can not say it is on unlike pole yet it is also there on like poles." [see Diagram 7.4 above]

Students in group A1 are objecting to the suggested link "unlike poles attract – magnetic flux". Their objection is not based on there being no relationship between the two but rather on the omission of other facts. The correction implied in this extract is of removing magnetic field and linking it to the magnet, as indicated in Diagram 7.1. This is what these students did (see Diagram 7.6 for example). Some students linked magnetic field to poles. Consider for example Diagram 7.9 below

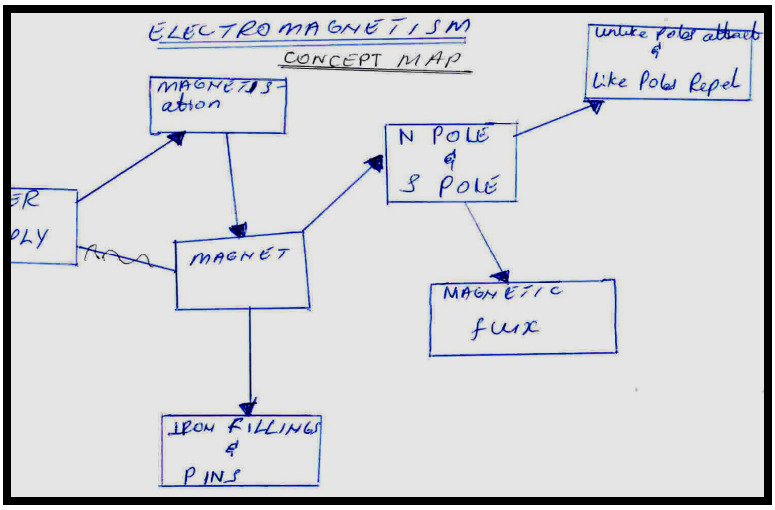


Diagram 7.9: 2003 A4 Concept Map

In Diagram 7.9, "magnetic field" is related directly to poles. Students in group A4 realised a shortfall in Diagram 7.1 and their correction implies that magnetic field is around the whole magnet. The interpretation of the phrase "magnetic flux is around the magnets" in group A1's note above suggests two models of situation definitions. The first model derives its basis from the pattern implied in the phrase. The pattern normally implied is suggested in diagram 7.10 below.

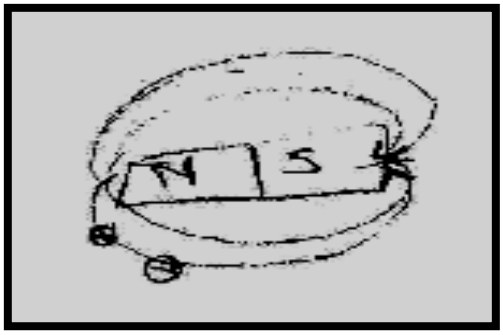


Diagram 7.10: Students' initial diagram of magnetic field

Diagram 7.10 is drawn from 2002 data but diagrams of this form were also common in 2003. For example

> After some few minutes I started moving around to see what they were drawing. Some of them were drawing the usual diagrams students draw (2003 Journal notes)

The "usual diagrams" referred to in the extract are diagrams of the form of Diagram 7.10. A distinct feature of these diagrams is the lines that start from one end of the magnet and end on the other.

The second model relates to the relationship between existence of magnetic field and application of force. Discarding a link between "magnetic field" and "unlike poles attract" in Diagram 7.1 acts as an indication that some students' understanding of the phrase "unlike poles attract" has little to do with application of force. The comments that groups A1 above and A7 made show that the consideration that the students were making was not on application of force but rather on mere existence of magnetic field.

Existence of magnetic field has little to do with the application of force, according to these models. Magnetic field lines are merely lines that start from one end of the magnet and end on the other.

Direction of magnetic field lines: The notion of direction of magnetic field contributes significantly to the Physics register associated with the concept of interaction of magnetic field. The students' talk about direction of magnetic field lines is therefore pertinent. In Diagram 7.1 the related link is between "magnet" and "iron filings and pins". The designer does not link them to "magnetic flux" and/or to "poles". It is perhaps important to note that they included "pins" not for clear reasons except if they were thinking of tracing light rays in optics. Thus, for analysis purposes the term "iron filings and pins" was considered to imply "iron filings". This diagram therefore implies the situation definition that disconnects direction of magnetic field from the actions of repulsion and/or attraction. Inevitably the changes that students suggest reflect their situation definitions of magnetic field.

Table 7.1 shows that six groups changed the concept pairs involving the three concept words. One pair that changed the concept pairs is A7 and their new concept map is shown below.

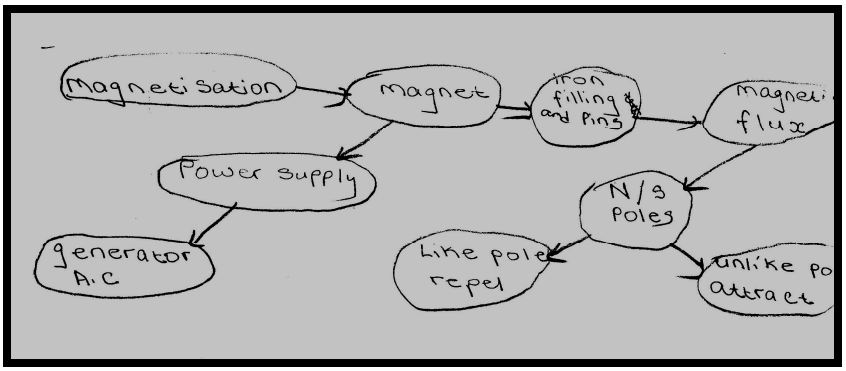


Diagram 7.11: 2003 Group A7's Concept Map

Group A7 accompanied this diagram with the following comment whose second part relates to the direction of magnetic field.

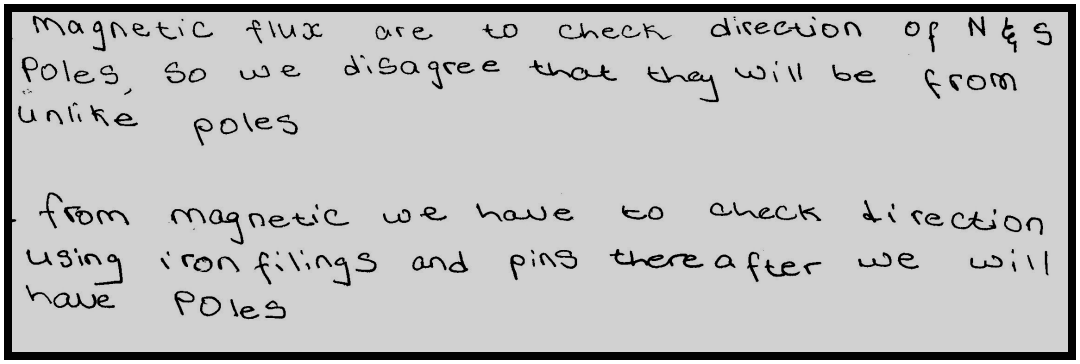


Diagram 7.12: Group A7's views

The essence of this comment is that direction of magnetic field is determined by using iron filings. It is not clear how iron filings determine direction of magnetic field, though.

It is clear therefore that these students had initial situation definitions and were able to agree on common ground. However, the concept maps do not reflect whether students had different views or not at the beginning of talk. They do not show how talk contributed to the sharing of these situation definitions.

7.7 Student – Student Communication and Communicative Approaches

Talk that took place in Conceptual Foundation stage was in two main categories; student – student communication and teacher – student communication. Because of the nature of

the stage the prevalent form of communication was student – student communication. An important consideration therefore is to understand communicative approaches that emerged and to relate them to the nature of concept maps and understandability of those concept maps. An analysis of communicative approaches will show that there is a relationship between all these and the meaning making process. That is, the meaning making process relates to how people engage in talk.

The analytic tool, see section 4.2.2.1, discusses classification of discourse patterns that students can engage as they discuss an idea. It shows that such patterns can be used to define two communicative approaches, deep dialogue or surface dialogue. Deep dialogue involves students engaged in an interpersonal communication, not just accepting another's view but scrutinising it until they agree on it or reject some or all elements of the suggestion. Surface dialogue involves an almost one way communication in which a student suggests an opinion while the other just accepts it.

As mentioned earlier, students talk in the Conceptual Foundation stage was mostly captured through the use of voluntary audio taping and, to a lesser extent by video recording. A pair of students, Kabi and Thabiso, audio taped their discussion and produced a concept map labelled A1. This data is discussed above.

7.7.1 Surface Dialogue

The data in this study shows that this form of interpersonal communication between students was more frequent throughout the conceptual foundation stage. Section 4.2.2 suggests that the dialogue should be assumed to be *surface* if:

- people involved in a discussion do not debate a suggested idea. That is, if one person makes a statement and the other simply accepts it; and
- the suggested idea is not backed by a justification.

To highlight the two characteristics the following episodes are considered.

Episode 7.2

1. Kabi By means of direct current we can magnetise a magnetic substance to make it a magnet. Ha ke re? (**Isn't it**?)

2. Thabiso Ee **(Yes)**
3. Kabi Ene ntho engoe (**And the other thing)** we cannot use ac, ha ke re ua bona (**you see isn't it?)** ... Because *silence* we only need direct current so as to *silence*. Re ka khona hore e etse south hantle e tse le north hobane ua bona moo lintho, hakere ha e le ntho, ha ele, ha ele, ha ke re north li tlamehile li ee ka nqa e le 'ngoe. **(We can manage to form a** south **and form a** north **because you see here, if it is, if it is** north **they must go to one side, isn't it?)**

In this episode, students Kabi and Thabiso are discussing magnetisation of magnetic materials by electric method. The portion of Diagram 7.1 that they are discussing should be the concept pairs "magnet" and "power supply" and "power supply" and "generator ac". Student Kabi introduces the process of magnetisation of magnetic materials. He is suggesting to student Thabiso that direct current can be used to magnetise a magnetic material and that the alternating current cannot be used. The response of Thabiso is a simple confirmation of what Kabi says. This discussion has taken a form of statement – accept – statement. The next episode, immediately following episode 7.2, takes the same format.

Episode 7.3

1. Thabiso Ehe **(That's it)**
2. Kabi le south lie ka nqa, li-negetive lie ka nqa e le 'ngoe le li-posetive li ea nqa e le 'ngoe. Hore re tle re be le north le south, joale ha li hlekehlane ha e sa le ntho **(and** south **they must go one side**, negatives **should go to one side and** positives **should go to one side**. **So that we have a** north **and** south, **but if they are facing in all directions, it is no longer this thing)**
3. Thabiso Ha e sa le magnet **(It is no longer a** magnet)
4. Kabi Ha e sa le magnet. So mona re ke (break) re ka etsa joang? E hlile nthoena mohlomong e ntse e le moja, e ntse ele hantle oa bona? (**It is no longer a** magnet. So **here we can** (break) **we can do what? Yes, maybe this thing is still ok, it is still correct you see?)**
5. Thabiso Ee **(Yes)**

In this episode, students Kabi and Thabiso are now discussing formation of poles in a magnet. Even when they discuss this second idea the roles have not changed. We still have a statement – accept – statement.

Because the discussion, as illustrated in the two episodes above, was one way, the depth of what student Kabi says is crucial. To understand it, the Toulmin's framework of interpersonal communication is used. The diagram below conceptualise the Toulmin's framework to analyse episode 7.2.

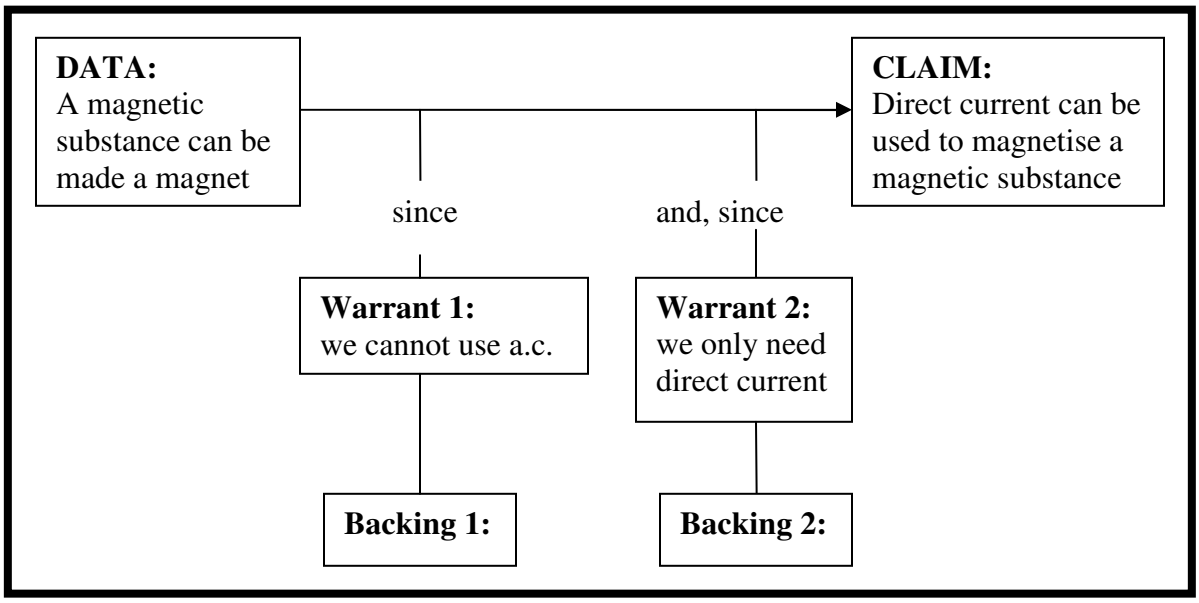


Diagram 7.13: Toulmin's analysis of episode 7.2

In order to justify his claim, Kabi eliminates another possibility without showing why it is incorrect. Perhaps it is because the discussion is at macroscopic level and expects Thabiso to know the difference between direct current and alternating current. The role that Thabiso plays leaves questions regarding the level of agreement between them. He does not require any explanation but simply agrees. Though there is an incidence when the voice of Kabi went too low, the interval is not long to suggest a considerable loss of talk. Thus, in episode 7.2 Kabi does not engage much in justifying the claim that he makes and Thabiso does not pursue the idea that Kabi suggests.

In the second episode the discussion is about formation of the poles of a magnet. Kabi talks about "negatives" and "positives" moving, or being pushed, to the sides and relates them to "north" and "south" poles. The phrases "…negatives **should go to one side and** positives **should go to one side**." and **"… if they are facing in all directions, it is no longer this thing"** suggest that Kabi was trying to talk about alignment of dipoles in a magnetic material. Had the role of Thabiso not been of accepting what Kabi had to say,

the meaning could have been clear. Applying Toulmin's framework to this episode shows a similar situation to the one above.

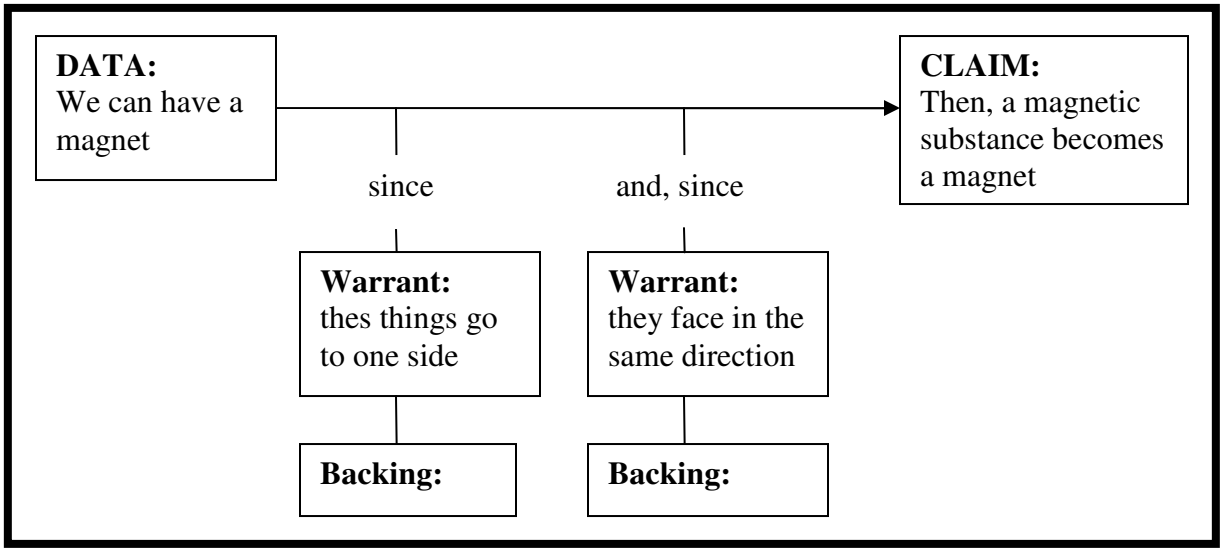


Diagram 7.14: Toulmin's analysis of episode 7.3

The diagram shows no change in the discourse pattern that these students follow. Kabi still does not give backing to the warrants he makes and Thabiso still plays a role of accepting what Kabi suggests.

The episodes above reflect discussion of two concepts, method of magnetisation and formation of poles and/or alignment of dipoles. The situation definition reflected here is one of magnet having two distinct parts. In two cases the discourse pattern that emerges is a statement followed by a confirmation from another participant and then another statement. The response that the second participant makes reflects an agreement on the situation definition that they use.

In surface dialogue, therefore, discussion assumes Statement – Accept – Statement form of discourse pattern. The response only confirms the statement regardless of the weaknesses or ambiguities in the statement. Edwards' (1997) classification of shared knowledge is perhaps ideal in understanding Kabi and Thabiso's talk. Edwards (1997) classifies shared knowledge into three categories; *cultural knowledge*, *mutual knowledge*, and *pragmatic intersubjectivity*. *Cultural knowledge* comprises things that people

generally know, or can be expected to know, about the world. *Mutual knowledge* refers to the things that individuals are involved in a discussion assume each other to know, and expects the other person knows what he/she knows. *Pragmatic intersubjectity* on the other hand comprises shared knowledge as participants' practical concern; *i.e.* what their talk treats as shared. The fact that Kabi and Thabiso's talk leaves a number of issues not deliberated, possibly because they assume each other to know, classifies their agreements as mostly *mutual knowledge*.

7.7.2 Deep dialogue

A dialogue was characterised to be *deep* if people involved in a conversation were exchanging ideas. That is, if one person makes a statement and the other responds in such a way that the first person reflects on his statement. This form of communication, not common at this stage, takes the form of exchange and debate of ideas suggested by one student. The following episode illustrates the typical properties of this approach.

Episode 7.4

1. Thabiso Magnet cannot produce power ha ke re? (**isn't it**?)
2. Kabi E magnet cannot produce power, empa ka magnet le power supply u ka khona ho iketsetsa generatora ha ke re? U ka khona ho etsa genaratora nthoane ea ntho! Hana ho thoe keng? Ha na ho thoe keng? Ntho, re ka khona ho etsa generatora, ha re e revisa ka generatora, ok ka ntho, ka this current, ha re sebelisa, e ehlile ha re sebelisa nthoena, re khona ho etsa magnet joalo kaha re ne re re re ea magnetisa mona, ha ke re? (**Yes** magnet cannot produce power, **but with a** magnet **and** power supply **you can make a generator, is it not? You can make a generator, that thing of** (break) **What do they call it?** (break) **What do they call it? This thing, we can make a generator,** ok **with that thing**, **with** this current, **if we use, yes we can if we use this thing, we can make a** magnet **like we were saying we are magnetising here, isn't it?)**
3. Thabiso E, so but oa bona **(Yes** so but **you see)** in this case ke nahana hore (**I think that)** on top of electromagnetism we need a current, ngee **(this thing)**, a power supply and what? a sort of a solenoid where would be insetting what? a magnetic substance in order to produce this magnet in order to carry out magnetization ha ke re? **(isn't it?)**

In the episode students Kabi and Thabiso want to establish the suggested meaning in the links between the three concept words "magnet", "power supply" and "generator AC".

Thabiso makes a claim **"magnet cannot produce power"**. Kabi agrees with him but goes further to suggest an alternative interpretation of the link. Though the utterances are clouded with thinking about what to say, characteristic of a newcomer in a new setting, Kabi's contribution influenced Thabiso to consider an alternative interpretation. Thabiso now investigates the suggested meaning **"magnet and power supply can be used to form an ac generator"**. The direction of thinking that this discussion would have taken if Kabi did not raise his opinion changed. These discussions have led them to agree on links which required introduction of new concept words and to relating all those to the process of magnetization. Thus, unlike in surface dialogue, the communication in deep dialogue approach comprises Statement – Question – Agreement pattern of discourse. Parties involved in the communication contribute ideas thus leading to a negotiated agreement. This pattern of communication benefited the communicators, Kabi and Thabiso, in that before achieving a conclusion, other options were investigated and others eliminated as possible meanings of a link.

Applying Toulmin's framework of analysis on episode 7.4 provides another perspective of what is taking place in this episode and thus provides another essential characteristic of deep dialogue. The characteristic, exposed by Toulmin's diagram, is that in deep dialogue students contribute towards the ultimate claim.

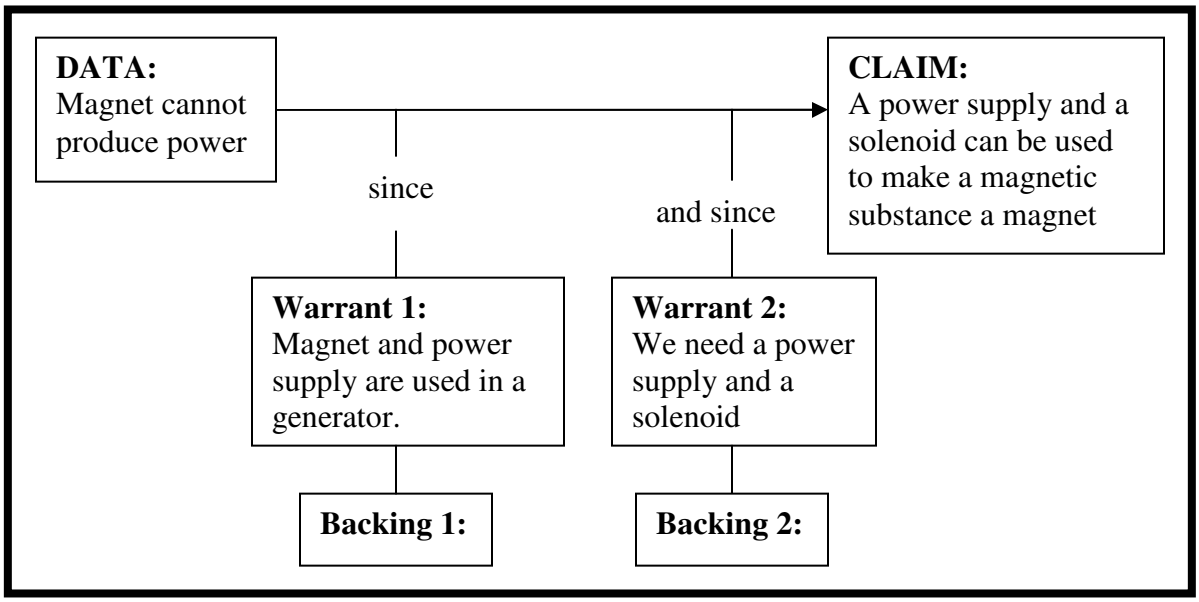


Diagram 7.15: Toulmin's analysis of episode 7.4

In the Toulmin's framework Diagram 7.15 above, the roles of Kabi and Thabiso are clearly highlighted. Both students have contributed towards the final claim. Thabiso provides some data which Kabi supports by providing a warrant. As a result of this exchange of opinions they agree on both the data and the warrants. Then Thabiso draws what finally is taken as the main claim. In terms of the components of the framework the discussion still lacks backing of the warrants but what appears to be crucial in this discussion is the roles that the two students have played to achieve a conclusion.

In deep dialogue therefore communicators negotiates the conclusion and the pattern they follow becomes Statement – Question – Agreement. The agreement they arrive at therefore is a product of deliberations between them and in terms of Edwards' (1997) classification of shared knowledge the pattern takes the form of *pragmatic intersubjectivity*.

7.7.3 The Concept maps and the talk

Students in group A1 adopted varying discourse patterns, surface and deep dialogue. Their concept map is categorised under concept maps whose concept pairs reflect both qualitative and quantitative changes, compared to Diagram 7.1 and some of the changed and/or new pairs had intended meaning clear. As stated earlier, one consideration that must be made is how these two observations come together.

The incidences of surface dialogue shown above reflect students discussing the relationship between "magnet" and "ac generator" in episode 7.2 and alignment of dipoles in episode 7.3. In episode 7.2 Kabi is battling with how to relate the two concepts but Thabiso is only accepting what he says. At the end of their discussion, as shown in Table 7.3, they produced a pair with unclear meaning. In Episode 7.3, where they discuss alignment of dipoles, students could be discussing one of the concept pairs "steel & iron" and "poles" or "magnet" and "poles". At the end of that discussion the intended meaning is also not clear.

The incidence of deep dialogue, episode 7.4, shows a changed pattern. In this episode students are discussing magnetisation by electric method. This discussion ended up with concept pairs from "ac generator" through "power supply" to "magnetisation" as reflected in Diagram 7.6. Importantly, this dialogue resulted in new pairs being formed and a linking phrase being used. Thus there appears a direct relationship between components of Discourses. Therefore this discussion suggests that the more intense the talk the better the product of that talk.

7.8 Concluding Remarks

The purpose of this chapter was to analyse talk occurring as part of Discourse at conceptual foundation stage. In particular, the chapter analyses the initial situation definitions that LP's access students had about magnetic field, prior to their learning of magnetic field interaction, and the extent to which talk contributed towards the shaping of these situation definitions.

The central thesis in this study is that talking in science classrooms, particularly in a second language setting, is crucial and should be emphasised as a method of facilitating the process of meaning making. It is on the basis of this understanding that it is further argued that it is important to understand the nature of talk that students can engage in this stage. In other words talking at this stage is understood to be a necessary vehicle of learning. The following lessons are learned in this chapter:

- LP's access students had initial situation definitions of magnetic field: Literature on alternative conceptions shows that students have alternative conceptions in electromagnetism (Borges & Gilbert, 1998; Qhobela & Stanton, 1998) and that these conceptions are resilient and world wide (Head, 1986). Their initial situation definitions include;
  - magnetic field as lines that originate from one end of the magnet to another. These lines have direction to be specified from north pole to south pole
  - magnetic field as having little to do with application of force by magnets.

- Concept mapping gave students opportunity to share their situation definitions of magnetic field. The students' (Kabi and Thabiso's) talk in general reflects agreement on specific issues, although in some instances it is not clear what exactly are they agreeing on. Using Edwards' (1997) classification of shared knowledge, Kabi and Thabiso's talk is classified as mostly mutual knowledge with some occurrence of pragmatic intersubjectivity. This is mostly reflected in Kabi's tendency to pose a claim without properly justifying why it is acceptable and Thabiso's tendency not to pursue Kabi's claim but simply accepting it. Their talk is therefore over shadowed by the assumptions: *the other understands what I mean* and *I know what the other means*.

- Students' talk does not reflect what they assume meanings of concepts to be. Setati and Adler (1992) have drawn trajectories of language that students use to talk about concepts. For example they show that students can start to express a concept using an informal spoken main language and then use the formal spoken main language and finally use formal spoken Language of Learning and Teaching (LoLT). Informal language refers to the language used in every day lives to express ideas. In this study two communicative approaches deep and surface are reflected at conceptual foundation;. The statements that students make are mostly informal and lack scientific meaning of the concept being referred to, thus confirming Setati and Adler's (2001) conceptualisation of language at an early stage of starting to use talk as a meaning making process.

CHAPTER 8

Starting to use Discourses of Science

The qualitative characteristic or psychological content of an activity can be of many kinds. The first place is held of course by productive, working activity. But other forms are possible, as, for instance, cognitive activity, which is of particular interest to us; in reality this is an activity which is directed not at the object and event of the external world but, through them, at the very subject of the activity. But it is important to stress that this activity is also not a mere process of 'drinking in' some sort of external information; a necessary condition for cognition is active interaction with its objects, and only as a 'ricochet' do we come back to subject of the activity. It is precisely for this reason that one should not teach a pupil a foreign language if he is going to have no opportunity to speak it. **[Leontiev, 1981]**

8.1 Introduction

In Chapter 7, which presents the first results of the semiotic aspect of the SAMPS system of Discourse analysis, the following issues were noted about the Conceptual Foundation stage:

- LP's access students had initial situation definitions of magnetic field which included the pattern magnetic field forms around a bar magnet and their relationship with the application of force. They also use magnetic flux to mean magnetic field.
- Concept mapping gave students an opportunity to share their initial situation definitions of magnetic field. However, students' talk at Conceptual Foundation is over-shadowed by assumptions that the other communicator follows what his/her pair mate is saying.
- Students' talk during Conceptual Foundation stage does not reflect what students assume meanings of concepts to be. Their talk mostly adopts a surface dialogue in which no justifications of claims are made.

Chapter 6 briefly discussed the activity aspect of the SAMPS system of Discourse analysis. Of particular interest in this chapter is the discussion of the predetermined stage of Conceptual Initiation. Three emergent categories have been identified as being critical about the stage. They are internalisation, supporting internalisation and promoting talk.

Discussion of these emergent categories underlines the importance of introduction of talk, and emphasising of talk insofar as it is related to the scientific phenomenon. In summary, Conceptual Initiation stage dealt with the fundamental issue, introduction of Discourses of learning science. This chapter concentrates on the semiotic aspect of the analysis applied to this stage. The understanding behind the introduction of Discourses of science was that meaning–making will be enhanced through the process.

The key question when applying semiotic aspect has to be reiterated. That is, what meanings are constructed and/or signalled in any given situation. When responding to this question, the chapter deals with the following questions, regarding the Conceptual Initiation stage.

- What were the features of the LP access students' Discourse that defined the Conceptual Initiation stage?
- What communicative approaches and patterns of discourse emerge as students discuss concepts at the stage of Conceptual Initiation?
- Did students' discussion of concepts help them to achieve some level of intersubjectivity?
- How did the process of Conceptual Initiation introduced by the teacher impact on the access students' learning of the concept of magnetic field introduced?

In answering these questions, and therefore discussing the meanings constructed, the chapter discusses the following two main issues appearing in this predetermined stage:

- The process of talking science followed during the lesson, and
- The communicative approaches and discourse patterns that appear in this stage.

Prior to answering the above questions, and with the aim of reviewing the necessary background, the chapter describes the data, the predetermined stage, and the analysis used.

8.2 Description of data in this chapter

This chapter analyses data collected during the second stage of the intervention. Although the data sources have been described in detail in Chapter 5, they are briefly described again below.

- *Field Notes*. The chapter made use of the field notes produced by the researcher's colleague on the 9th and 10th September, 2003.
- *Students' Magnetic field line diagrams*. At the end of the second lesson students were required to submit diagrams of magnetic field lines patterns which they had just drawn. These diagrams were labelled from A1 to A13 for analysis purposes. Effort is made to maintain the labelling followed in Chapter 7 so that labels in this chapter match with of the concept maps.
- *Video and Audio Transcript*. Video and Audio transcripts are other sources of data that are analysed in this chapter.

8.3 Conceptual Initiation

Chapter 5 presented the four stages of the intervention adopted in this study, namely Conceptual Foundation, Conceptual Initiation, Conceptual Formulation and Conceptual Application. In the interest of conceptualisation and because of the criticality of the Conceptual Initiation stage, a brief explanation is given here. This is the second stage of the intervention in which the main objective was to encourage students to understand how to talk about the phenomena and start to use the introduced talk. Table 8.1 below, extracted from Chapter 5, consolidates activities of this stage.

Date	Hour	Topic	Meaning making activity	Report
09/09/03	3 & 4 (2 Hrs)	Magnetic field	Students ➢ Drew magnetic field around bar magnets ➢ Studied magnetic field interactions around bar magnets ➢ Read & summarised the given text on magnetic field around, a current carrying conductor	➢ Submitted diagrams of magnetic fields ➢ Oral summary of text to the whole class
10/09/03	5 (1 Hr)	Magnetic field interaction	Students ➢ Studied magnetic field interaction between magnetic fields due to bar magnets and a current carrying conductor	➢ Oral presentation

Table 8.1: The Conceptual Initiation Stage

Table 8.1 mainly summarises activities which students did during the stage. The purpose of these activities was to make students appreciate the phenomenon. For example, when students are asked to study and draw interaction of magnetic field lines, the aim is to encourage them to situate meanings of words and phrases that the teacher introduced. In Chapter 6, it is shown that the teacher moved from one pair to another, offering support. In particular, he was engaged in the following main activities:

- Inspecting students' drawings: The purpose was that the teacher should be around to look at the diagram, and/or conclusions that students were making. Having seen the diagrams, for example, the teacher would offer support such as asking students to improve some critical features where they were missing in the diagram.
- Demonstrating how to talk about the phenomenon. After inspecting diagrams and/or studying conclusions, the teacher helps students to talk about their diagram and/or explain their decision. For example, when students have drawn a diagram of magnetic field lines around two bar magnets with like poles facing each other, the teacher introduces the way of talking about the interaction between the poles and the resulting action of magnets.

8.4 Analysis

Data analysis in this chapter was handled in a manner similar to the one in Chapter 7. A few changes were inevitable because the main focus of this chapter is different. This chapter studies the students' Discourses and how they were accepted after being introduced. Thus, different sources of data were considered and analysed differently, depending on the nature of data.

- *Field Notes*: The method of analysis used in this chapter is similar to how field notes were analysed in Chapter 6.

- *Students' Magnetic field line diagrams:* The diagrams drawn by pair A2 have been analysed in comparison with their audio and video transcripts. The discussion of these diagrams appears in section 8.5.

- *Audio and Video Transcript.* Transcripts and translations were done, following the procedures discussed in Chapter 7. Likewise, episodes were formed by dividing data into small clusters of ideas that were being discussed by students. Then they were grouped according to the nature of their contribution to the discussion.

In this chapter episodes and extract were built up as described in Chapter 7. However, the meaning of these data pieces were purely analysed following the SAMPS system explained in Chapter 4. The reason for this variation is the difference of purposes of the two chapters. Since this chapter's emphasis is more on Discourses, the SAMPS system was ideal.

8.5 Talking Science

Chapter 6 discussed emergent categories and sub-categories of activities that ultimately define the predetermined stage, Conceptual Initiation. Of particular importance, in what these categories reveal, is the process of introduction of Discourses of science that are central to promoting meaning making during the learning and/or teaching of scientific concepts. The chapter highlighted introduction of talk and scientific phenomena that was associated with the talk. This was done in line with the main thesis of this study, which perceives talk as a constituent of Discourses of science (Gee, 1999; Lemke, 1990) that are central in meaning making and that, if introduced in association with the phenomenon of the process of meaning making, is initiated.

The scientific concept that was being introduced in the intervention was interaction of magnetic field lines. In Chapter 7 it is shown that students had initial situation definitions of magnetic field. The chapter also shows some students' Physics register associated with the concept of magnetic field. Most importantly, it is argued that students had initial situation definitions of the existence of magnetic field lines and direction of these lines.

- **Existence of magnetic field:** It is argued in Chapter 7 that the LP's access students perceived existence of magnetic field to have little to do with the application of force. Students also perceived magnetic field lines as merely lines that start from one end of

the magnet and end on the other rather than perceiving them as lines that signify force.

- **Direction of magnetic field lines:** It is argued in Chapter 7 that these access students do not associate direction of magnetic field with the actions of repulsion and/or attraction. Students also associate, in a special way, direction of magnetic field with iron filings.

8.5.1 Forming a mental picture of magnetic field lines

Introducing the concept of interaction of magnetic field lines comprised of a variety of activities. Firstly, students had to appreciate how the phenomenon looks. In doing so, they form a mental picture of such a phenomenon. To achieve this, students were given an opportunity to display magnetic field around magnets (see activity 1, appendix 2). Then, they had to talk about, and draw, these magnetic field line patterns among themselves. As they were drawing and discussing the patterns, the teacher would introduce ways of talking about the phenomenon. This talk related to interactions of magnetic field lines due to magnets and/or magnets and current carrying conductors as well as the application of force due to this interaction.

The first activity required students to draw three diagrams, a representation of a magnetic field around a bar magnet, two magnets with like and unlike poles. Diagram 8.1 below shows the pattern of magnetic field lines drawn by pair A2. This diagram is considered for analysis because pair A2 audio recorded their discussions.

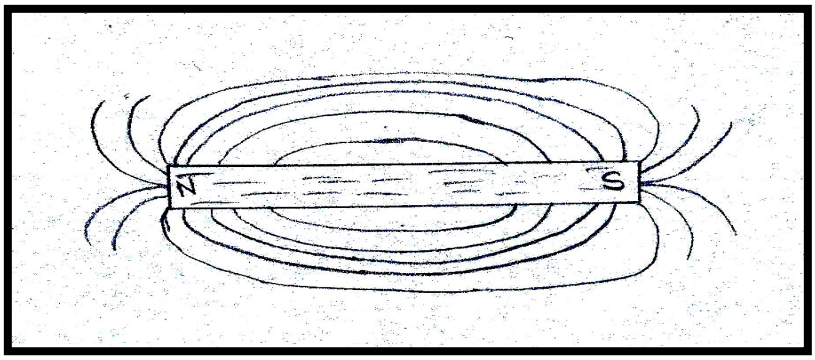


Diagram 8.1: Magnetic field lines around a magnet

It is worth noting that although this diagram is meant to show the magnetic field pattern, depicted by iron filings on a plane sheet, students in this pair labelled their magnet with N (north) and S (south). Why do they insist on this labelling? There is no data that could help answer this question. However, the magnets that they were using had two colours (red and blue). Normally this colour coding is associated with poles. Nowhere in the data is the determination of poles reflected. It means therefore that their prior knowledge of magnets was used to help them label this diagram. Why did they find it important to label these poles? Again, there is no conclusive answer from the data. There are possible causes. Firstly, it is that the students' mental picture of a magnet that has two distinct parts, north and south poles, was reigning. Secondly, it is possible that the construct of direction of magnetic field influenced them to at least include these labels. Lastly, they may have been influenced by their experience that in science a diagram must have labels. However, they do not label the magnetic field lines.

Diagram 8.2 below shows a magnetic field pattern around two magnets, with unlike poles facing each other, that pair A2 drew.

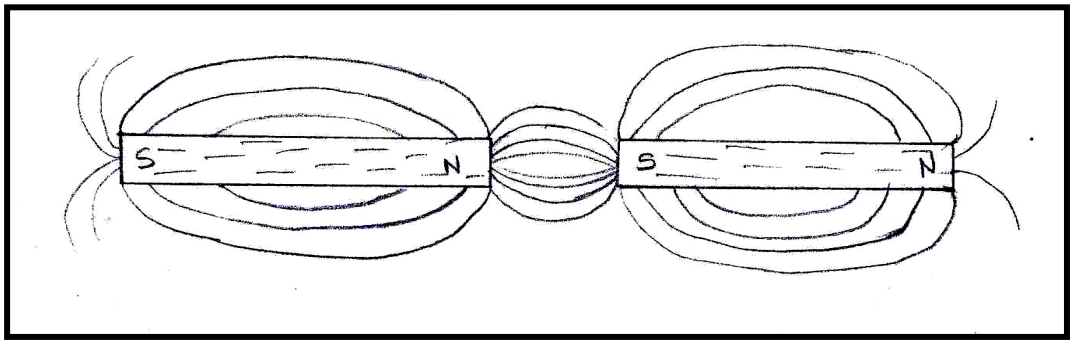


Diagram 8.2: Magnetic field lines between unlike poles-A2

Diagram 8.2 shows features that students in pair A2 deemed important and that must therefore be drawn about the pattern. How they decided to show the interaction between the poles is an important issue. The diagram shows lines starting from one pole and ending on the other. The feature is important because the aim of the lesson was to introduce the interaction of magnetic field lines and the resulting force.

They also presented the following diagram of magnetic field lines around two magnets with like poles facing each other.

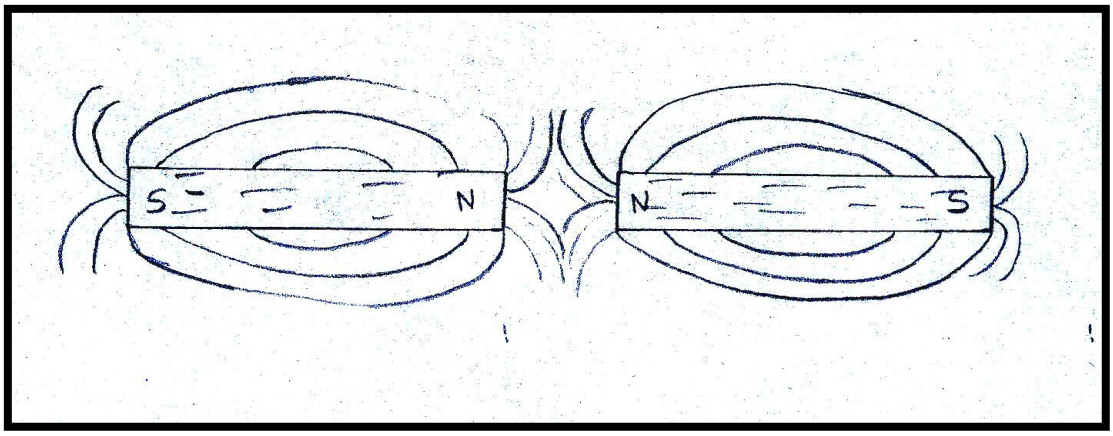


Diagram 8.3: Magnetic field lines between like poles-A2

Diagram 8.3 shows identified features similar to Diagram 8.2, except in between the poles. The notable issue in Diagram 8.3, which was not as clear in Diagram 8.2, is the number of lines on both sides of each magnet. The diagram shows the same number of lines on top as in the bottom of each magnet, starting and ending at almost the same point.

It is noted that students' tendency to label the diagrams is consistent in all the three diagrams. The main purpose of this activity was to help students to sharpen their mental picture of magnetic field lines around a magnet (Diagram 8.1) and appreciate the interaction of magnetic field lines between poles of magnets (Diagrams 8.2 and 8.3). It is difficult, looking at these features of diagrams, especially Diagram 8.1, to match them with a single Borges and Gilbert's (1998) models of magnetism. Borges and Gilbert (1998) identified five models of magnetism among different sample groups, including university students and physics teachers. Briefly, these models are:

- Model A (Magnetism as pulling): In this model the notion is that magnetism is an attraction exerted on an object in the region surrounding a magnet.
- Model B (Magnetism as a cloud): In this model magnetism is viewed in terms of the action of a region around a magnet.

- Model C (Magnetism as electricity): In this model magnetism is viewed to be arising from access of electrical charges at the end of the poles and a lack of charge at the other.
- Model D (Magnetism as electric polarization): Magnetism is explained in this model by assuming the positive and negative electric charges separated in the magnet and giving rise to its poles.
- Model E (Field Model): In this model magnetism is viewed to exist at a microscopic level as a result of electrically charged particles' motion in the atom or existing elemental magnets.

These models are found important because they can be assumed to be a general indication of students' situation definitions. It is important therefore to compare diagrams in this study with Borges and Gilbert's (1998) models.

Understanding magnetic field also required seeing the relationship between it and the current. Students studied magnetic field lines around a current carrying conductor from the textbook and the teacher led the summarising session at the end of the activity. Other stuff Discourses such as drawing and reading contribute significantly towards the process of enculturation in which students are made to see scientific learning as a process of understanding a phenomenon.

8.5.2 Talking about magnetic field patterns

An extract in Chapter 6, a portion of which is reproduced below, reflects Rethabile and Nthabeleng engaged in producing diagrams of magnetic field patterns of the kind of Diagrams 8.1 to 8.3. This includes talking about the portrayed pattern and representing it in a drawing.

> Rethabile drew a diagram showing direction of magnetic field lines. Then she stopped and looked at Nthabeleng's diagram. They discussed and then took an eraser and erased her drawing and started afresh. (2003 video transcript)

The extract above is a testimony that Diagrams 8.1, 8.2, and 8.3 are products of diverse interactions among students and inevitably between the teacher and students as earlier discussions have alluded. The extract below further highlights some of these interactions.

> Teacher- "what we have here, doesn't look like what we have there" to another group.
> Teacher - asks one student to get another magnet. The (students) start sprinkling with the guidance from the Teacher. Teacher showing students what to do
> Teacher - is with another group helping them, "you can't tell me there's no difference between this and this"
> Some students are busy drawing the magnetic fields copying from the experiment.
> One student is still sprinkling the filings and a colleague takes a ruler to try to spread the filings on the paper. (2003 Field notes)

The extract shows the following interactions between the teacher and the students and among the students.

- the teacher helps students to appreciate the differences between diagrams that they drew and the pattern portrayed by iron filings. The two phrases "what we have here, doesn't look like what we have there" and "you can't tell me there's no difference between this and this" reflects some discussion between the teacher and students. In both cases the teacher is pointing at material things and forming some connections between drawn diagrams and portrayed patterns. The teacher, not satisfied with the diagrams, is insisting that students' diagrams do not show all features of portrayed patterns.
- students were engaged in exposing the phenomenon. This included sprinkling and tapping the paper to force iron filings to portray a clearer pattern, and
- students drawing portrayed magnetic field lines patterns.

The problem though with the extract above is that it does not show any talk between students which would give a rich picture as in Rethabile and Nthabelleng's case in Chapter 6. Rethabile and Nthabelleng's case has shown that drawing of these patterns was accompanied by discussion. Episode 8.1 below shows a discussion, such as the one summarised above, between two other students, Bohlale and Tsebo. Like Rethabile and Nthabelleng, Bohlale and Tsebo presented similar diagrams to Diagram 8.1 to 8.3 at the end of the lesson. In episode 8.1 Bohlale and Tsebo are discussing a magnetic field pattern formed around the magnet, with unlike poles facing each other.

Episode 8.1

1. Bohlale Our diagram 2, um, *e etsang* (**what does it do)**, ... two magnets and
2. Tsebo Between the poles
3. Bohlale North south
4. Tsebo there is something like this, ok
5. Bohlale *ea*! (**yes!)**, something like a circle and some what's this? (Silence) between the two magnets. *Ho na le li* (**There are)** straight lines, *ha ke re*? (**isn't that so**?)
6. Tsebo *Ee!* (**yes!)**
7. Bohlale *Ea!* (**yes!)**
8. Tsebo …

In this episode Bohlale and Tsebo are trying to understand features of the magnetic field pattern that they had portrayed. The talk in episode 8.1 refers to a pattern similar to Diagram 8.2. They made the following observations

- "…something like a circle…": This talk must be referring to the lines that they drew on and around the magnet, except between them. To them the pattern shows circular lines. In actual fact, they drew these lines such that they portray a "circle" cut by a magnet.

- "…between the two magnets. **There are** straight lines…": This refers to the pattern between the poles of the two magnets. The diagram gives the contextual meaning of the word "straight" as used by Bohlale in turn 5. None of the 8 turns, in Diagram 8.2, drawn between these two magnets conform to the scientific understanding of the term "straight".

Two critical issues are observable about talk in episode 8.1. These are use of Discourses and the language that Bohlale and Tsebo used. Accordingly and inevitably Bohlale and Tsebo have identified, and talked about, two regions in their portrayed magnetic field pattern that are obviously eye catching. As practising of Discourses of science, identifying features of a phenomenon and talking about such features is an important and pertinent aspect of learning science. Bohlale and Tsebo's talk therefore shows engagement of "other stuff" Discourses whose importance both Gee (1999) and Lemke (1990) have emphasised in learning to talk science.

The language that Bohlale and Tsebo used is also of critical importance in understanding meanings reflected in the episode. Bohlale uses the phrases "…something like a circle…" and "…between the two magnets. **There are** straight lines…" in turn 5. The student's intention when uttering these phrases was to explain the magnetic field pattern around the magnet and the interaction of magnetic field lines between the two unlike poles. Both phrases reflect everyday language which lacks accuracy and precision. The phrase "…something like a circle…" reflects a situation in which precision was not an issue. The student uses a comparative language "something like". A more scientific language, showing a similar intention, could have been "they are circular". The other utterance "…between the two magnets. **There are** straight lines…" also shows similar features; that is, it lacks precision and accuracy. He says the lines between two unlike poles of a magnet are *straight*. The use of words that lack precision and accuracy is characteristic of everyday language.

Bohlale and Tsebo went further to discuss the magnetic field patterns between the like poles of a magnet, a discussion which resulted in a diagram of the form of Diagram 8.3. Episode 8.2 below shows the discussion

Episode 8.2

1.	Tsebo	This one is, is like, when
2.	Bohlale	They are going out, they don't wana (**want to)** touch each other like … like it was doing with straight lines *mane ha ke re*? (**there isn't that so**?)
3.	Tsebo	umm, they … as if it is one magnet cause this one is ...
4.	Bohlale	Ok, so you can say they are repelling here at the centre umm ok
5.	Tsebo	…

Episode 8.2 clearly has similar features to episode 8.1 above in which practising of Discourses and the language used are reflected. In this episode Bohlale and Tsebo are explaining the portrayed pattern between the like poles to each other. Tsebo's utterance, turn 3, compares the pattern with the one formed around a single magnet "as if it is one magnet". According to this explanation, the pattern formed by two magnets with like poles facing each other maintains the pattern formed by a single magnet. That is, Diagram 8.3 has similar features to Diagram 8.1. Although there is some part of this

utterance that is inaudible, Tsebo does not show the difference between the two diagrams. In the transcripts there is no episode that can clearly be linked to a discussion of Diagram 8.1. This poses some difficulty in understanding the meaning that Tsebo suggests. However, Bohlale's utterance, turn 4, is helpful in construing the agreement of the group. He uses the phrase "…they [magnetic field lines] are repelling here at the centre…" The picture that they leave is of two magnets maintaining the patterns of their magnetic field lines, similar to Diagram 8.1.

The crucial thing here is to understand the language that these students use, particularly Bohlale's utterances in turns 2 and 4. In turns 2 and 4 Bohlale is describing the pattern that is formed between the two magnets. He uses two phrases to explain this magnetic field pattern "They are going out, they don't **want to** touch each other" and "they are repelling here at the centre". The two utterances represent two worlds, scientific and everyday worlds. In the first part of the phrase, Bohlale is saying magnetic field lines *are going out*. What this phrase precisely means is problematic to the science community. It can only be meaningful in everyday language where precision and accuracy play no significant role. In addition, to say that "magnetic field lines don't want to touch each other" is an everyday language where "touching each other" has multiple meanings. In the second part of the utterance he uses a scientific term "repelling". Though the meaning of this phrase may also be problematic, characteristic of meanings from a newcomer, the phrase itself signifies a scientific way of talking about force. That is, it shows what is applying a push and where the push is applied.

The use of the word "**want**" by Bohlale, turn 2, reflects an important aspect of language. The translation comes from a "street talk", "wana". Things do not "want" in English. The Sesotho translations of the word allow Bohlale to use the word the way he is using it. Thus, the use of the word reflects the complexity of using LoLT, English, which is not the students' mother tongue. In fact, Bohlale has personified magnetic field. The consideration has to also be conceptual.

The teacher's talk, extract below, adds a valuable dimension to the understanding to the process of enculturation of students in this access programme.

> T: This is now ehh the kind of pattern which we have. Between the lines ehh *are being bent upwards* like that [*cellphone rings*] so so that emm at the end of this I have two lines emm have two lines, I mean two patterns ehh the other *one bending downwards* while the other goes upwards. Now so I have those. Now you can realize that in between here there would then be a point where these fields would not get to because *they would all be bending*. (2003 Audio transcript)

The teacher's talk above emphasises the activity, which will result in application of force, between the poles of the two magnets, which is the point of application of force. Bohlale, in episode 8.2, and the teacher in the above extract, refer to the same pattern. Bohlale says the magnetic field lines "…are going out,…" and "…repelling…" while the teacher uses the term "bending" to refer to both cases. In Chapter 6, a similar teacher's talk is discussed with the observation that the process emphasized "interaction of magnetic field lines" and "the observed application of force". It is important therefore to observe Bohlale and Tsebo's effort, in episode 8.2, in this direction.

8.5.3 Learning to talk science

The foregoing discussion highlights significant issues, unfolding in Conceptual Initiation, in relation to talking science. Firstly, the language used by Bohlale and Tsebo, as reflected in episodes 8.1 and 8.2, shows characteristics of everyday language dominated by lack of precision and accuracy. It goes without saying that without accuracy and precision the meaning in any talk is compromised. What caused this lack of accuracy and precision in this study? When interpreting the observation, the following issues have surfaced to be significant.

- Proficiency and/or use of second language: A mere inspection of the language used by Bohlale and Tsebo, acknowledging that some bits and pieces of data were not inaudible, shows that their proficiency of English, the LoLT at LP, was not the best. The challenges that Rollnick (2000) raises about the use of second language as LoLT in schools become an obvious issue. Obviously Bohlale and Tsebo lacked scientific words and expressions to use, but this was worsened by their fluency of LoLT. It has

to be noted though that they were free to use their mother tongue, Sesotho, and that at some stage they did. However, most of the talk was done in English.

- The social meaning of words: The data discussed above relates the social nature of talk to accuracy and precision of meaning. The observation to some extent agrees with Gee's (1999) claim about the social nature of talk. Gee (1999) explains the social meaning of words by using an example of a lady talking to her mother and a boyfriend. He shows that the language used in both cases, to express the same story, differs considerably. In the above episodes, Bohlale and Tsebo are engaged in a social activity and should be understandable, therefore, that the language they use can be an everyday one. It can be expected, according to Gee's (1999) argument, that their talk to the teacher about the same thing could change and the accuracy and precision of words be improved. Thus, Bohlale and Tsebo might have understood what they meant and that the scientific story was also understood. When Tsebo, in episode 8.2 turn 2, says '…they are going out…" referring to the pattern in Diagram 8.3, and the teacher says "…are being bent upwards…" the meanings are clear, especially when reference to a phenomenon is made. This marks the importance of everyday language when used at lower levels of talk. However, as talk starts to deal with abstract concepts, scientific terms become necessary.

The second issue, as reflected in this part of the study, which is equally related to learning to talk science is learning to use Discourses of science. The data above shows not only the benefit but also the interrelation between Discourses of science. Drawing of a phenomenon, as reflected by Diagrams 8.1, 8.2, and 8.3, and at the same time talking about the phenomenon, as reflected by episodes 8.1 and 8.2, signifies the relationship of Discourses to this notion of learning to talk science. Lemke's (1990) contention on what it means to talk science surfaces as an important concept. He has argued that learning to talk science includes things like learning to identify, observe, describe, compare, question, generalise, report and write. In these episodes, Bohlale and Tsebo had to identify, compare, and describe features of magnetic field patterns which were finally drawn.

The next issue, also pertinent in teaching students to learn to talk science, is the dilemma that the teacher sometimes finds him/herself in. As observed above students tended to use everyday language characterized by lack of accuracy and precision. Moje (1995) observes that it is not advisable for a teacher to emphasise precision and accuracy because doing so sends a wrong message about the nature of science. Hodson (1999:786), agreeing with Lemke, noted that

> Emphasizing the formal language of science to the exclusion of everyday ways of speaking and writing, and insisting too early in a child's science education on careful and precise language, may help promote an ideology of authority concerning science and lead students to believe that scientific knowledge is fixed and certain…

One may argue that the Conceptual Initiation stage fits well in Hodson's (1999) reference to "…too early…" The dilemma that a teacher faces when introducing the language of science is to head-on the everyday language which students use. Moje (1995) has advised that the way out of the dilemma is to show students how scientific terms develop from everyday ways of seeing and talking. The idea of learning to talk science as reflected in this study certainly addresses this dilemma.

8.6 Student – Student Communication and Communicative Approaches

The discussions (section 8.5) above have defined the Conceptual Initiation stage and illustrated the nature of Discourses that students engaged. It is crucial to reiterate the observation that students' language was dominated by everyday language which lacks precision and accuracy. To further understand the nature of the language that students used, this section presents the communicative approaches and discourse patterns that students followed in their discussions.

The analysis of communicative approaches and discourse patterns illustrated in Conceptual Initiation stage reflect both surface and deep dialogue types of interpersonal communicative approaches. The operational definition of surface and deep dialogue has been made in Chapter 4. Briefly, surface dialogue involves a communication pattern in which one student suggests an opinion and the other just accepts it. On the other hand

deep dialogue involves a communication pattern in which students do not just accept another's view but also shifts the discussion towards scrutinising it until they agree on something.

8.6.1 Surface Dialogue

Communication between Bohlale and Tsebo throughout the stage is dominated by statements that state observations. This feature of their communication influenced their discourse patterns and domination of surface dialoque communicative approach. Thus, the most common approach engaged was surface dialogue. In episode 8.3 below, Bohlale and Tsebo make observations regarding magnetic field patterns between two magnets.

Episode 8.3

1.	Bohlale	Ok, why are they the same?
2.	Tsebo	They are the same in the middle
3.	Bohlale	In the middle they are still in circles,
4.	Tsebo	Umm **(Yes)**
5.	Bohlale	Which means the field, fields lines
6.	Tsebo	The difference is where ehh near the, near this … like poles
7.	Bohlale	Ea! (**Yes**!) because it is …

Episode 8.3 shows a communication between Bohlale and Tsebo in which they compare the pattern formed by like poles with the pattern formed by unlike poles drawn earlier, Diagrams 8.3 and 8.2 respectively. Bohlale, turn 1, is astonished that the patterns look alike and poses a question "why are they the same?" Tsebo, not sharing the same view, points at parts of the diagram that look alike "In the middle they are still in circles". This is a question – statement type of interaction that these students are engaged in. The question that Bohlale, turn 1, made demands an explanation from Tsebo who, instead, offers a simple factual statement. Tsebo does not agree with the view that they are the same. It is worth reiterating that since Bohlale had asked a question, the expectation would have been an explanation from Tsebo. That explanation would show that there is a difference, except "…in the middle" and show what the difference is. Obviously, the interaction of magnetic field lines between like and unlike poles does not look alike, as also indicated in Diagram 8.2 and 8.3. If indeed he realizes some similarity then he should have been looking at the pattern around the magnets excluding the patterns in

between them. Later, turn 6, Tsebo changes his position by being more careful and says "The difference is where ehh near the near this *inaudible* like poles". Bohlale accepts this position. The interaction at this stage is therefore a statement – accept kind of interpersonal communication pattern. Students in Episode 8.3 are engaged in a surface dialogue kind of communicative approach.

The semiotic aspect of this situation, episode 8.3, has important lessons to be noted. The nature of talk that these students used remains everyday language. Tsebo, turn 2, uses the phrase "…in the middle". "…in the middle" refers to a material thing, a point, which when comparing with both Diagrams 8.2 and 8.3 shows that they do not refer to it. The scientific understanding of the term "middle" does not apply in this case, turn 2. Clearly, the word is used without any precision. However, Bohlale, turn 3, situates the meaning of the word in his utterance "In the middle they are still in circles". Comparing this with Diagram 8.3 Bohlale suggests the meaning of "middle" to refer to the sides of the magnets. This is suggested by use of the phrase "…are still in circles". Use of "near", in turn 6, by Tsebo further highlights the nature of the language that Tsebo and Bohlale use. Comparing with the diagrams, the word must be referring to "between". Bohlale still makes meaning of what Tsebo is suggesting. Two conclusions are possible from this discussion.

- The episode becomes a living testimony that meaning of words is social and distributed over artifacts. Two issues are important about this observation. Firstly, it is not clear, from studying of the meaning of words used, what are the meanings suggested by students. Secondly, communicators were able to make sense of utterances.

- The choice of words that Bohlale and Tsebo make highlights the problem of proficiency of LoLT. The mere choice of "near" instead of "between", somehow shows lack of proficiency of the language.

Toulmin's analysis of Episode 8.3 helps in construing the agreement between Bohlale and Tsebo.

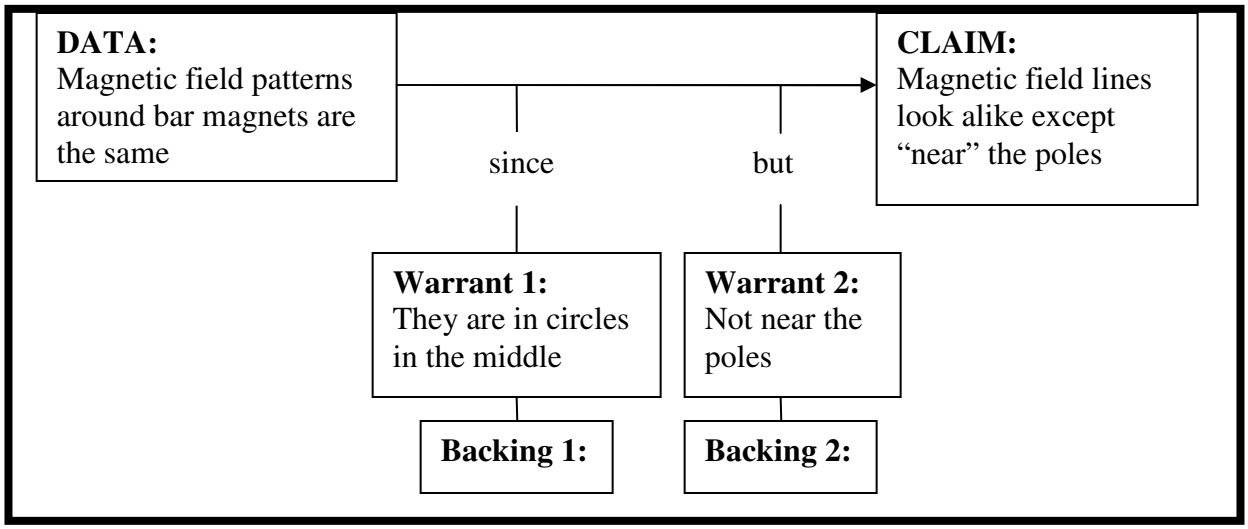


Diagram 8.4: Toulmin's Analysis of episode 8.3

Diagram 8.4 above displays a conclusion reached by Bohlale and Tsebo, that the patterns of magnetic field around two, irrespective of arrangement, are alike but not "near" the poles. To support their claim they have stated two observations, "They are in circles in the middle" and "Not near the poles", but did not back them. This analysis shows that in surface dialogue there is intersubjectivity that is reached but not with necessary support by the communicators.

The following episode highlights other characteristics of surface dialogue.

Episode 8.4

1.	Tsebo	Here is a south pole
2.	Bohlale	north pole
3.	Tsebo	and the north pole
4.	Bohlale	mmm
5.	Tsebo	So the magnetic field lines came from which *noise*
6.	Bohlale	From north to south
7.	Tsebo	to south pole
8.	Bohlale	from north pole to south pole

Episode 8.4 shows a series of statement – accept – statement kind of interaction between Bohlale and Tsebo. In turns 1, 2, and 3 the interaction is such that Tsebo makes an observational statement, Bohlale also makes a leading statement, and Tsebo makes an affirmative statement. The exception is in turn 5 where Tsebo makes a question and Bohlale, in turn 6, responds by making a factual statement.

It is worth noting in this episode, turns 2 and 7, the leading role Bohlale adopts. In turns 1 and 3, Tsebo makes a suggestion in the form of naming the parts of a magnet but even before he finishes Bohlale interrupts, turn 2, to lead him. Similarly, in turns 6 to 8 the roles remain in this form. In this episode therefore we see the role of accepting one's suggestion being substituted by a leading statement. It is also worth noting that when exercising the leading role the student is not rejecting what the other is about to say. Thus the discourse pattern, statement – accept – statement, is maintained.

In conclusion, the discussion above reflects episode 8.3 and 8.4 highlighting a communicative approach in which the communicators, Bohlale and Tsepo, are engaged in surface dialogue. Of particular interest is the level of intersubjectivity that the discussion achieves. The issue that appears evident is that such intersubjectivity hardly reflects the depth of understanding communicators share.

8.6.2 Deep Dialogue

Deep dialogue episodes throughout the entire stage were scarce. It is believed that this low frequency is related to the observation made above, namely that students tended to make observational statements with less of argumentation. Episode 8.5 shows a discussion between Bohlale and Tsebo immediately after displaying and drawing a pattern similar to Diagrams 8.1 to 8.3. The actors are discussing the success, or otherwise, of their experiment.

Episode 8.5

1.	Tsebo	Ok, our experiment has been successful from ehh in diagram 1 to diagram 3.
2.	Bohlale	… how do you know that it is successful?
3.	Tsebo	you can see … when you compare with the field, you can see, this is north to south, *ke ena* (**here it is),** you can see there some attractions, it shows like straight lines they are different, like you see from a book, right
4.	Bohlale	…
5.	Tsebo	so … you see *hore ntho tsena* (**that these things)** they are kind of repelling *ha re*? **isn't it**?
6.	Bohlale	Umm (**Yes)**, each one is, behaving as if

7. Tsebo no since there is no magnet, **yes**, so this one … been successful. So now we can draw it. (*Tape recorder tampered with.*)

Episode 8.5 shows Bohlale and Tsebo engaged in a statement – question – explanation type of discourse pattern. This pattern is a typical example of deep dialogue communicative approach in which communicators contribute towards an agreement. Tsebo, turn 1, makes a statement "…our experiment has been successful…" and Bohlale, in response, asks a question "…how do you know that it is successful?" In response to this question Tsebo, turn 3, explains "…you can see … when you compare with the field, you can see, this is north to south **here it is** you can see there some attractions, it shows like straight turns they are different, like you see from a book, right". The assumption is that Tsebo is referring to diagrams similar to Diagrams 8.1 to 8.3. Whatever the case, he makes a statement that Bohlale does not just accept but requires an explanation. Tsebo explains his point in turn 3. The discussion, turns 5 to 7, that follows shows a similar pattern and the two students in agreement.

The conclusion reached between Bohlale and Tsebo in episode 8.5 is a product of inputs from both students. To further understand the constructed meaning in the episode, the Toulmin's analysis highlights the intersubjectivities between them by the end of this communication.

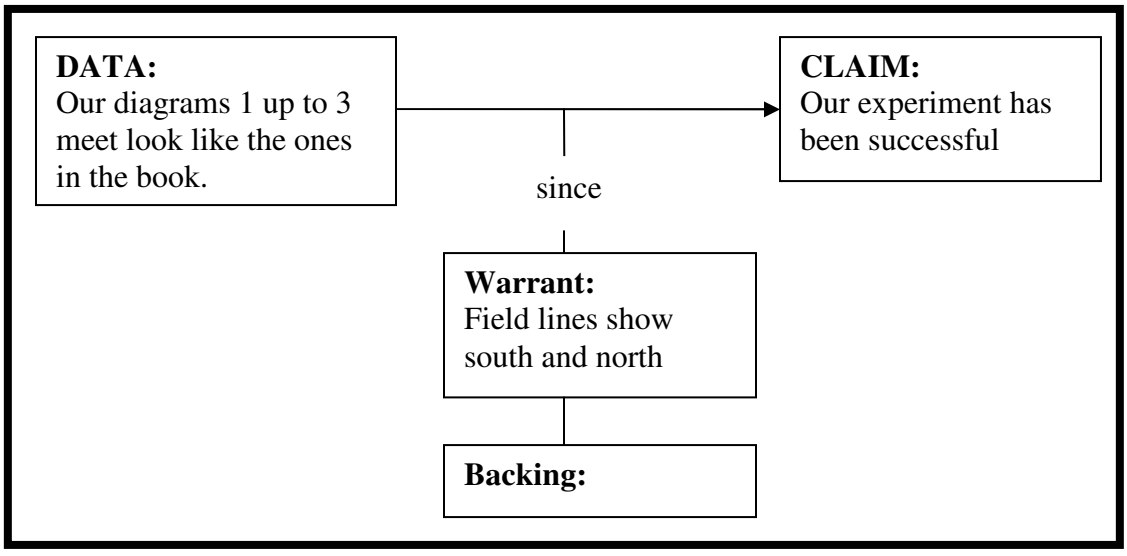


Diagram 8.5: Toulmin's Analysis of episode 8.4

Diagram 8.5 therefore shows that the claim was justified and the agreement reached by the communicators was understood by both.

Episode 8.5 exemplifies significant issues in relation to how students professed the process.

- Bohlale is happy that they achieved what is expected: The satisfaction that Bohlale shows is a consequence of how they got into the activity. It is possible that they are engaged in an activity that is not familiar and they finally achieve a product they should have been concerned about achieving. That their *experiment has been successful* refers to completing the task and to achieving an expected product, as shown in Diagram 8.5.

- They compare their diagrams with a referent. Tsebo's utterance "like you see from a book" positions a book as a way of justifying his claim "our experiment has been successful". In the utterance the authority of the book and/or its author(s) is put to the fore. The episode portrays here a "novice – expert" scenario in which the expert's voice has authority. The fact that the book is used as a way of justifying one's position is synonymous to saying "*who are we not to believe the authority*". Implied in this utterance is a cultural model (Gee, 1999) that gives some authority to textbooks.

The satisfaction of Tsebo and the implied authority of the textbook suggest an important element of identity and membership within a community. The purported success and the affirmation from the book gives Tsebo, and in a way Bohlale, a sense of belonging into a community represented by the author(s) of the book that is being referred to. While care has to be noted in order to avoid exaggeration, it is suggested here that as students learn a concept they, at the same time, struggle to become, and to be recognised as, members of a community.

- Magnetic field lines show north and south poles of a magnet. Episode 8.5 also signifies conceptual understanding that Tsebo and Bohlale have about magnetic field

patterns. Tsebo argues "…you can see … when you compare with the field, you can see, this is north to south, **here it is,** you can see there some attractions, it shows like straight lines they are different, like you see from a book, right." Tsebo claims in this utterance that he can identify a north and south pole of a magnet by merely looking at the magnetic field patterns portrayed. Obviously Tsebo, in response to Bohlale's question, compares two diagrams "…like you see from a book…" For them to see "…north to south" it implies they indicated "direction" in their diagrams. It is important to note that:

i) Authority of the book is once more acknowledged, and/or

ii) inclusion of direction proofs the power of prior knowledge in influencing meaning making.

It also has to be noted that Tsebo claims that "you can see there some attractions…" and that "…they are kind of repelling…" An important lesson though is that the episode shows conceptual understanding that Bohlale and Tsebo have about magnetic field patterns.

8.6.3 Students' Communicative Approaches

The discussion of talk above engaged by Bohlale and Tsebo, has lessons to note about the two communicative approaches engaged, surface and deep dialogue.

- Frequency and/or engagement of the approaches: Surface dialogue appears to have been engaged more often than deep dialogue. It is suggested therefore, in this chapter, that surface dialogue will often be engaged when students are making observations.

- Achievement of intersubjectivity: Students in this stage appear to agree after engagement of both surface and deep dialogue. In surface dialogue students seem to agree on observations that the other makes. In deep dialogue incidences students seem to accept the explanation that the other gives.

8.7 Concluding Remarks

This chapter has conceptualised the Conceptual Initiation stage, the second stage of the intervention. Specifically the chapter discussed Discourses appearing during the stage and in particular the introduction of talk and the associated phenomena. Issues that have immerged in this chapter are the following: meaning making process, communicative approaches and discourse patterns, and identity and membership within a community.

- Meaning making process: The results presented in this chapter demonstrate the challenges faced in the meaning making processes. The chapter observes that access students used everyday language which does not aim at scientific precision and accuracy while talking about the phenomena they were observing. There are critical considerations if this observation has to be construed in its correct perspective. Firstly, it is the issue of potential problem caused by the use and proficiency of LoLT which is not the students' mother tongue. Secondly, it is the issue of socially distributed nature of meaning of words and utterances. Lastly, it is the dilemma of addressing the precision and accuracy of words that students use and introduction of the scientific words.

- Communicative approaches and Discourse pattern: Two communicative approaches were observed in this stage, the surface dialogue and deep dialogue. When engaged in surface dialogue students followed statement – accept – statement type of discourse patterns. On the other hand, students followed statement – question – explanation type of discourse patterns when engaging in deep dialogue. The surface dialogue appears to be the dominant approach possibly due to the nature of tasks that students were engaged in. Students were mainly making an observational statement. It is crucial to observe that in both cases, surface or deep, students were reaching some intersubjectivity on the issue in discussion. However, when engaged in surface dialogue the actual content of what they agree on remains vague.

- Identity within a community: The data in this chapter reflect moments when students wanted to view their learning products in conjunction with what authority figures

would say. It is argued that this tendency gives students some element of identity as young members of a community represented by the authority figures.

CHAPTER 9

Meaning - Making

Because science involves a process of social construction of knowledge, this means that the terms, the models, and ways of seeing the world agreed upon by scientists are human products – they are not directly perceived from nature. Giving learners access to these "ways of seeing" requires more than giving them access to phenomenon. It means inducting learners into the particular ways of representing the world used by scientists and socializing them into adopting the conceptual tools of that culture. Through this process learners are introduced to a new language to represent and to describe the world around them, a language that enables them to portray the world in new ways…(Driver et al., 1998)

9.1 Introduction

The activity aspect of the analysis, whose results are presented in Chapter 6, has made the understanding of Conceptual Formulation and Conceptual Application stages clearer. It is argued, in Chapter 6, that the Conceptual Formulation stage gave students an opportunity to progressively start ventriloquating Discourses of science and that this process progressively develops until a person is able to talk with confidence and understanding. The analysis also shows that the Conceptual Application stage allowed students to situate knowledge of a learnt concept within an artifact. This chapter, like the previous one, discusses results of the semiotic aspect of the SAMPS system of Discourse analysis. Semiotic analysis, as noted in Chapter 4, concerns studying of sign systems engaged by students (Chapman, 1993; Kress, 1996). The sign systems analysed in this chapter are talk, generated at group and classroom levels, and text, generated at group level. Broadly, this chapter discusses how meanings were generated through talk and writing during the Conceptual Formulation and Conceptual Application stages. In doing so, the chapter uses data from these stages to respond to the following questions.

- How did the two stages impact on access students' talk, writing and thinking about scientific concepts?
- How did engagement of Discourses of science improve the students' learning of the concept of magnetic interaction?
- What patterns of discourse emerge as students talk about and formulate their

understanding of concepts?

Similar analysis in Chapter 8 has resulted in the following observations:

- Students at LP's access programme tended to use everyday language while talking about the phenomenon that they were observing.
- Students' communicative approaches consisted of surface and deep types of dialogue. In the former, students tended to use statement – accept – statement discourse patterns, while in the latter students tended to use statement – question – explanation discourse pattern. The surface dialogue was more frequent than the deep dialogue.
- Students tended to view their learning products in conjunction with what authority figures would say.

9.2 Description of data in this chapter

Data analysed in this chapter are drawn from the third and fourth stages of the intervention, Conceptual Formulation and Conceptual Application. The data collection methods, as described in the other two result chapters, are Journal Notes, Field Notes, Students' reports, and Video and Audio tapes. In this chapter data are primarily drawn from students' reports as well as video and audio transcripts. These data sources have been described in detail in Chapter 5.

- *Students' Reports*. Students' reports analysed in this chapter refer to assignments that are submitted at the end of the two activities; electric bell model and artifacts. The two activities are explained in section 9.3 below.
- *Video Tapes and Audio Transcripts*. Video and Audio transcripts are other sources of data to be analysed in this chapter.

9.3 Conceptual Formulation and Conceptual Application Stages

The two stages Conceptual formulation and Conceptual application have been described in Chapter 5. Table 9.1 below, extracted from Chapter 5, summarises core activities of these two stages.

Date	Hour	Topic	Meaning making activity	Report
11/09/03	6	Electric bell model	Students ➢ Studied electric bell model ➢ Formed opinion on whether to agree with designer or not	
12/09/03	7	Electric Bell Model	Students ➢ reported their views and were asked questions ➢ given a speaker or ammeter to study	➢ submit written report ➢ oral presentation
16/09/03	8 & 9	Induction	Students ➢ Studied a given passage ➢ Filled missing words in a paragraph	
17/09/03	13	Operation of speaker/ammeter	Students ➢ Reported how they operate ➢ Asked questions and debated	➢ oral presentation ➢ submit written reports

Table 9.1: The Conceptual formulation and Conceptual application

Table 9.1 summarises activities in the two stages of the intervention. The main activities are discussed below.

9.3.1 The Electric Bell Model

Discussion of the electric bell model was designed to allow students to start ventriloquating Discourses that were learned in the earlier stage, Conceptual Initiation. Activity 4 of appendix 2 shows the actual story given to students. To conceptualise the activity, Diagram 9.1, extracted from activity 4, is reproduced and discussed below.

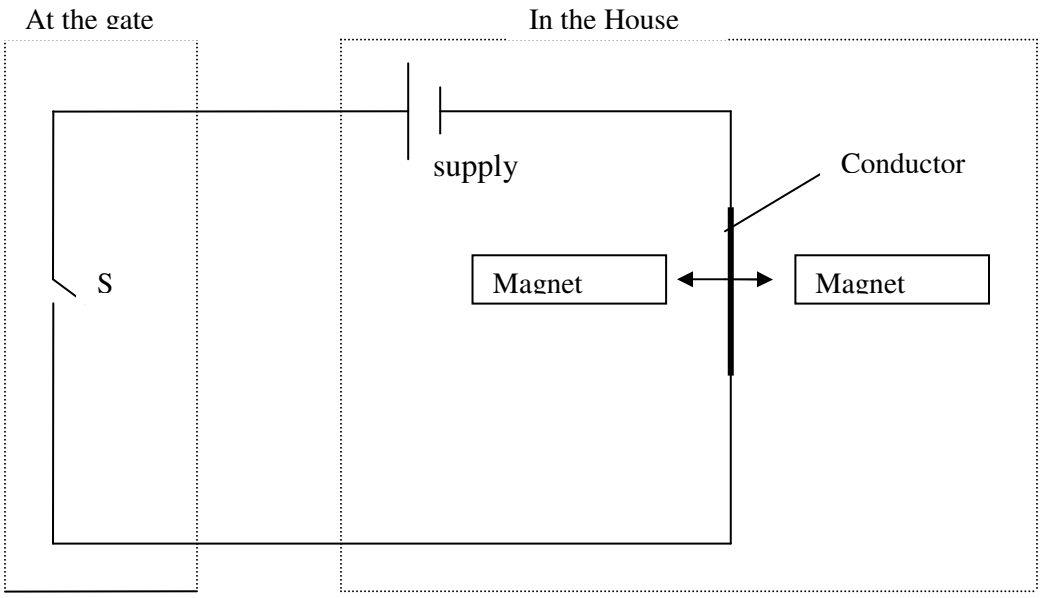


Diagram 9.1: Electric Bell Model

Students were expected to discuss the feasibility of this model working as an electric bell. The following instruction was given (see appendix 2).

> Study this design and decide whether you agree with this student. Support your answer by drawing magnetic fields due to both magnets and a current carrying conductor and hence show a resulting motion of the conductor.

The expectation was that students would consider the following issues

- The feasibility of the current carrying conductor to move as indicated in the diagram. In principle this is viewed as the main objective behind the activity. The design would not work as claimed. The central idea of discussion in the Conceptual Formulation stage was to encourage students to start ventriloquating Discourses of science. In principle therefore, the primary aim of the activity was two fold. Firstly, the activity gave students an opportunity to ventriloquate sources of the magnetic field, as magnets and current carrying conductor and practice drawing interaction of these field lines. Secondly, the activity gave students an opportunity to practice, using the language of science and/or the "other stuff" Discourses introduced in the earlier stage.

- The likelihood of production of sound if the currying conductor hits any of the two magnets.

9.3.2 The Ammeter or Speaker Activity

As indicated in appendix 2, activity 5, students were given a brief instruction. That is, to study the principle of either an ammeter or a speaker and produce a report showing how one of these appliances work. The expectation was that

- Students would open one of the artifacts and identify its components, paying particular interest to components where electromagnetism is applied.
- Students would discuss the operation of those components and produce a report, showing their findings.

9.4 Analysis

Data analysis in this chapter was handled in a similar manner to Chapter 7. A few changes were inevitable because of differences in the nature of data and purposes of each stage. This chapter studies students' Discourses displayed at Conceptual Formulation and Conceptual Application stages. Thus, different sources of data were considered and analysed differently.

The students' reports were critical at the Conceptual Formulation and Conceptual Application stages. This is because these reports, in a special way, reflect "other stuff" Discourses that could not be captured through talk due to technological shortcomings. Thus, they have to be analysed differently. Using the SAMPS system, these reports are classified under semiotic aspects. To understand the meaning signaled in this report, the following steps were taken.

- Firstly three questions were asked about each report;
  i) did students use a diagram showing interaction of magnetic field or not?,
  ii) did they refer to interaction of magnetic field lines in their report?,
  iii) did they accept the proposal and if not, why not?
- Then to understand the meaning that they attach to each diagram, a Toulmin's Framework of analysis was used.

9.5 Talk and "other stuff" Discourses

The central activity in both the Conceptual Foundation and the Conceptual Application stages was interpersonal communication between students. These communications, in both stages, occurred at group and class levels. This section discusses, and compares, the nature of talk, and Discourses in general, in these communications and the meanings generated during such communications.

9.5.1 Small Group Talk

Results of activity aspect of Discourse analysis, discussed in Chapter 6, presents talk, at Conceptual Foundation, particularly in small group level as ventriloquation between students engaged in an interpersonal communication. The same results however show that at the Conceptual Application stage, the sophistication of talk implies talking with a higher degree of understanding. Talk at this stage was referred to as Cross Pollination. Firstly, it is prudent to understand the ventriloquation, pursued from the semiotic aspect of the SAMPS system of Discourse analysis. The extract below illustrates the discussion, taking place at group level, between two students, Sello and Mahlomola. This discussion occurred at Conceptual Formulation stage and is therefore a discussion on the feasibility of operation of an electric bell model, briefly explained in section 9.3.1. This means that Sello and Mahlomola are discussing Diagram 9.1.

Episode 9.1

[**bold = translation from Sesotho,** *italic = Talk in Sesotho,* Name = pseudonym, **… = *inaudible***]

1. Sello — *Hopola, hopola ntho tsane tse tharo tseo re neng re li etsa maobane. Tsena tseo re neng re li etsa … re droea li field tsa tsa tsona … tsena. A wire carrying a current in a magnets …* Ok! [Silence] *Ha ke re ho thoe a wire carrying a current has a field around it* (**Remember, remember those three things which we were doing yesterday**. **Those ones we were doing** … **we drew our, our** field**s .. these ones**. A wire carrying a current in a magnets … Ok! *Silence* **Isn't it they say** a wire carrying a current has a field around it?)
2. Mahlomola — Mm! **(Yes!)**
3. Sello — *Ebe ho thoe direction of field …* Ok! *ke ne ke batla … eo ba reng* a solenoid and bar magnets produces the same field. (**Then, they say** direction of field … Ok! **I wanted** … **which they say** a solenoid and bar magnets produces the same field.)
4. Mahlomola — Ooo! **(Ok**!)

5.	Sello	*Ua utloa?* **(You understand?)**
6.	Mahlomola	Which means
7.	Sello	*Ha li produsa same field u nahana ho tla etsahala joang?* (**When they produce** same field **what do you think will happen**?)
8.	Mahlomola	The same field but it doesn't say anything about the direction because the field on a south pole is the same as the field in a north pole. The only difference may be direction.
9.	Sello	Ooo! **(Ok**!)

Episode 9.1 highlights a number of pertinent aspects of a situation helpful in defining vetriloquation at Conceptual Foundation stage. Actors in this episode, Sello and Mahlomola, are discussing the possible operation of an electric bell model, Diagram 9.1. The episode is extracted just after the two students started their discussion. Sello, turn 1, is recalling and thus reminding Mahlomola what they learned, in the previous lesson, about magnetic field lines due to magnets and "…wire carrying a current…" Sello is therefore forming some kind of a connection between what they learned, interaction of magnetic field lines, and what they need to discuss and decide now, feasibility of operation of electric bell model. Although Sello started by reminding Mahlomola yesterday's discussion he ended up confused and finally posed a question. What causes this confusion? The response to this question lies in the fact that Sello's talk is a ventriloquation in which recollection and starting to use Discourses, particularly talk, are brought together in a complicated manner. It is important to also note that Sello is not merely ventriloquating what they were "told" but what they "did". Reference to "**things which we were doing yesterday**." does not refer necessarily to actions only but rather to what was learned in the previous lesson. Thus Sello's talk characterises ventriloquation at Conceptual Formulation as a way of further internalisation of concepts.

Sello, turns 1 and 3, recollects two critical issues about magnetic field; "a wire carrying a current has a field around it" and "a solenoid and bar magnets produces the same field". The first phrase, "a wire carrying a current has a field around it", states a scientific observation. It is noted though that Sello does not use the descriptor "magnetic". It can only be assumed that he believes that it is clear that the discussion is on magnetic field and not electric field for example. This is an example of what Edwards (1997) referred to

as *Pragmatic intersubjectity i.e.* what their talk treats as shared and thus needs no further deliberation.

The second phrase, "a solenoid and bar magnets produces the same field", needs unpacking. The implication in this phrase "…produces the same field" is one that needs some understanding. The following considerations are pertinent. 1) What do Sello, and in a way Mahlomola, understand by **producing the same field**? 2) Do they relate this phrase to interaction of magnetic field lines or not? A closer look at this phrase suggests that the utterance has connotations of an end product rather than a process. That is, the critical word in this utterance is not "produces" but rather the word "same". If this is so, then the utterance refers to the pattern and not the process of interaction of magnetic field patterns. Sello claims that the pattern of magnetic field lines around a solenoid and a bar magnet look the same. It has to be noted though that Sello used the utterance "they say". There are at least two implications of this utterance. Firstly, the utterance puts some element of somebody's or a community's authority to the fore. According to this interpretation, the utterance carries "truth" that is learned, and/or given by somebody out there and this "truth" cannot be challenged by the actors, Sello and Mahlomola. Thus, the first implication relates to the nature of science and how students view scientific knowledge. Secondly, the utterance suggests that what follows is a recollection. That is, one is recollecting what somebody, with some authority said. It is the latter implication that assists to construe Sello's utterance as merely a recollection of the given, the pattern, and not the process. That is, Sello is using the word "same" to show similarity of magnetic field lines around a bar magnet and from a solenoid. The actors are not necessarily discussing the process of interaction of magnetic field patterns in this episode.

Mahlomola has used the word "same" differently in turn 8 when responding to Sello's question, in turn 7. The question wanted Mahlomola's view on what might happen if a solenoid and a magnet produce the "same field". Mahlomola says "…the field on a south pole is the same as the field in a north pole…" and Sello concurs in response. This time Mahlomola is referring to the nature of the field pattern. The first part of Mahlomola's utterance, turn 8, suggests that the situation definition of Mahlomola's "same fields" must

include direction. Mahlomola's response in turn 8 is also not making mention of the interaction of magnetic field.

The issue that concerned actors, in particular Mahlomola, in episode 9.1 was the direction of magnetic field lines that was not stated. In the model, the direction that was not known was of magnetic field lines due to magnets. That direction would be determined from the labeling of poles of the two magnets in the diagram. Sello, turn 6, after recollection of magnetic field lines properties asks Mahlomola "**when they produce** same field **what do you think will happen**? Mahlomola's response, turn 8, includes "…it doesn't say anything about direction…" Mahlomola has a point. In order to deal with the concept of interaction of magnetic field lines pattern it is critical to know their direction. However, in Chapter 7 it is shown that students had some definition of direction of magnetic field lines that makes understanding of their situation definition somehow difficult. It is not clear why absence of mention of direction impeded them. Perhaps it is prudent to question the absence of labeling of magnets as posing a problem. There is no data to support a response to this question but it is supposed that the problem had to do with the students' perception of science and scientific knowledge, namely the way students perceive scientific knowledge as the known and given. Evidently, the intention of allowing students to start using interaction of magnetic field lines in their argumentation was negatively influenced by absence of this labeling.

The labeling of Diagram 9.1 was left without details to encourage students to make decisions that will allow them to explore all possibilities. The episode below emphasises the purpose.

Episode 9.2

1. Mahlomola *Re ne, re ne re botsa hore na monana re nka magnet ona ele li-north pole kapa re ka decida feela?...* (**We were, we were asking if here we can assume this** magnet **to be having north poles or we can just decide?...)**
2. Teacher *Ea!* just decide (**Yes**! Just decide)
3. Mahlomola Oh! *re ka decida ka borona hore na ebe e tje. Re ka nahana hore ho tla ba joang?* (Oh! **We can decide ourselves whether it should be like this. We can think of what will happen?**)

4. Teacher *Mm!* … **Yes!**

Episode 9.2 reflects an incident where the teacher visited Sello and Mahlomola's group as he was moving from one group to another. He is asked by Mahlomola whether they, Sello and Mahlomola, should decide on the labeling of the diagram. The teacher, turn 2, encourages them to do so. Making decisions is perceived to be a critical part of "other stuff" Discourses in science. Hence the decision that led to allowing students to make decisions and scrutinise them.

On the other hand, Sello's two phrases in episode 9.1 "a wire carrying a current has a field around it" and "a solenoid and bar magnets produces the same field." highlights usage of everyday language in the students' communication. The usage of the word "wire" and not "conductor" in the first phrase suggests that the conduction properties of a material are assumed. It is also important to note that the subject in this phrase is the "wire". Similarly, the usage of the utterance "…produces the same…" in the second phrase lacks precision. It is argued in Chapter 8 that the use of words and/or phrases which lacks accuracy is typical in everyday language.

The transcript of Sello and Mahlomola reflects students' difficulties all the way due to the absence of direction of magnetic field lines. The episode below, extracted towards the end of their discussion, highlights their predicament.

Episode 9.3

1. Mahlomola *Hae monna! ntho tsena li tla tsoarisa motho hlooho tsena.* **(No man! these things will make one crazy)**
2. Sello *Hee uena monna! 'na ehlile ke lumellana le* designer. (**Hey man! I really agree with the** designer.)
3. Mahlomola *U lumellana le eena?* (**Do you agree with him/her**?)
4. Sello *Mmm!* **(Yes!)**
5. Mahlomola *Ka mabaka a fe?* (**What are the reasons**?)
6. Sello [There is background noise] *Ka hore ntho tsena ha eka ba li-***(Because if these things are)** south poles there will be that attraction. The field will be showing the the attraction the attraction this side and … attraction this side …
7. Mahlomola *Ka mokhoa ono ene e kanna ea ba re iphokoletse mosebetsi, oa bona! Re re feela re lumellana le designera hobane* **(In that way we might**

be making our task easier, you see? We should just say we agree with the designer because)

8. Sello *re re …* (**we are saying …)**
9. Mahlomola *Taba ke hore na re tla re ntho e tla produsa sound ke e feng? Hobane u ntse u hopola* (**The issue is, what should we say produces sound? Because you still remember**)

Episode 9.3 also adds to critical aspects of a situation that defines ventriloquation at Conceptual Formulation stage. The episode reflects actors, Sello and Mahlomola, at the verge of making a decision of agreeing with the designer. That is, they are about to accept the suggestion that the proposed electric bell model can function as an electric bell. Sello, turn 2, signals concurrence that the design will function as an electric bell. His justification, turn 6, is "**Because if these things are** south poles there will be that attraction. The field will be showing the … attraction … this side and … attraction this side …". This justification signals intention of employing the interaction of magnetic field patterns. Perhaps it is important to note that at least two issues are implied in the phrase;

- "…**if these things are** south poles there will be that attraction." This utterance suggests that like poles will attract. Data in Chapter 7 however suggests that Sello did not mean it. The critical consideration then is why did Mahlomola, in turn 7, not correct Sello. His statement accepts the suggestion just made. Is he accepting because they were stuck or because he did not understand the suggestion?

- "The field will be showing the…attraction … this side and…attraction this side". It is not clear how attraction can be reflected on both sides. It is assumed that the "sides" refer to regions between the current carrying conductor and the two magnets. If Sello was considering interaction of magnetic field lines then attraction could not result on both sides. It can only be assumed that he was simply making a claim. Such a claim reflects ventriloquation but at a stage where there are facts that a student already appreciates.

Mahlomola's response, turn 7, summarises the group predicament. He says

> "**In that way we might be making our task easier, you see? We should just say we agree with the designer…"**

This utterance is an admission of being completely stuck or a sign of wanting to fulfil the required task. However, in turn 9 Mahlomola realises a catch "**The issue is, what should we say, produces sound?**" The earlier utterance was a shortcut but they are left with having to consider the last issue; what will produce sound? Incidentally, it is this consideration that influenced them to change their minds and disagree with the designer.

The justification employed by Sello, turn 6, also sheds light on the nature of the language that students engaged in this episode. When this claim is subjected to Toulmin's framework of analysis, it is evident that the argumentation had shortcomings. The utterance "…**if these things are** south poles there will be that attraction." is not supported by any backing. Similarly, the second part of the phrase is not supported by evidence. This is again typical of influence of everyday language, where the supporting argument is not given priority.

It is crucial at this juncture to define and further understand characteristics of ventriloquation as a central activity in Conceptual Formulation. The foregoing discussion identifies the following characteristics as defining ventriloquation.

- Recalling and mimicking: The two episodes, 9.1 and 9.3, characterise actors, mainly recalling and mimicking the written or spoken talk made in earlier lessons. Students tended to use utterances such as "you remember…" or "they say…" which reflects recollection of what was said. Sello's utterances in episode 9.1 for example, turn 1 and 3, clearly reflect mimicking of talk made earlier. Similarly, in episode 9.3, turn 6, Sello is mimicking what can be regarded as backing of his earlier position. The fact that it is argued that Sello is not claiming that "like poles attract", suggests that the utterance "**Because if these things are** south poles there will be that attraction." is a mimicking of an earlier talk done without understanding.

- Reference to product than to process: The data discussed above shows students referring to the product of interaction of magnetic field lines, resultant motion, and not to the process itself. Therefore the talk at this stage highlights awareness of a process that results in a comprehensible product. Although an indication is made that

this is not enough, it must be noted that that students realise existence of what causes force is a valuable addition to the students' register of force.

- Reference to authority: Utterances such as "they say…" implies a third party whose authority is noted and whose word must be accepted. In other words, students viewed themselves as novices and that there exist experts elsewhere.

- Transparency: The data above shows visibility of absence of labels in Diagram 9.1 to have affected students' talk. Evidently, talk during this stage was handicapped by absence of labels in some cases.

- Use of everyday language: The talk between Sello and Mahlomola reflects the use of everyday language which lacks a scientific backing.

Having defined talk as ventriloquation in Conceptual Formulation, it is appropriate to understand talk occurring as Cross Pollination between students, in Conceptual Application. The talk that students engaged during this stage is perceived to be critical since it is expected to reflect a higher degree of fluency in the use of Discourses in general. That is, it is expected that students talk, or at the least mimick, with some understanding of scientific knowledge in discussion. In episode 9.4 Kabi and Thabiso are discussing the functioning of the coil in the ammeter at group level.

Episode 9.4

1	Thabiso	*ha ke re ua bona ho na le, le* those ehh those what ehh coil around this, this ehh wire here?(**Do you see that there is** ehh those what ehh coil around this, this ehh wire here?)
2	Kabi	Ok! *Nthoena ua tseba…* [interrupt] (Ok! **This thing you know …)**
3	Thabiso	*Ua e bona?* (**Do you see it**?)
4	Kabi	[continues] *maneneng, ua hopola nthoela re itse ha re re ke* north*, ke* south *ka nqenana, nako eo lintho,* this field, field *li tsoang ka ka ho* north *le tsane li, li lo kena ka ho* south *ka mola? E ea holimo, oa bona? Joale* in this way *ha ke re rea tseba ha e ka re ha ele* north*, ha ele* north *ka lefteng* (**over there, you remember we said if this, this is the north, its** south **this side, by the time these things,** this field, field **comes out of the** north, **and those also**, **also gets into the** south

		this side, it will go upwards you see? Now, we know, isn't it?, that if it is north, **if it is** north **on the left**
5	Thabiso	south [talking at the same time]
6	Kabi	south *ele ka righteng,* direction*, ka hobane e hlaha ka northeng ntho, ntho,* this wire *etlo ea holimo, ha ke re?* So*, rona mona re ka nka* wire *ele ngoe feela ea* coil *ena, ra inkela ele ngoe feela, ra e sheba hore na e beheifa joang. Joale ha re sheba re fumana hore moo* wire *ena,* wire *enaa e tlo tla e etsa, ua bona, e kanna ea ba* current*,* direction *ea* current *e fapane le eane e maneneng, ke mokhona e ka eang tlase. Ok! ka nqena, ka nqenaa ha ke re ua tseba ha u ka chencha li* magnets*, ua li soapa, ntho* direction *ea ntho, ea, ea, ea,* that wire, motion *o tlo tla o chencha … e tlo tla e chencha e so tlo tla e ea fatse, ha ke re? Ha u ka chencha* direction *ea* current *kapa ua chencha li* magnets. (south **on the right,** direction, **because it comes from the north, this, this,** this wire **will go upwards, isn't it?** So, **we can consider just one** wire **of this coil, we consider just one, and study how it behaves. Now if we study this we find that where this** wire, **this** wire **will, you see, maybe** current, direction **of** current **is opposite to the one over there, this is why it may go downwards.** Ok! **This side, this side you know, isn't it?, that if you change the** magnets**, just interchange them,** this direction **of this, of, of, of,** that wire, motion **is going to change** … **it is going to change and go downwards, isn't it? If you change** direction **of** current **or change the** magnets.
7	Thabiso	*Ua isa* north *ka nqele, ee ka nqela … e phushe, e phushe* **(you take** north **that side, this that side** … **it pushes, it pushes**
8	Kabi	*e se tlo tla e ea tlase* (**it is going to move downwards)**
9	Thabiso	*e ea tlase* (**it moves downwards)**
10	Kabi	*Mmm ee*! (**Yes! Yes!)**

The two actors, Kabi and Thabiso, had identified different components of the ammeter and in episode 9.4 are now trying to make sense of the functioning of the coil. Kabi, turns 4 and 6, spends some time explaining the resultant motion of the current carrying conductor. Perhaps the power aspect of SAMPS system is reflected in this episode. The domination, reflected by the length time taken by Kabi, highlights some element of distribution of social goads during the communication. It was observed that Kabi later become a central player when other students joined their group. Kabi did all the oral presentations. Though there is not enough data here to explain this phenomenon, why Kabi appears to be doing most of the talking, it is evident that there was an element of distribution of social goads in this group.

Kabi, turn 4, commences his response to Thabiso's question, turn 1, by reminding him that

> "…**you remember we said if this, …is the north, its** south **this side, by the time these things,** …field **comes out of the** north, **and those also**, **… gets into the** south **this side, it will go upwards you see?…**"

In response to Mahlomola's question in this utterance Kabi is forming connections between what they are studying and what they learned earlier. While forming these connections Kabi uses personal phrases "…we said…" as positive signs of engagement. The use of personal phrases such as this one shows a shift from recognition of authority figures, as indicated in Conceptual Formulation, to viewing communicators as important players. That is, Kabi's talk reflects actors recognising their views, and/or conclusions, of what is being discussed as having necessary weight. Such a tendency is a positive step in learning viewed as enculturation.

Kabi, turn 6, utters a variety of pertinent claims in relation to the motion of a conductor and magnetic field lines. He claims

> "…**Now if we study this we find that where this** wire, **this** wire **will, you see, maybe** current, direction **of** current **is opposite to the one over there, this is why it may go downwards**…"

Kabi, in this statement, is concerned about direction associated with two material things "…**this** wire…" and "..**the one over there**…" Thus, the conclusion he makes, "…**this is why it may go downwards**…" is based on consideration of these two directions. This utterance further underlines the importance given to direction of magnetic field lines by students. Kabi and Thabiso were expected to talk about interaction of magnetic field lines due to magnets and the current carrying conductor. As noted above, during Conceptual Formulation stage, direction of magnetic field lines appears to have been a challenge. In this utterance however, turn 6, Kabi uses it as the necessary evidence to justify the resultant motion. He does not refer to what will happen to magnetic field lines directed opposite to each other. The talk therefore reflects awareness of the process but does not go as far as discussing it in detail. Awareness of the process, is an important aspect insofar as the understanding of definition of force is concerned.

Kabi also claims, turns 6 and 8, "…**If you change** direction **of** current **or change the** magnets…" and "**it is going to move downwards**". The claim alone carries an ambiguous meaning, "**change the** magnets…". Changing magnets may not necessarily affect direction of the motion of the conductor as Kabi claims. If Kabi is referring to "change of poles" then the utterance is an example of a case where accuracy is compromised. Thabiso constructed a different meaning, and most likely what Kabi intended, of this claim. That is, he understood it to mean changing poles of magnets. It is interesting to imagine why Thabiso constructed this meaning. Throughout the cause of this explanation, turn 6, Kabi did not use "changing poles" but rather used "changing magnets". The episode is not helpful in shedding some light on why Thabiso constructed this meaning. It remains evident that "something" contributed towards this meaning making. There may be many possible explanations. For example, it is possible that there are gestures that Kabi used, and could not be captured by the audio recorder. Another option would be that they were discussing a diagram. Whatever, that "something" is, it is clear that this talk is situated on some kind of artifact.

Episode 9.4 further highlights Kabi's, and in a way Thabiso's, meaning of direction of magnetic field lines. Kabi, turns 4 and 6, claims "…**if it is** north **on the left** … south **on the right,** direction, **because it comes from the north**…". This meaning, direction portrayed as a material thing that comes from the north, has occurred in different episodes in different stages of the intervention.

Episode 9.4 above reflects talk, between students at group level, during Conceptual Application stage, as highlighting the following issues;

- Product versus Process: Kabi's suggestion to study "one wire" of the coil clearly suggests studying of the interaction of magnetic field lines. During this stage therefore students were able to determine direction of magnetic field lines and thus could concentrate on the process. It has to be noted however that they only make reference to the process.

- Acknowledging Authority: During this stage students were beginning to use personal phrases such as "we said" which is viewed to acknowledge their participation in learning as being important. Students are beginning to reduce their dependence on authoritative figures to develop scientific arguments.

- Lack of accuracy: The words that Kabi used reflected lack of accuracy. However, Thabiso constructed a plausible meaning. This is interpreted as showing the situatedness of meaning. Audio taping could not capture other Discourses such as drawing and gestures. Because of this situation, it is not clear why Thabiso was able to construct this meaning. These "other stuff" Discourses are pertinent in meaning making.

This section has presented data, in the form of talk, extracted from the last two predetermined stages of the intervention; Conceptual Formulation and Conceptual Application. The talk further defines the emergent categories of ventriloquation and cross pollination discussed in chapter 6. Perhaps it crucial to note that, when interpreting these data, their primary sources are different pairs of students and therefore it is not wise to make comparative claims. In ventriloquation talk is, and in general Discourses are, used to share ideas, but, and most importantly, in a mimicking form. The discussion above shows that ventriloquation is characterised by recollection of past experiences and consideration of products rather than the process. The recollections that students make can either take the form of what was said or done by the teacher or by the students. The link that students make between recollection and conclusion during this stage can be weak. For example, in episode 9.3, turn 6, Sello forms a weak claim between "attraction" on both sides of the magnet and the existence of south poles. As argued above Sello does not show why attraction happens in both sides. Nor does he relate it to the process of interaction of magnetic field lines. In addition, in episode 9.1, Sello is merely using phrases which were said in the previous lesson, according to his recollection. Ventriloquating talk therefore marks an important stage where students are beginning to use Discourses of the aspired community. In cross pollination, talk reflected expression of what a student wants to say. The conclusion above, in relation to the process, is

critical in defining this emergent category. In episode 9.4, turn 6, for example, Kabi discusses interaction magnetic field lines and in turns 9 and 10 they reach a conclusion. A central issue here is that students construct meaning by studying the process that will lead to some level of intersubjectivity.

It is necessary to reiterate what is new, concerning the emergent categories and the Discourses that students engaged. Students, coming from a culture that is dominated by teacher lead activities and learning in second language, are finally talking and sharing meaning. They express Discourses of science to construct scientific meaning of concepts. Evidently, both ventriloquation and cross pollination have contributed towards meaning making of concepts. Literature, discussed in chapter 3, could be used to predict some degree of progressive development of engagement of Discourses from ventriloquation to cross pollination. According to Duran *et al.* (1998) and Setati *et al.* (2002), for example, this trend could have been predicted. Setati *et al.* (2002) have argued that there are different trajectories that one can follow to develop talk, from informal exploratory talk to formal discourse-specific talk. Thus, Ventriloquating talk, though not necessarily informal, can be expected to develop to cross pollinating talk. The next section discusses talk from Kabi and shows that talk developed from vetriloquation to cross pollination.

9.5.2 Whole Class Talk

Class talk refers to reporting that is done by students. It refers to reporting of conclusions, regarding assignments discussed in sections 9.3.1 and 9.3.2, and discussions that immediately followed the presentation. The talk discussed in this section happened at the end of Conceptual Formulation and Conceptual Application. Analysing class talk is critical insofar as it enriches understanding of talk in these predetermined stages and most importantly in highlighting the progression from ventriloquating talk to cross pollinating talk.

The extract below is the oral report made by Kabi at the end of Conceptual Formulation. Kabi is discussing the feasibility of the electric bell model performing the claimed function (see section 9.3.1). He started by drawing the following diagram on the board:

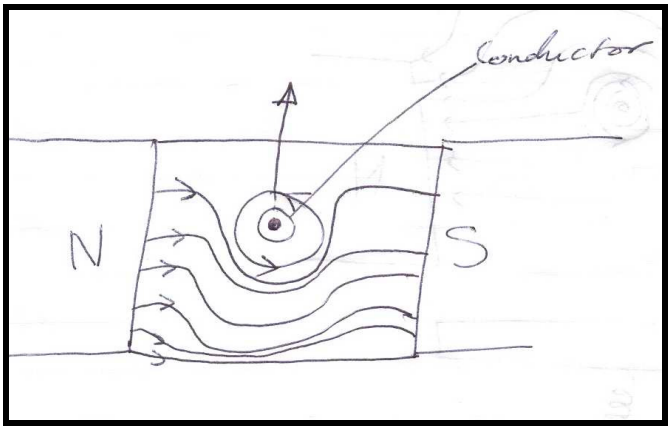


Diagram 9.2: Students' analysis of Electric bell design
(Reproduced by researcher)

Then he explained

Kabi: Ehhm Here we said the conductor is between two metals, two two magnets and the magnets have the magnets have these field lines going from north to south. And when closing the the the switch, the conductor will have that anticlockwise movement of anticlockwise movement of ehh the magnetic field around it. So we think this this conductor will go up instead of hitting the magnets because as we see here there are more, there are more, there are more magnetic field lines under this below this conductor. So suppose we, suppose we say this magnetic field lines are some stretched elastic elastic, some stretched elastic elastics, they will try to straighten up because this direction because the the direction below this conductor …the direction is the same of the conductor, of the magnetic field around the conductor and the the north side because here we see that the magnetic field of the conductor opposes with this ehh with with the magnetic field from the north, we think it will be weaker here than this side. So due to this ehh we think this conductor will go upwards instead of hitting this and that means that there will be no electric bell. (2003 Video Transcript)

Kabi's talk in the extract above is summarised into the following points

- the electric bell model comprises a conductor between two bar magnets,
- the two magnets have magnetic field lines whose direction is from north pole to south pole,
- the conductor will have magnetic field lines directed anticlockwise,
- there are more magnetic field lines below the conductor,
- magnetic field lines will behave like "stretched elastics", and
- the conductor will finally move upwards.

The above summary shows how Kabi's talk acts as a testimony to the degree of impact of the Conceptual Formulation on students' learning. There is no doubt that Kabi's group was able to unpack the story and hence decide on the feasibility of the electric bell model functioning as claimed by its designers. It is proper to understand Discourses reflected in this extract. The presenter in this extract is defending the view of the group, summarised above, that the electric bell model will not function as the designer claims.

The extract above explains features shown in Diagram 9.2. To further understand the views expressed in this extract, Diagram 9.3 below summarises arguments assumed to form the core of Kabi's presentation.

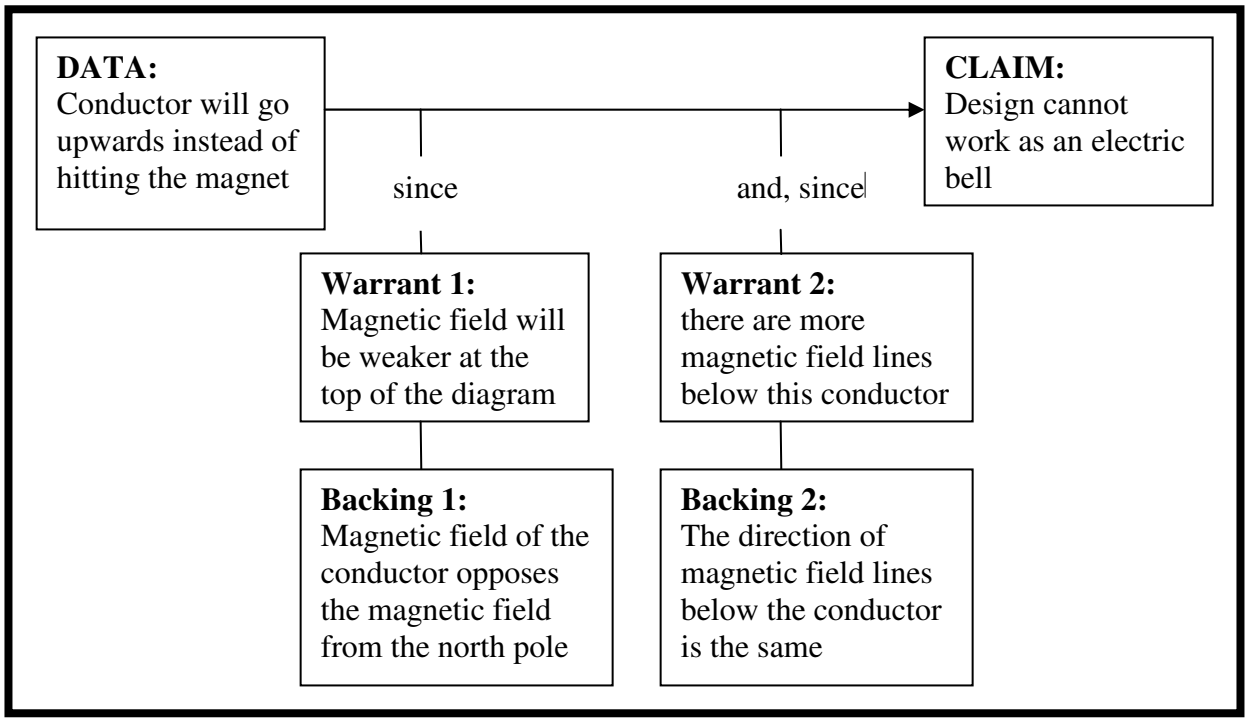


Diagram 9.3: Toulmin's analysis of Electric bell design

The Toulmin's framework demonstrated in Diagram 9.3 reflects a well thought argument. The students in the group, represented by Kabi, have considered the effect of interaction of magnetic fields at points of interaction. However, discussion of interaction of magnetic field lines is taken as given.

In the extract above Kabi mentioned the direction of magnetic field lines. The students use the utterances "…the magnets have … these field lines going from north to south."

and "…the conductor will have that anticlockwise movement of …the magnetic field around it." In the first utterance the student is saying "…field lines *going* from north to south..." The usage of the word "going" does not only highlights direction but also a physical motion from a certain point, north, to another point, south. Similarly, the second phrase reveals a physical circular motion of something. The student argues "…the conductor will have that anticlockwise movement…" The student is therefore using direction of magnetic field lines in a manner that implies physical motion of magnetic field lines.

The phrases above show an important feature of the language that students used too. The students tend to use everyday language in which scientific meanings are not expressed accurately. The student uses two phrases to refer to density of magnetic field lines above the conductor and below "…there are more magnetic field lines under this below this conductor." and "…we think it will be weaker here than this side." In these phrases the student uses the words "more" and "weaker" to compare between the situation above the conductor and below it. The two words have different connotations. The word "more", as used in the phrase, refers to the quantity of magnetic field lines, while the word "weaker" refers to strength of magnetic field lines and therefore, by assumption to force. The third phrase "… they will try to straighten up…" have a similar connotation. It is not clear what the intended meaning of "straighten up" is.

The obvious characteristic in the extract above is the repetition as the student talked. For example, he says "So suppose we, suppose we say this magnetic field lines are some stretched elastic elastic, some stretched elastic elastics…". In this phrase the student said "suppose we, suppose we … stretched elastic elastic, some stretched elastic". The repetition signifies thinking about what to say. This thinking about what to say is symbolic of talking, using a language that one is not so fluent in. The analogy that Kabi uses "…stretched elastics" is also an interesting idea. The analogy sheds a picture in which Kabi is thinking of the force, resulting from the interaction of magnetic field lines, as a reaction force in which something is "stretched" and then applies force in an attempt to "straighten up". Kabi is suggesting that the conductor is pressing magnetic field lines

downwards and the magnetic field lines, in reaction, push the conductor upwards. It is clear then that because Kabi and his group mates did not discuss the interaction when magnetic field lines meet, they had to find a seemingly scientific reason.

Kabi's presentation, in the extract above, contributes towards further understanding of ventriloquation which is core to Conceptual Formulation. Discussion of this extract reflects the following

- Direction of magnetic field lines: Kabi's talk in the extract emphasised the view that students use direction of magnetic field lines to imply a physical motion of something from the north pole to the south pole of magnets or around a current carrying conductor.

- Use of everyday language: The extract reflects Kabi maintaining use of everyday language to express scientific concepts. The major problem is that the intended meaning is left unclear.

- Use of "other stuff" Discourses: The discussion above shows Kabi employing "other stuff" Discourses to express the group's conclusions. The outstanding Discourses are reflected when
  - he drew Diagram 9.2 that is used to explain the view of the group, and
  - he justified his claims. The justifications are shown in Diagram 9.3.

As noted earlier, Conceptual Formulation stage has had a recognisable and fruitful impact on the learning of interaction of magnetic field lines. Evidently students are able to talk about scientific concepts in a much more scientific way. The extract further adds to this conclusion an important element about the stage. That is, by this time students were already engaging "other stuff" Discourses to make meaning of concepts. This further supports the understanding that ventriloquation is a process starting from mere mimicking of talk to some stage where one is able to talk about concepts with some understanding and confidence.

The extract below illustrates the oral presentation, given by Kabi in Sesotho, on how a speaker functions. This talk occurred at the Conceptual Application. He first drew Diagram 9.4 below. The diagram is reproduced from notes taken during the presentation by the researcher for the purposes of Journal notes.

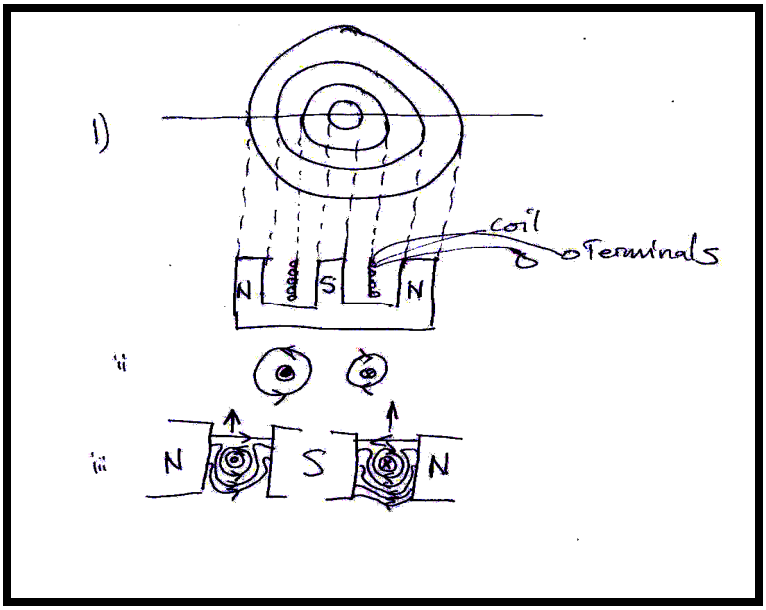


Diagram 9.4: Student's illustration of Operation of Speaker

Diagram 9.4 was drawn in 3 steps, (i) to (iii). Kabi started with part (i) before commencing to talk and then drew parts (ii) and (iii) as he presented. The extract below is a translation of talk in appendix 9.

Kabi: Ehh We came up with this *inaudible*. We, **that is**, *stops and add to the drawing(ii)* Ehh **We viewed this speaker in this way with my colleague. We, this thing, this speaker, here this is, this is when you view from above**. **Here it is if, isn't it that if you cut here you will see this things like this? Here is a** Coil, **here is a** coil, **and then a circular magnet is here. We took this one as** north, **and the we took this one as** south. **Then we have terminals connected here**.

Then we said, we said if current**, if this** current, **here if we view it from here, we find** current **going this way**, **this side we said** current **is in this direction**, **there is** current **in this** coil, **if you, if you cut it this way**, **and view it this way**, **you see it is going away**, **if you view it from this side it looks like it is coming towards you**. **Now, we said, we said** *stops and adds drawing(iii)* ehh **here we said this thing here, this** current, **because** current **here is going this way**, direction **is** anticlockwise. **Here where, where it is coming to you, where it is going away**, *interference from group mate*, **here because** current **is**, is going away **we said this thing,** field lines **are**

clockwise, **isn't it**?(*to his groupmate*). **Here where it is coming towards us they are going** anticlockwise. **Then, when we came to draw this thing here looking at** interaction**s** of the field lines **we found that** north, **when they they because the** field lines **come from the** north **they will not interact with this ones, of this thing, of the** wire. **We took one** wire **of this coil here**, **we took only one** wire. **Then we said this thing will cause this** wire **to go upwards. Because of this** interaction, **when we determine it here, we find that below** direction **is the same, that means there will be a number of them here below, the** field lines. **Similarly this side will also have a number of them**. **Then we took it that this thing will go upwards. Then when we connect a battery to this speaker, it will go upwards because of this here**.

In this extract Kabi is explaining how a speaker operates. The first part of the extract was an introduction of the diagram in which he is introducing the parts of a speaker. In summary this is what Kabi says

- A speaker has a coil, a circular magnet with north and south poles, and a coil connected to terminals,
- There will be a current in the coil, with one side of it showing a current coming and another showing a current going,
- There are field lines around current carrying conductor,
- Field lines interact, and
- Interaction leads to upwards motion of conductor.

Diagram 9.5 below presents an analysis of Kabi's presentation.

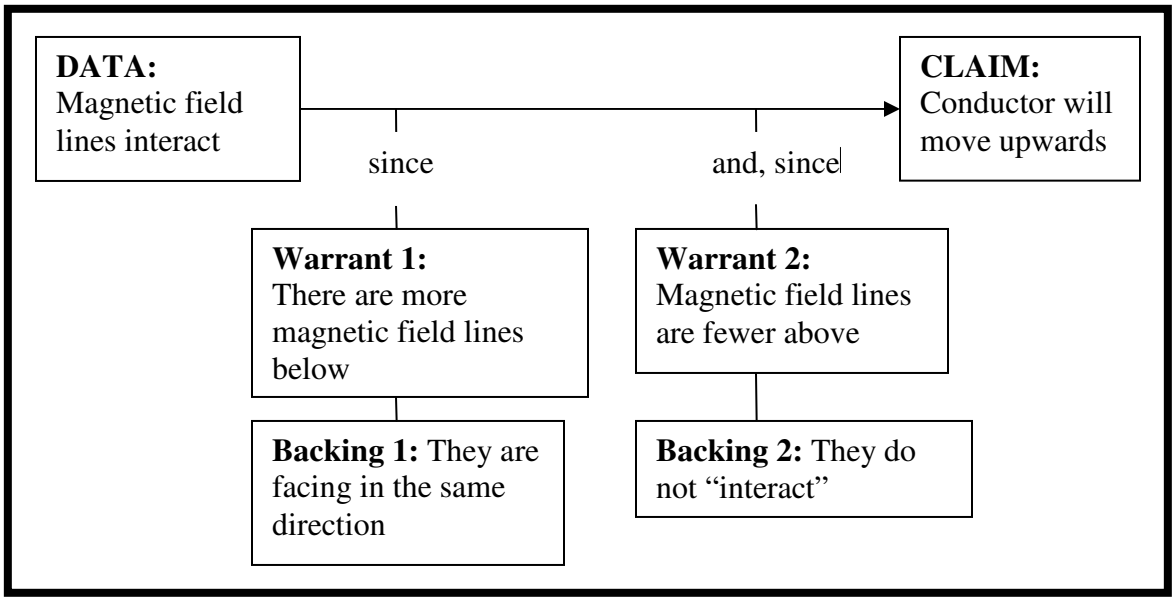


Diagram 9.5: Toulmin's analysis of Kabi's talk

The SAMPS system reflected in Kabi's talk above highlights the group's understanding of what it takes to talk to other students about their findings. Basically, Kabi understood the initial task, when presenting their opinion as identifying material aspects in his drawing. These are the coil, terminals, a "circular" magnet, and poles. This activity therefore formed the basis for mutual understanding between the presenter, Kabi, and his audience, fellow students and the teacher. Then Kabi dealt with interaction of magnetic field lines. At this stage he drew part ii, and later part iii, of Diagram 9.4. Finally, Kabi concluded by highlighting the resulting motion of the conductor. An omission in the presentation is that Kabi does not relate the motion of the conductor and production of sound. That linking is crucial since it highlights the richness of the student's Physics register.

The presentation in the extract, occurring at the end of Conceptual Application, highlights two pertinent issues about learning at this stage.

- Use of interaction of magnetic field lines and Discourses of science: It is evident, from the Toulmin's framework, that in this stage Kabi and his group mate used ways of talking that are scientifically acceptable. Though he never finished his warrant 2, Kabi did complete other parts of the framework. It is also noted that they have used interaction of magnetic field lines to back up their arguments. Diagram 9.4 reflects a product of careful analysis of the artifact and a sophisticated bringing together of Discourses of science, e.g. talking, drawing, identifying.

- Students' language: The language that Kabi used further highlights the students' situation definition of magnetic field lines and their direction. When Kabi refers to the direction of magnetic field lines he used the following phrases "...direction **is** anticlockwise.", "...**they are going** anticlockwise." and "...**the** field lines **come from the** north..." The last two phrases imply a physical motion of magnetic field lines. The implication of the last phrase is that magnetic field lines around a magnet are moving from the north pole to the south pole. Similarly, the second phrase implies that magnetic field lines, around a current carrying conductor, are moving anticlockwise. The first

phrase, though not employing enough data, sheds some light on language issues rather than their comprehension. There is no single word in Sesotho, the students' mother tongue, that corresponds to the scientific term "direction". The two common phrases deduce meaning from words that correspond to "facing" and "moving towards". This could therefore be the main contributing factor.

The two presentations that Kabi made above took place on two different days, as indicated in Table 9.1. A crucial consideration is whether there is a progression between the talk that Kabi made as ventriloquating talk and that he made as cross pollinating talk. That progression is significant, since it has a direct implication on the effectiveness of the mediation strategy. A characteristic that comes to the fore in ventriloquating talk is that Kabi does not discuss the process, interaction of magnetic field lines. Reference to this process is critical since the aim of the intervention is stated as introducing the concept of interaction of magnetic field patterns (see section 5.7). Kabi makes the following utterance "So we think this … conductor will go up instead of hitting the magnets because as we see here there are more … magnetic field lines … below this conductor." It has to be reiterated that this talk is a ventriloquating talk in which the student, Kabi, mimicks scientific phenomena (e.g. magnetic field patterns and motion of conductor) without coordination of how they relate. The earlier utterance, to the one above, had shown existence of magnetic field lines but did not highlight their interaction. The utterance that followed, the one above, illustrated application of force by the "… more magnetic field lines … below this conductor." metaphorically. It can only be suspected that this mimicking is informed by knowledge that a "current carrying conductor in magnetic field will move". This characteristic of ventriloquating talk is compared to the cross pollinating talk that Kabi made when discussing the operation of a loud speaker. At this stage Kabi makes the utterance "**Because of this** interaction, **when we determine it here, we find that below** direction **is the same, that means there will be a number of them here below, the** field lines. **Similarly this side will also have a number of them**. **Then we took it that this thing will go upwards."**. In this utterance the conclusion "... **this thing will go upwards"** is based on consideration of interaction of magnetic field lines "... **this** interaction, **when we determine it here ..."**. There has been a progression

therefore from ventriloquating talk, where Kabi did not consider the process to cross pollinating talk where he makes a conclusion, based on consideration of a process.

Engagement of "other stuff" Discourses also reflects this progression. Not only that Diagrams 9.3 and 9.4 reflect some differences in terms of complexity of presentation of process of interaction of magnetic field lines, but also how they were presented. Diagram 9.4 was developed in stages, as Kabi was presenting views whereas Diagram 9.3 was developed before the presentation. Diagram 9.4 progressed with the talk. The two extracts therefore show a progression from the ventriloquation to cross pollination of the practice of Discourses of science.

9.5.3 Enculturation

This study advocates the concept of enculturation in an access Physics classroom, and of course in science classrooms in general, whose primary purpose is to promote the sense of becoming intellectually autonomous (Yackel and Cobb, 1996; Roth, 2001; Hodson, 1999). The operational definition of intellectual autonomy is the ability of a student to engage Discourses of science to learn scientific concept without assistance. In Vygotskian terms, achieving intellectual autonomy is compatible to acquiring the level of actual development. The process of enculturation, as viewed in this study, calls for introduction of Discourses of science, particularly talking, by the teacher and practising of these Discourses by students. That is, students have to be given the opportunity to talk and write scientific concepts (Lemke, 1990). In so doing, students were given opportunity to practise Discourses until they can reasonably engage them independently. This study sought to inculcate this kind of culture. The discussion above reflects this study achieving this culture through two main processes.

- Ventriloquating: It is argued in the above sub-sections that students started mimicking talk without necessarily understanding it and progressively reached a level where they used talk with some understanding of the concept. It is also shown that students started to engage Discourse progressively. Access students in this study started ventriloquating through another person's voice until they could use the language patterns for their own purpose (Duran *et at.,* 1998).

- Cross Pollinating: The discussion in the two sub-sections above show that students access artifacts and learn their functioning through talking to each other. Cross pollinating comprises practicing of Discourses of science by students at group level and sharing of the understanding of how artifacts function.

These two processes are basically reflecting engagement of talk, and/or Discourses of science, at different level of ability to use language of science to express scientific level. As part of process of acquiring knowledge the two processes have proved successful.

9.6 Texts

According to Gee (1999), writing is one of the "other stuff" Discourses critical in science learning/teaching. This view is backed by other educators in the field (Rivard, 2004; Rivard and Straw, 2000). As noted in section 9.3 above at the end of both the Conceptual Formulation and Conceptual Application stages, students were expected to hand in written reports summarising their learning in each stage. Table 9.2 below presents the summary of semiotic aspect analysis of SAMPS system of groups' written reports submitted at the end of the Conceptual Formulation stage. Critically, table 9.2 presents a summary of justifications students used to decide on the feasibility of the proposed electric bell functioning as claimed. The justification is determined from the actual text in the form of explanations and the reflection of "other stuff" Discourses such as drawings in each report. It is worth noting that the number of final reports, as shown in Table 9.2, has dropped from thirteen, as reflected in Chapter 7, to five. Other students opted to submit individual reports.

Group No.	Diagram showing interaction	Reference to Interaction	Accept/Reject	Main Points
A2	Yes	No	Rejection implied	No sound produced because of absence of a metal plate
A4	Yes	Yes	Rejection implied	Magnetic fields of the magnet "reacts" with magnetic field of current in the wire
A5	Yes	**Uses magnetic field**	Rejection implied	There will be high production of magnetic field lines in the lower part
A6	No	Yes	Rejected	Magnets are not labelled
A7	Yes	No	Rejection implied	**Explains how to improve design**

Table 9.2: Summary of Electric Bell Model Group Reports

From this table it can be concluded that

- All the groups did not agree with the story. That is, they did not believe that the suggested model could function as an electric bell. The main considerations for rejecting the proposal are reflected in the table.
- Students made use of diagrams that analysed interaction of the magnetic field patterns. Some referred directly to interaction of magnetic field lines.

It is critical to understand Discourses, drawing and justifying, that students considered important when making conclusions. The value of their importance is reflected by their inclusion in the reports. As reflected in Table 9.2, students included drawings, with the exception of group A6, as part of their explanation of their conclusions. The type of diagrams, based on interaction of magnetic field line patterns, has an implication on their talk and their learning. Two categories are reflected in students' reports.

The first category reflects magnetic field line patterns between magnets as straight lines and lying only between the poles. For example group A2 presented the following diagram;

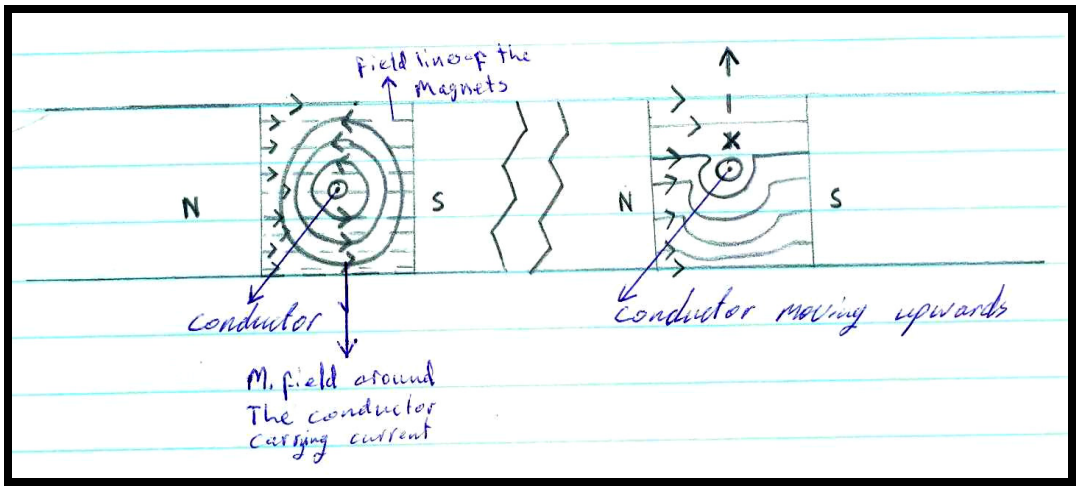


Diagram 9.6: 2003 group A2 analysis of electric bell

It is advisable not to read too much into the tendency of only drawing magnetic field lines between the poles. Arguably, students wanted to concentrate on showing the interaction of magnetic field lines which occurs in between the magnets. The magnetic field line patterns need unpacking, since much of the semiotic meaning lies there. However, it is noted that students in group A2 seem to be suggesting that the magnetic field patterns between the unlike poles form straight lines. This is consistent with their pattern in Conceptual Initiation stage. It is also important to note that their thinking pattern is reflected in this diagram. In the first diagram they show magnetic field lines before interaction. In the second diagram they show the pattern after the interaction. Kabi, who is a member of this group presented and drew Diagram 9.2. Thus, the second part of Diagram 9.6, in which they have shown a result of the interaction process, can be compared with Diagram 9.2. Importantly there must have been a discussion whose end product was a move from the initial consideration, the first part of Diagram 9.6, to the conclusion, the second part of Diagram 9.6. That discussion is summarised in the extract below, submitted as an explanation of Diagram 9.6.

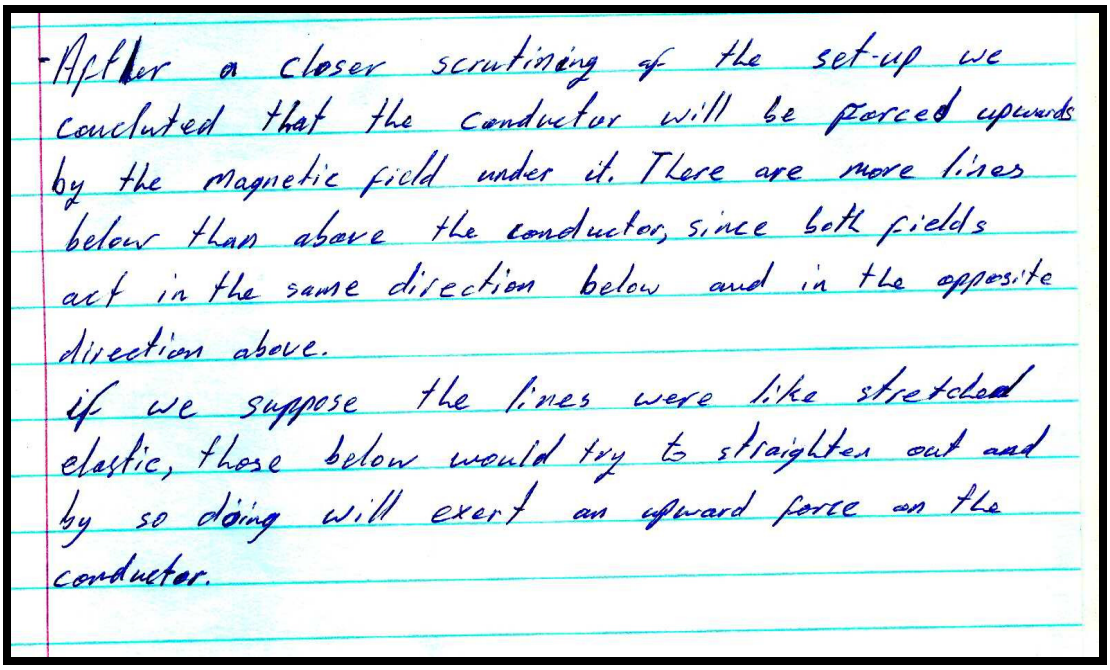


Diagram 9.7: Group A2's description of the electric bell design

The conclusions, and hence the suggested meanings, this group reached are

- The conductor will move upwards. In doing so it will not strike any of the magnets; thus it will not produce any sound,
- The density of magnetic field lines below the conductor is higher than above, and
- Magnetic field lines "…act in the same direction below and in the opposite direction above."

Evidently, the amount of learning reflected in this extract is enormous. Members of group A2 were able to relate the concept, interaction of magnetic field patterns, to the given story, and use it to support the view on the resultant motion of the conductor. Members of group A2 also used "other stuff" Discourses to make the meaning of the story. For example they were able to analyse the story using diagrams. They further used analogies to explain what will happen to the current carrying conductor. All this took place through activities that were discussed in Chapter 6.

The second category shows that magnetic field lines from the magnet and the current carrying conductor do not interact. Diagram 9.8 below, presented by A4, represents features of this category.

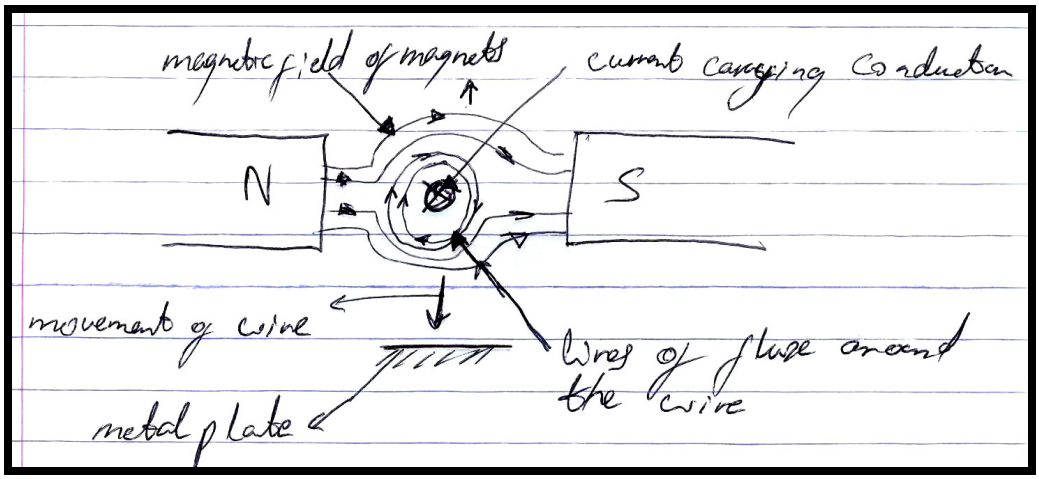


Diagram 9.8: 2003 group A4 analysis of electric bell

An outstanding feature of Diagram 9.8 is the non interaction of magnetic field lines from the current carrying conductor and the bar magnets. A portion of explanation that they gave is reflected in the extract below.

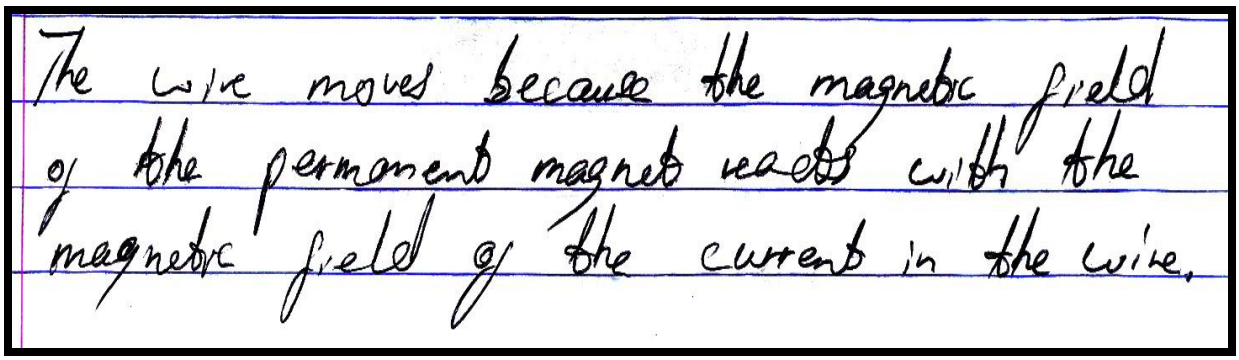

The wire moves because the magnetic field of the permanent magnets reacts with the magnetic field of the current in the wire.

Diagram 9.9: Group A4's description of electric bell design

Members of group A4 are making the following claims

- The current carrying conductor will move downwards, and
- The conductor moves because the magnetic field lines interact.

Similarly group A4 has had a valuable learning experience. It is worth noting though that the lessons in the justification of motion of the conductor that the group makes. The direction of "movement of wire" shown in the Diagram 9.8 and the meaning in the extract above reflects members of group A4 as having an understanding that interaction of magnetic field line patterns occur. The use of the word "reacts" in the extract has implications of language concerns. Two issues are noted about the use of this word.

- Students have used the word to imply "interaction" of magnetic field line patterns, and
- There is a problem with the scientific meaning of the word. The Sesotho translation of the word is **kopana** which has the same connotation as the English word "interact". Thus, the problem of meaning, in the extract is associated with use of LoLT and not necessarily conceptual.

Discussion of Discourses at Conceptual Formulation, reflected in text, further defines ventriloquation, as explained in Chapter 6. The following can be observed

- Diagram 9.6 reflects ventriloquation at a much advanced stage. It is clear that members of this group know that there is interaction of magnetic field lines but explanation of formation of point "x" is lacking. Students now know, therefore, that at that point the direction of magnetic field lines is opposite but do not explain the formation of the point. In other words, they use or mimic the point without clear understanding of what it is?

- Diagram 9.8 reflects an earlier stage of ventriloquation where students just know that there will be an interaction of magnetic field lines. This diagram has similarities with the first part of Diagram 9.6.

This text therefore further defines ventriloquation as a process where communicators start by merely mimicking the talk and later, as they use the talk, develops some understanding and thus use talk with understanding.

As noted earlier, talk engaged at Conceptual Application stage concentrated on establishing the operation of either of the two artifacts; Speaker or Ammeter. Thus the written reports, summarised in Table 9.3 below, presented issues that students identified as being crucial to explaining how any of these artifacts operate. Chapter 6 has introduced emergent categories of activities through which students learned the operation of these activities. Occurring at group level, the emergent category was named Cross Pollination. Table 9.3 therefore presents results, from group level, of the cross pollination.

Group Number	Diagram	Reference to Interaction	Artifact	Main Points
A2	Yes	Yes	Speaker	▪ Has coil between magnets ▪ Magnetic field lines interact ▪ Interaction results in motion of coil
A2*	Yes	No	Ammeter	▪ Has coil around soft iron ▪ Current causes couple to act on a coil causing it to rotate
A4	Yes	No	Speaker	▪ Has coil lying at right angles to the magnetic field ▪ Coil moves back and forth due to Fleming left hand rule
A5	No	No	Speaker	▪ explanation contains nothing on electromagnetism
A6	No	No	Ammeter	▪ Has horse shoe magnet, coil, fixed soft iron coil spring, pointer ▪ Incoming current makes strong magnetic field which will enable coil to move
A7	Yes	Yes	speaker	▪ Has coil between cylindrical permanent magnet ▪ When current flows field lines interact causing coil to move up and down
A10	Yes	Yes	Ammeter	▪ Interaction of radial field from magnet and field from coil cause pointer to move ▪ Hair springs enable the pointer to return

Table 9.3: Summary of the written reports of artifacts
* did ammeter as an extra task

Table 9.3 reflects all groups, with exception of A5 and A6, presenting reports which have a diagram showing interaction of magnetic field lines. As noted above inclusion of diagrams is associated with talk and in particular with Discourses employed by students. The diagrams referred to in the reports reflect two categories of magnetic field lines interaction.

The first type of interaction shows magnetic field lines as straight lines originating from the magnets, between the two poles. This type of interaction is observed in some diagrams coming from Conceptual Formulation discussed above. For example, the members of group A2, who gave the oral presentation discussed above, presented the following diagram.

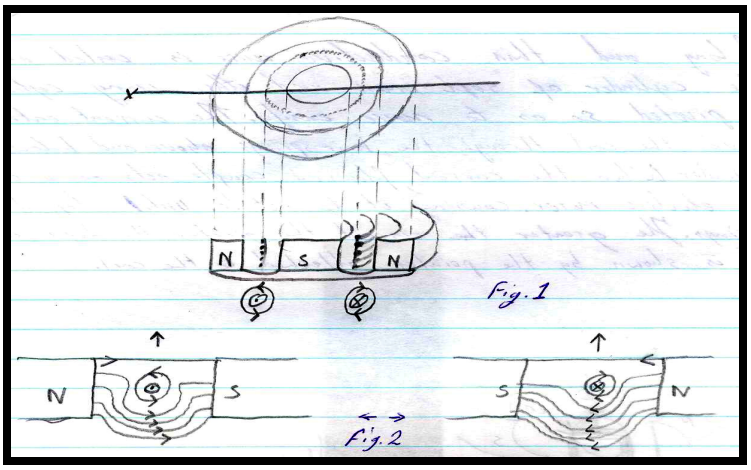
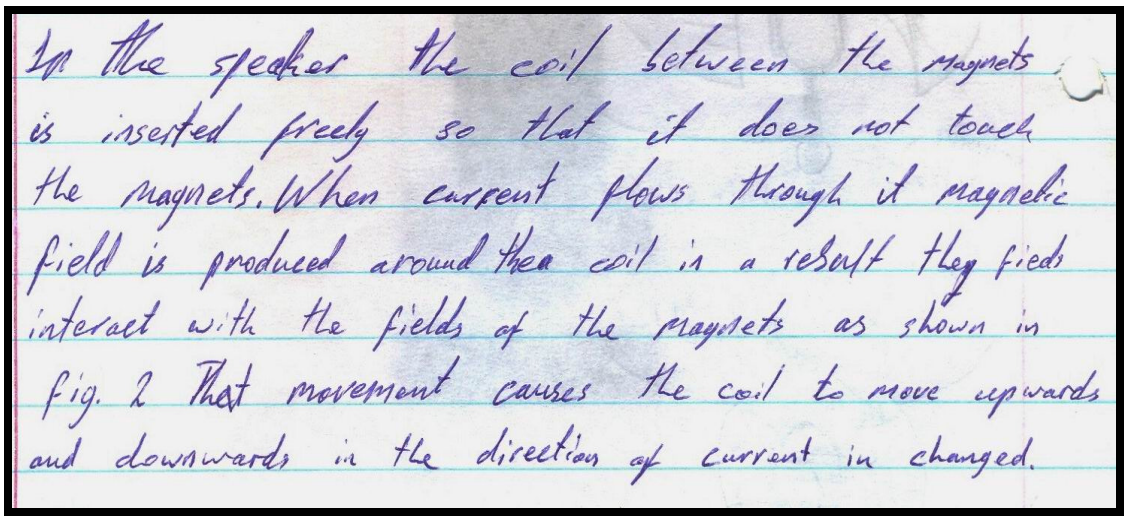


Diagram 9.10: 2003 group A2 analysis of a speaker

The two parts of Diagram 9.10, "fig.1" and "fig.2", show consistency in how members of group A2 thought about magnetic field line patterns' interaction. It is evident that fig.1 reflects identified components of a speaker where electromagnetism is applied while fig.2 reflects analysis of the interaction of magnetic field lines. That is, they first thought of the pattern before interaction and then analysed the interaction. The following extract reflects the arguments that members of group A2 presented as their conclusions.



In the speaker the coil between the magnets is inserted freely so that it does not touch the magnets. When current flows through it magnetic field is produced around the coil in a result they fieds interact with the fields of the magnets as shown in fig. 2 That movement causes the coil to move upwards and downwards in the direction of current in changed.

Diagram 9.11: Group A2's description of a speaker

The extract above raises important issues.

- The presenters argue that "…in a result the fields interact with the fields of the magnets as shown in fig.2". This phrase makes reference to interaction of magnetic

field lines but falls short of explaining it. Though the process of interaction is not explained, it is evident that its importance was noted.

- The other utterance, "…the coil to move upwards and downwards in the direction of current in changed…" suggests a relationship between motion of coil and change of direction of current. The relationship however is not explicitly established. It is not clear if this is because the students were thinking of their teacher as the audience and therefore knowing what they are talking about. It is pertinent to note though that the utterance reflects grammatical errors that can only be associated with the use of LoLT.

Understanding the meaning in the extract above reflects what students have learned about the artifact. The Toulmin's framework below, Diagram 9.12, reflects the claim that members of group A2 are making about the speaker.

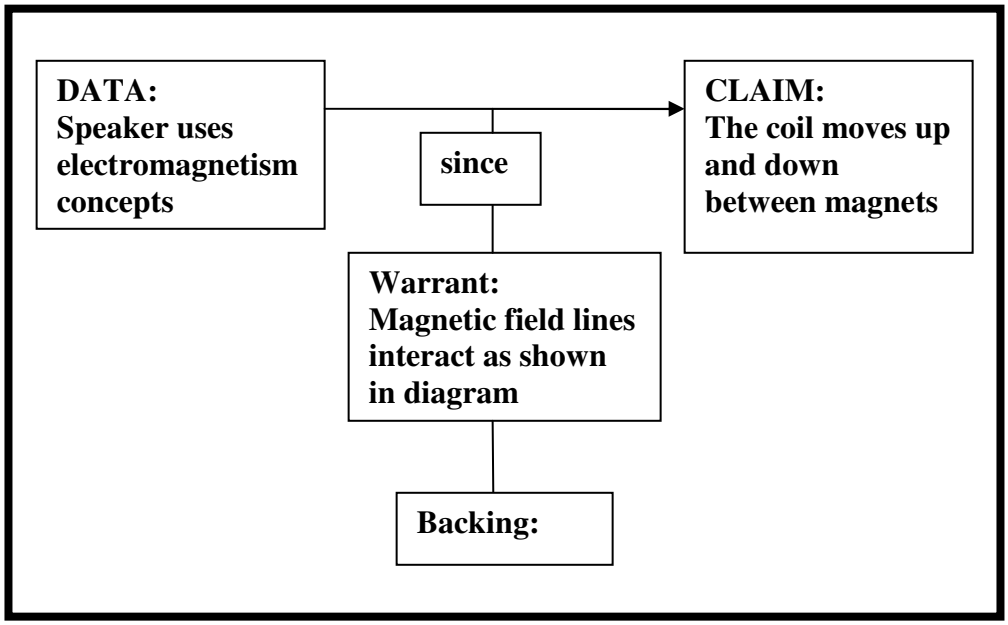


Diagram 9.12: Toulmin's analysis of Group A2 report

The Toulmin's framework suggests the following issues:

- Members of group A2 could identify components of the speaker in which electromagnetism is applied, and
- were able to employ interaction of magnetic field lines as a crucial concept of explaining the operation of the speaker.

Members of group A2 did not provide any backing for their warrants. The presentation is different from the submitted report. In the presentation, backing was provided. Comparison of this explanation in the extract above, with their presentation discussed earlier, suggests that this lack of backing could be related to an understanding of the audience as the teacher.

The second type of diagrams shows magnetic field lines between poles as radial. A typical example is a diagram in group A10's report.

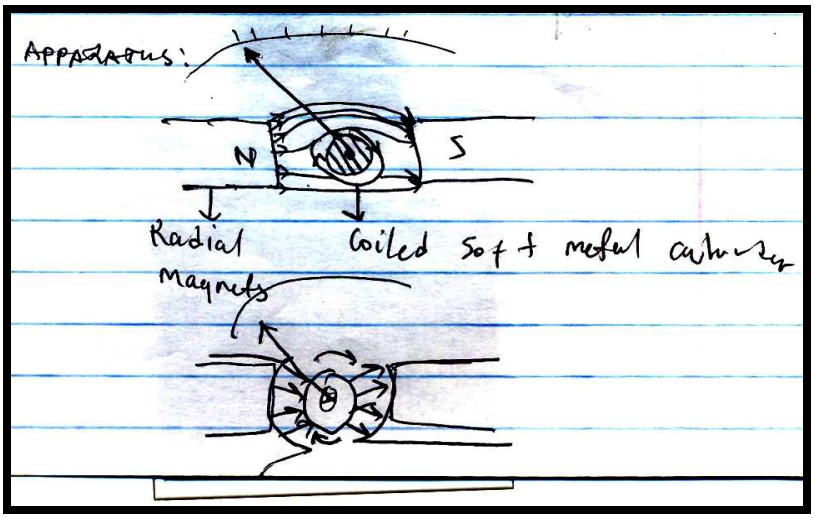


Diagram 9.13: 2003 group A10 analysis of ammeter

An observable feature of Diagram 9.13 is the non interaction of magnetic field lines from the current carrying conductor and the bar magnets. The extract below highlights group A10's submission, explaining the diagram above.

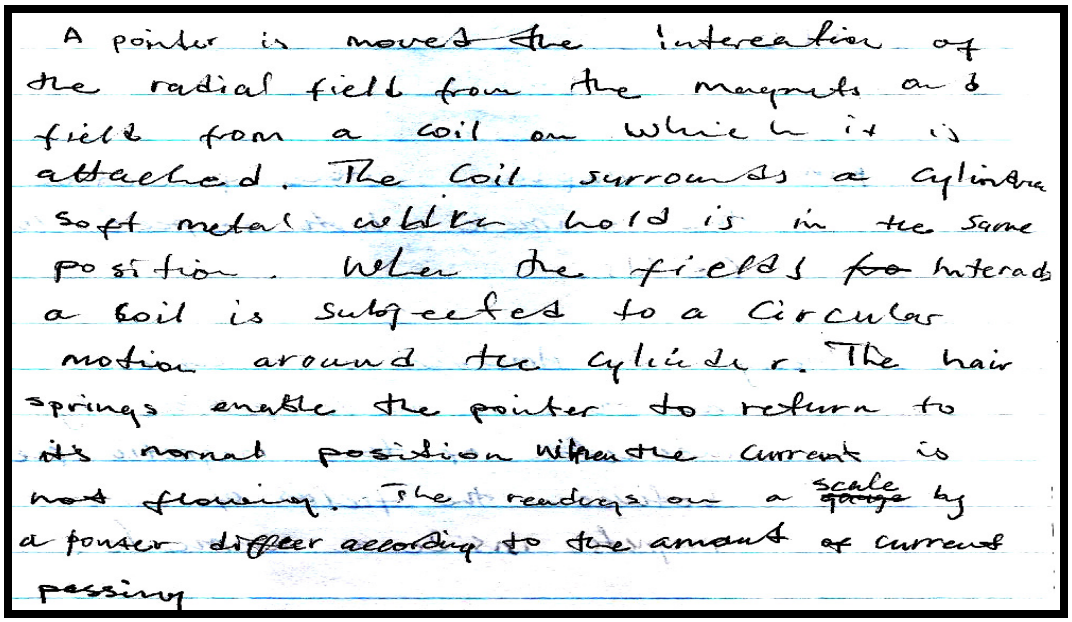


Diagram 9.14: Group A10's description of ammeter

In the extract above members of group A10 have raised issues that must be unpacked.

- They argue that "when the fields interact, a coil is subjected to a circular motion around the cylinder." Although the group did not explain the interaction of magnetic field line patterns referred to, they evidently use it to justify their claim.

- The utterance "A pointer is moved [by] the interaction of the radial field from the magnets and field from a coil on which it is attached." is an acknowledgement, by members of group A10, that interaction of magnetic field lines results in movement of the pointer.

The member of A10 therefore acknowledges effects of interaction of magnetic field lines as causing the pointer to move.

The Toulmin's framework below summarises what members of group A10 learned about the operation of the ammeter.

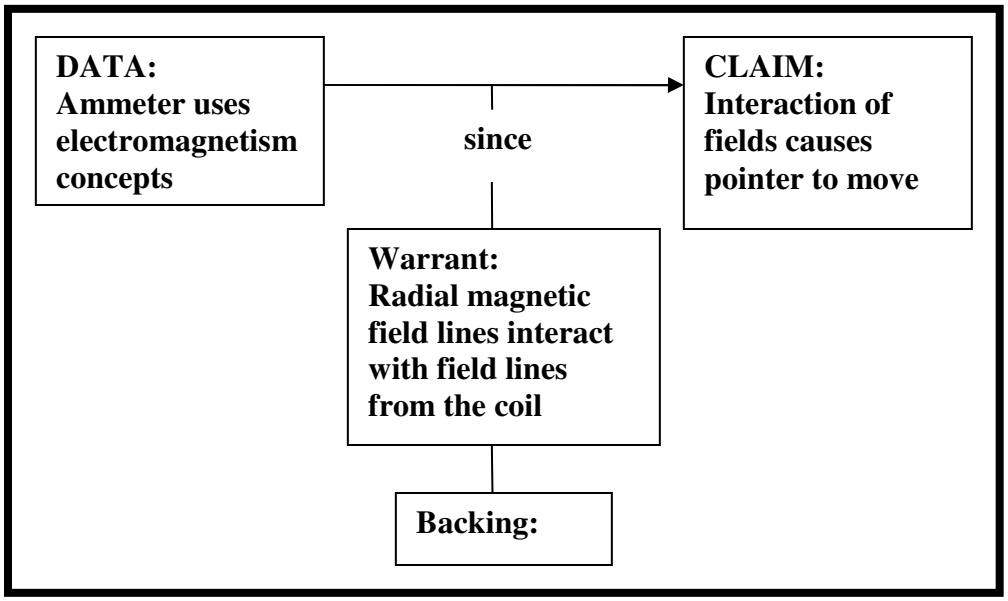


Diagram 9.15: Toulmin's analysis of A10 report

Members of group A10, just like those of group A2, have not provided backing to the warrant they made. However, it is evident that

- they were able to identify components of the ammeter where electromagnetism was applied
- they used interaction of magnetic field patterns to justify their claim.

9.7 Interpersonal Communicative approaches and Discourse patterns

The interpersonal communicative approaches students employed in the Conceptual Formulation and Conceptual Application stages retained similar features to what surfaced in earlier stages, Chapters 7 and 8. That is, students tended to employ *surface* and *deep dialogues* approaches with statement – accept – statement and explanation – question – explanation patterns of discourses respectively. Similarly, as noted in the earlier results chapters, the surface dialogue approach remained dominant in both stages.

9.7.1 Surface Dialogue

The interpersonal communication approach between two students, Sello and Mahlomola, mostly formed surface dialogue communicative approach. The episode below highlights properties of surface dialogue at Conceptual Formulation stage.

Episode 9.5

[**bold = translation from Sesotho,** *italic = Talk in Sesotho,* Names = pseudo names, **… = *inaudible***]

1.	Sello	*Mm! 'Na ke nahana hore, e hlile ha ke nahane eka ba nthoena e tla ea ka ho tsona li le peli. Ke bona eka eka khona ho ea ka ho ele ngoe.* (**Yes! I think that, indeed I don't think this thing will go to both**. **I think it can only manage to go to one**.)
2.	Mahlomola	*Mm!* **(Yes)**
3.	Sello	*Hae feela …* **(Hey! But** *…)*
4.	Mahlomola	in other word they are like poles
5.	Sello	Like poles?
6.	Mahlomola	*Mm*! **(Yes!)**
7.	Sello	*re nka ele* south *le* south **(should we assume it to be** south **and** south)
8.	Mahlomola	*Mm!* **(Yes)**

In episode 9.5 students, Sello and Mahlomola, are discussing the feasibility of movement of a current carrying conductor shown in the electric bell design. A consideration they are making is whether the conductor will move to towards the magnets and hence produce sound on striking it. Sello, turn 1, explains his view of what might happen and in response Mahlomola, turn 2, accepts. Sello is claiming that the conductor can only go to one side of the diagram. In other words his consideration is the physical motion of the conductor and not what causes it. Mahlomola is also not demanding an explanation. Sello, turn 3, is uncomfortable with his explanation. Then Mahlomola, turn 4, makes a statement in response to Sello's doubt. Mahlomola's statement, turn 4, beginning with "in other words…" is a confirmation of what Sello, turn 3, might have said. Though the complete utterance in turn 3 cannot be captured, its effect has not been to encourage Mahlomola to offer an explanation, but rather to offer another view expressed in the form of a statement. This turns their discussion to a statement – accept sort of communication. The last half of the episode follows the same pattern. Thus, this type of communication approach is called surface dialogue.

Toulmin's framework below, Diagram 9.16, summarises the intersubjective opinion that is reached in extract 9.5.

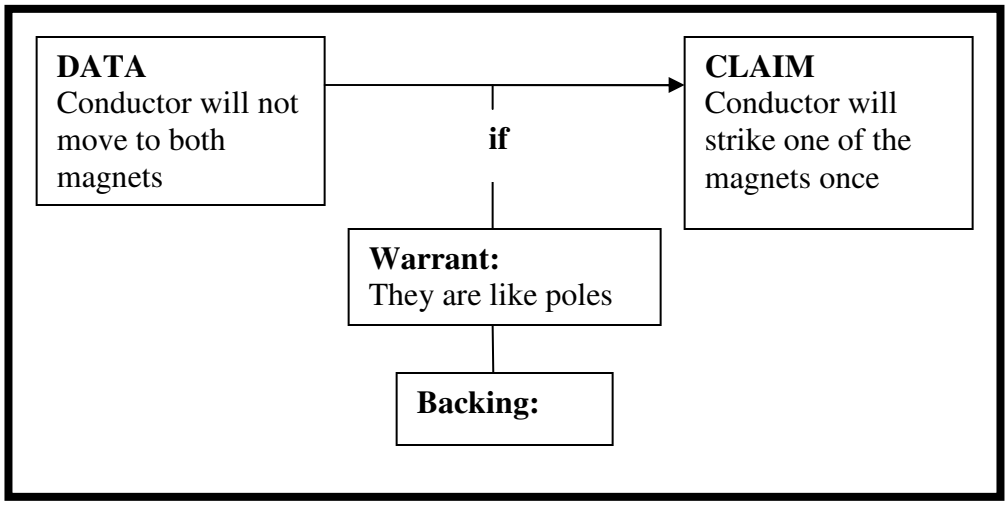


Diagram 9.16: Toulmin's analysis of episode 9.5

The main components of Diagram 9.16, Data and Claim, are suggested by Sello while the warrant is suggested by Mahlomola. An important point in this diagram is to note that none of the two communicators was justifying their views. Though some element of intersubjectivity was reached by both Sello and Mahlomola, it is difficult to draw the exact meaning. Consideration of the source of the above data and the stage from which it is extracted may be helpful in understanding this observation. The data is drawn from the ventriloquation stage (see section 9.5) and thus by its nature students are mimicking the earlier talk. This is further complicated by the manner in which they contributed towards meaning making. They are engaging statement – accept discourse patterns. Diagram 9.16 therefore reflects a deficiency, typical of surface dialogue pattern, in argumentation between Sello and Mahlomola.

A striking feature of talk, at Conceptual Formulation stage is that while students are expected to ventriloquate, they did not talk about interaction of magnetic field lines to support their views. A possible explanation could be centering on the Lave and Wenger's (1991) concept of transparency of the electric bell model. In particular that there were other features of the model that were not invisible. In the earlier section, section 9.6, it is shown that absence of direction of magnetic field lines from the magnet distracted the students. Evidently, labels of magnets in Diagram 9.1 became visible to

students, to the detriment of interaction of magnetic field lines. Thus, the invisibility of the features of a model can affect Discourses of science.

Episode 9.6 below is extracted from the Conceptual Application stage. In the episode the two students, Kabi and Thabiso, consider the interaction of magnetic field lines from the current carrying conductor and a magnet.

Episode 9.6
[**bold = translation from Sesotho,** *italic = Talk in Sesotho,* Names = pseudo names, **… = *inaudible***]

1.	Kabi	*Ee! Ha current e flowa mononong magnets tsenana le li field e around that ntho coil* (**Yes**. **When** current **is flowing there, these** magnets **and the** field**s** around that thing, coil)
2.	Thabiso	*Mm!* **(Yes!)**
3.	Kabi	*le field ea teng, magnetic field o around that coil le ona oa ntho, li ea interacta, ha ke re?* (**and its** field, magnetic field **that is** around that coil **and this one of this thing, they interact, isn't it**?)
4.	Thabiso	*Mm!* **(Yes!)**
5.	Kabi	*Joale due to change of ntho* (**Now** due to change of **this thing**)
6.	Thabiso	magnetic lines direction
7.	Kabi	No, change of current, *ha current e le ngata.* (No, change of current, **if** current **is strong**)
8.	Thabiso	*Mm!* **(Yes!)**
9.	Kabi	*Ntho, nthoena e ea holimo hobane, ha ke re oa bona ke nthoe tjee, ere re bone, ke nthoe tjee oa bona?* (**This thing**, **this thing goes up because**, **can you see it is something like this**, **let me see**, **it is something like this you see**?)
10.	Thabiso	*Mm!* **(Yes)**

A striking feature in this episode is the role played by Thabiso. Except in turns 2 and 6, Thabiso is always accepting Kabi's explanation or statement. The response, "**Yes"**, turn 2, was an attention affirmation while in turn 4 it was a response to "**isn't it**?" That leaves the first four turns of this episode to be reflecting an explanation – accept type of discourse pattern. In turn 6 he was helping Kabi to say what "**this thing**" was. Thus turning the communication between them to either a statement – accept or explanation – accept form of discourse pattern. Thus, episode 9.6 represents a surface dialogue communicative approach.

Toulmin's framework, Diagram 9.16, conceptualises the talk in episode 9.6

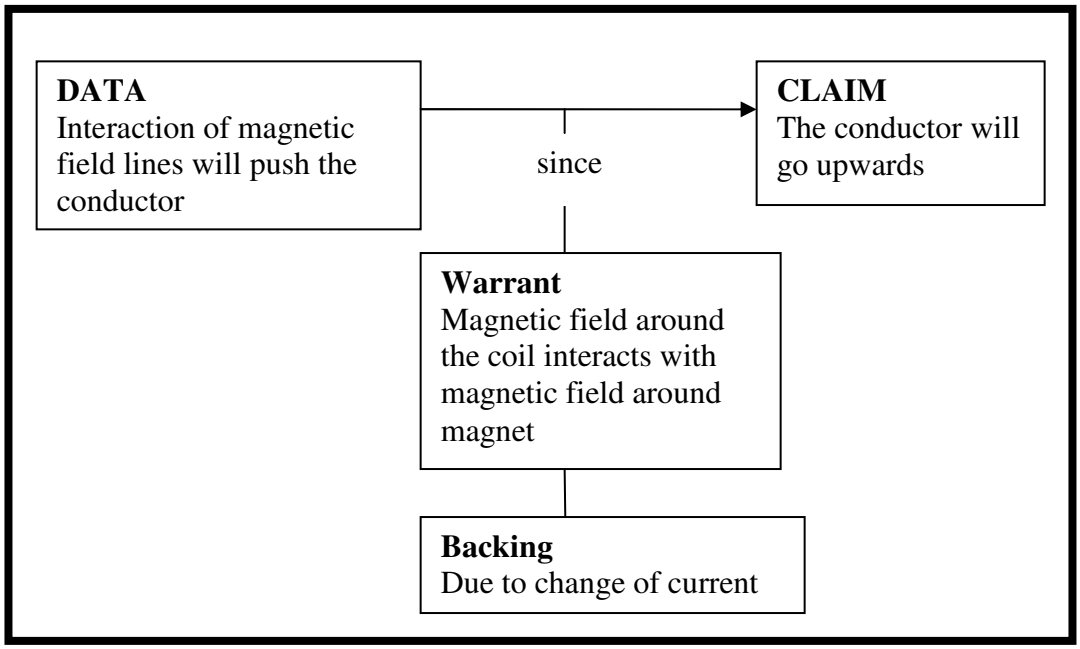


Diagram 9.17: Toulmin's analysis of episode 9.6

Diagram 9.17 comprises of elements of talk uttered by Kabi. That is, Kabi offered a view and provided some justification. But, and an important point to note, Thabiso accepts all the talk that Kabi made. Diagrams 9.16 and 9.17 are different therefore. The difference here, between Diagrams 9.16 and 9.17, is that Kabi gave justification of the claim in the form of warrant and backing. Perhaps it is important to note the contributing factor towards the difference between the two diagrams. The difference is attributed to the fact that Diagram 9.17 is made up of data extracted from the cross pollinating stage.

Comparison of the ways of talking in the two episodes 9.5 and 9.6 reveals clear differences.

- In episode 9.6, Kabi, turn 3, uses interaction of magnetic field lines. It is already noted that in episode 9.5 none of the students does so.
- Kabi justifies his claim in a more acceptable way than Kabi does above.

The episodes above, 9.5 and 9.6, show a surface dialogue in which one communicator suggests an idea and the other just accepts it. The episodes also show the discourse patterns as statement – accept – statement and explanation – accept – explanation.

9.7.2 Deep Dialogue

Deep dialogue incidences were not common in both the Conceptual Formulation and Conceptual Application stages. Episode 9.7 below, extracted from Conceptual Formulation stage, reveals some characteristics of the deep dialogue pattern.

Episode 9.7

1.	Kabi	*… ke nahana hore ha re ka nka mona ele north pole kamona ele south pole, ke hore le ha re ka nka ekare mona ke magnet o le mong, ona o tjena oa bona (…* **I think it we assume here as** north pole **this side as** south pole. **That is, if we assume this as one** magnet, **which is like this you see**.)
2.	Mahlomola	*Mmm* **Yes**
3.	Kabi	*Ee re nke eka ke magnet o le mong, rona re nke o kopana tjena. Joale ho feta wire between.* (**Yes, we assume that it is one** magnet, **we assume that it is joined like this**. **Then, a** wire **passes in** between.)
4.	Mahlomola	*Ha ke re direction of the field in this case e tla koa. Haeba ele ele li-unlike,* (**Isn't it that** direction of the field in this case **comes this way**? **If they are, if they are** unlikes?)
5.	Kabi	Mmm **Yes.**
6.	Mahlomola	*mona kere ke north, ha re ke, etla ba the, ee e ee tje. E tla be ele repulsion. Ka mane it ehh etla be ele attraction ka nqena. Ua bona? So ua tloa e tla ea siding le leng.* (**let me say this is** north, **isn't it? It will be** the, **yes it goes this way**. **It will be** repulsion. **That side** it ehh **it will be** attraction **this side**. **You see**? So **you understand it will go to one side?)**
7.	Kabi	*Mmm. Feela ntho ena e mona ke eona ena …* **(Yes**. **But this thing is the same thing here** *…)*
8.	Mahlomola	*Kaha tsena etla be ele repulsion, ka nqena ele attraction, ee movement o tlo tla ea koana feela so ntho ena e tlameha hore ha e tsamaea* (**Because this one will be** repulsion, **this side as** attraction, **yes** movement **will be in this direction,** so **this thing is bound to move**)
9.	Kabi …	
10.	Mahlomola	*e ee koana e otle ka nqena e khutle, ho lle, e 'ne e otle* (Kabi also saying something at the same time). *(***it should go this way and strike this side**, **sound comes out**, **and continue to strike** (Kabi is also saying something at the same time).)

In this episode Mahlomola and Kabi engaged in a discussion aimed at establishing the possibility of the current carrying conductor, in the electric bell design to strike the magnets and thus produce sound. It is worth noting that there is no definite role played by any of the actors in this episode. It is also worth noting that because of the nature of the discourse pattern different issues were considered by both actors. Kabi, turn 1,

suggests an assumption that could help them to achieve some conclusion and Mahlomola, turn 2, confirms attention. Then, Kabi continues to explain his point. Mahlomola, turn 4, makes a question that changes the direction of the discussion and Mahlomola, turn 5, confirms attention. In turn 6 Mahlomola makes an explanation. Disregarding attention confirmations incidences, the communication followed explanation – question – explanation form of discourse pattern up to turn 6. From turn 7 to turn 10, there is a statement – explanation – explanation form of discourse pattern. The communicative approach followed in this episode is therefore a deep dialogue.

The discourse pattern and change of discussion subject have complicated Toulmin's analysis framework. However, it is clear from this episode that both communicators were making an effort to explain their views. It is this practice that made it easier for the other communicator to suggest an opposing view and thus enrich the discussion. The episode therefore highlights Matusov's (1996) point that intersubjectivity must not only be viewed as agreement but rather also including disagreement.

The episode below shows interpersonal communicative approaches that Kabi and Thabiso engaged during the Conceptual Application stage.

Episode 9.8

[**bold = translation from Sesotho,** *italic = Talk in Sesotho,* Names = pseudo names, **… = *inaudible***]

1	Kabi	as current flows *nthoeno ebe magnetised eno*. (as current flows **that thing gets** magnetised**)**
2	Thabiso	*Ntho e bang magnetised mona ke ke this coil. Ntho eo re leng concerned ka eona ke movement of the coil. Ha coil ee e ea holimo, hono ho bolela...* (**What gets** magnetised **here is, is** this coil. **What we are** concerned **about is the** movement of the coil. **When this coil goes upwards, that means**…)
3	Kabi	*Coil eo u buang ka eona ke efe? …*(**which** Coil **are you talking about?...**)
4	Thabiso	*Coil ke ena e …* [Kabi interrupts] (**Here is a** coil **that**)
5	Kabi	Oh! this one.
6	Thabiso	*This is a spring. Hona ke spring. Coil ke ena mona. Spring sena sona ke hore e tle e khutle nako e etsang nako eo eo current e se e…* [Kabi

		interrupts] (This is a spring. **This is a spring. Here is a** coil. **This** spring **is meant to make it return when** current **is …)**
7	Kabi	*e theohileng. Mmm!* (**it reduces. Yes!)**
8	Thabiso	*na ntho e, what is this … soft iron* [silence] *mmm* [thinking] *e ka bang? Ha ke re iron ha e, ha e, e! ha e etse…* (**is this thing**, what is this … soft iron [silence] mmm [thinking] **what can it be? Isn't it iron? doesn't, doesn't, yes! It doesn't …)**
9	Kabi	*… na ke soft iron ntho e? kapa ke aluminum?, ha e se eka ke ntho e sa choukoeng, e sa choukeeng tje?* (*…* **is it a** soft iron **this thing? Or it an** aluminum? **as though it is something that cannot be attracted, why does it look like it cannot be attracted?)**
10	Thabiso	*Ke soft iron, e e hlilaneng ha e choukee ke soft iron.* Ok [silence], [interferes with recorder]. (**It is a** soft iron, **in deed it cannot be attracted it is a** soft iron. Ok)

The actors in episode 9.8, Kabi and Thabiso, are discussing the function of a coil in their artifact, an ammeter. The discussion in the episode shows combinations of statement – explanation and question – statement types of interpersonal discourse patterns. For instance, Kabi, turn 1, makes a statement and in turn 2 Thabiso, objecting, explains his observation. Thus the discourse pattern highlighted in this exchange is a statement – explanation. Kabi, turn 9, makes a question and in turn 10 Thabiso responds by explaining his view. Evidently, what comes to the fore, in this episode, is the trend of the student not merely accepting what the other was suggesting. They attempt to understand and make sense of each other's contribution in the manner that makes understanding of their shared meaning comprehensible. These patterns therefore show a deep dialogue form of communicative approach. As was the case in episode 9.7 above, the discourse pattern and the change of the subject of talk in this episode makes Toulmin's analysis framework complicated. This makes it difficult to identify a single point of intersubjectivity in the talk.

9.8 Concluding Remarks

The following issues have surfaced in this chapter

- Direction of Magnetic field patterns: Direction of magnetic field lines appears to have been a contributing factor towards the learning of, and/or talking about, magnetic field line patterns. In Conceptual Formulation stage, absence of the labeling of poles of magnets, the direction of magnetic field lines, became an obstacle towards

learning of interaction of magnetic field patterns. The students' operational definition of the word "direction" seems to have a connotation of physical movement. This definition, which conforms to Sesotho way of defining the corresponding phrases, contributed towards invisibility of interaction of magnetic field lines.

- The Discourses of science: The foregoing discussion reflects an improvement in students' use of Discourses of science. Though use of everyday language remained dominant throughout the stages, it is evident that there is change in so far as use of "other stuff" Discourses of science is concerned. Students have used, especially during oral presentations, ways of arguing that conform to Toulmin's framework of argumentation. This is an improvement, compared to the nature of discussions reported on in Chapter 7.

- Communicative approaches: The interpersonal communicative approaches displayed during the last two stages remained the same as in earlier stages. That is, students tended to employ surface dialogue more often than deep dialogue. Similarly, students tended to use statement – accept – statement or explanation – accept – explanation patterns of discourse.

CHAPTER 10

FINDINGS AND RECOMMENDATIONS

10.1 Introduction

This study, as discussed in Chapter 1, is primarily influenced by the need to address issues of learning science, at an access programme placed between secondary and tertiary levels, through the medium of second language in Lesotho. The study was conducted at Lerotholi Polytechnic (LP) where teaching and/or learning is done through the medium of second language, English. The study is also influenced by a strong view that effective teaching strategies, in any Physics classroom, must be informed by a sociocultural perspective.

In this chapter I consolidate the findings discussed in Chapters 6, 7, 8, and 9 and respond to the research questions stated in Chapter 1. Finally I make recommendations.

In order to conceptualise the results of this study it is perhaps important to reiterate the following issues regarding the sample, access students at LP, and the secondary education they came from.

- Access students at Lerotholi Polytechnic (LP): From 1994 to 2003, LP ran an access programme, Technician Induction Programme (TIP), whose duration was 10 weeks. The notion of an access programme, and in particular LP's TIP, has been briefly discussed in Chapter 2. Students enrolled in this access programme are LP students admitted into one of the following diploma programmes; Electrical Engineering, Mechanical Engineering, Construction Science, and Civil Engineering. The admission policy of the institution required students to have passed COSC examinations with the following grades: Grade 1 to 6 in Mathematics and Physical Science (Physics and Chemistry) and Grade 1 to 7 in English Language. In 2001, 803 candidates in Lesotho obtained the required grades in Physical Science and 8.4% of the pass rate in English was recorded (see Table 1.1). This number is shared by all

the major institutions, e.g. NUL, LP and LCE. This means that when interpreting this study's results it should be borne in mind that the sample in question represents the best school leavers.

- High school learning background: Most students enrolled at LP come from schools where chalk and talk teaching methods dominate, with less student talk and only occasional practical work. Factors contributing to this situation have been discussed in Chapter 1. However, it has to be observed that these factors can be complicated and require intensive research. This study, on the other hand, can be viewed to have a potential of shedding light in terms of how to address some of these factors.

- The official language of learning and teaching at LP in general, and thus in the access programme, is English. It is important to note that English language was a second language to access students in this programme. However, as can be noted in the episodes and extracts in the result chapters, students were free to code switch between English and Sesotho, as and when they felt the need to do so.

10.2 Reflections

An introspective analysis of the research journey reflects interesting lessons. The most important is the seemingly straight forward observation: *Researching is a learning process.* When I started this journey I was confident that I understood everything needed in this journey. Little did I know that this was not the case. An experience that will remain vivid in mind is the feeling of confidence and readiness about the analysis strategy. I am convinced that though this study had a proposal, at the time of collection of data my theoretical framework and analytic tool (Semiotic, Activity, Material, Power, Sociocultural system) had not developed to a stage where it is now. I must observe that a PhD study has been a long journey with, as I believe it is true for everybody, crests and troughs. It has been a journey of learning which resulted, at some points, in change of direction as better understanding unfolds and circumstances change beyond one's control. When I started, for instance, my perception of Discourse analysis was restricted to the semiotic aspect only.

Below are issues that appeared pertinent as I critically reflected on this study. I identified two issues; namely the intervention and methodological issues.

10.2.1 The intervention

The intervention, discussed in some detail in Chapters 3 and 5, had four predetermined stages as shown in Table 10.1. Table 10.1 shows the predetermined stages, in the sequence of implementation, and their desired characteristics. Table 5.3 reflected the exact dates of implementation of activities of these stages.

Stage	Characteristics
1. Conceptual Foundation	Students talking about prior knowledge and forming concept maps, understanding concept maps drawn by others
2. Conceptual Initiation	Understanding the teacher's talk and information from other sources, associating the talk with scientific concepts, establishing nature of the task and agreeing on how to tackle their tasks
3. Conceptual formulation	Working together to construct scientific meaning, access different meaning making sources, interpret experiences through scientific reasoning
4. Conceptual Application	Reporting work done orally and in writing, thinking about what else can be learned

Table 10.1: Predetermined stages of the intervention

This study, as discusses in Chapter 1, sought to introduce Discourses of science (Gee, 1999) to a Physics access class at Lerotholi Polytechnic in Maseru, Lesotho. The theoretical framework informing this study is the sociocultural perspective in which cognition is understood to be historical, cultural, and social in nature (Leach and Scott, 2003) and by situated cognition which underlines the importance of participation within a community of practice (Lave and Wenger, 1991; Wenger, 1998) and relates participation to talk, and/or Discourses of science, (Lemke, 1990; Adler, 1999; Duran *et al.*, 1998; Dawes, 2004; Gee, 2005). The design of this study therefore hoped to introduce and allow students to engage Discourses of science, and more importantly, progressively. The reviewed literature suggests that similar efforts had been made elsewhere. For example, similar studies have been done by Scott (1998) in the United Kingdom, Christie (1998) in Australia, and Duran *et al.* (1998) in Canada. Though in general terms the purpose of these studies is similar to my present study, there are considerable differences. For example, my study's design, discussed in previous chapters, differs from these

studies. As can be observed in Table 3.2, which compares the three studies, Christie (1998), Duran *et al.* (1998), and this study, the major difference in design is the level of opportunity for sharing prior knowledge and further participation provided through studying of artifacts; such as the ammeter and speaker. The three studies are conducted in countries that are economically richer, a factor that allows availability of teaching materials to be better than it is in Lesotho, one of the least developed countries in the world. Students in the present study come from a teacher dominated environment and as a result talking in classrooms is not a familiar construct.

In order to conceptualise the study, the results of the activity aspect of the SAMPS system of Discourse analysis, explained in Chapter 4, must be introduced. A major question addressed by this analysis was; what kind of Discourse enabling activity is practised in a given situation? Table 10.2 below summarises categories and sub-categories of activities that emerge as informative of the kind of Discourses engaged. A detailed discussion of these emergent categories has been done in Chapter 6.

Predetermi-ned Stage	Conceptual Foundation		Conceptual Initiation			Conceptual Formulation		Conceptual Application	
Emergent Category	Concept mapping	Voicing	Exploration	Promoting Discussion	Supporting Exploration	Facilitation	Ventriloquating	Cross Pollination	Dissemination
Sub-category	Drawing, Rehearsing	Students' voice	Students' appropriation	Initiating talk, Improvements	Peer support, Teacher support	Teacher assistance, Student assistance	Group talk, Oral talk,	Identifying, Argumentation	Oral Presentation, Students reaction, Teacher intervention

Table 10.2: Summarised Strategy

It is important to note that Table 10.2 above is an expansion of Table 10.1 with each predetermined stage sub-divided into emergent categories of activities. The emergent categories are further sub-divided into sub-categories. The strength of this design is reflected in analysis chapters (6, 7, 8, and 9) and in the subsequent sections of this chapter. It can only be noted at this stage that by the end of the intervention students reflected better understanding of the concept, interaction of magnetic field, and ways of talking about this concept. It is however important to reflect on a question regarding the design of this study: If given another chance would you like to introduce some alterations in this design? The response would be a resounding yes since there is no coin with one side.

The results of concept mapping, see chapter 7, as a core activity in Conceptual Foundation stage clearly shows that this learning tool must be introduced and practised at different stages of the learning process. In 2003 students were introduced to the tool as a summary in electricity and used in electromagnetism as an introduction. Given the fact that students come from a teacher dominated environment it looks reasonable to me that students must be given more time to use the tool. The aim of concept mapping was mainly an ice breaker and therefore it had to be understood so that it does not overshadow introduction of talking. A careful choice must be made however whether this stage deals with ice breaking or with sharing of prior knowledge or both. Such a choice though has implication for time allocated to the stage. Though consideration of time was complicated by other factors, such as the total time given to the access programme (ten weeks), it is possible to address parts of this design in other topics.

The other problem which requires attention is the transparency of the artifacts (Lave and Wenger, 1991; Adler, 1999) employed at both the Conceptual Formulation and Conceptual Application stages. The discussion of the electric bell model reflects visibility features of the diagram in the story which in turn make the desired practice of interaction of magnetic field lines invisible. The complexity of the ammeter when opened, compared to the speaker, also introduced some degree of invisibility of the concepts as students battled with seeing where the concepts are applied. Clearly the

design of the intervention should have addressed these shortcomings better. An attempt was made however, as explained in chapter 5, to reduce the possibility of the negative impact of this shortcoming. Students were advised to study one artifact. But they were also advised to create time to study the other artifact before the formal classroom discussion. There maybe differing ways of looking at this. There could be a school of thought that says this invisibility was a challenge while there could also be another that says it impeded talk. The position I take is that the invisibility should be addressed better, when designing the activities, to encourage a deeper dialogue of the application among students.

10.2.2 Methodological Issues

A critical reflection, with particular interest on weaknesses, needs to consider methodological issues. When I started this study my intention, as reflected in the proposal, was to conduct an action research study. This direction changed after rumours that the 2002 programme was to be the last programme. Though I refer to the phasing out of the programme as rumours, I had a strong indication from some Heads of Departments that it was being phased out. Apparently management of the Institution took its time to finalise the phasing out. The 2003 programme became the last one. There are a number of weaknesses noted in 2002 concerning how data collection was done. For example, it was clear that there was a need to train the person taking field notes so that the notes could cover analysable more aspects of the situation using the SAMPS system. Because of the uncertainty during the review period, planning became difficult. Specifically, the following are the weakness areas that I identified.

Data collection methods show weaknesses. I took a deliberate decision not to flood the classroom with modern technological devices that are not normally part of the classroom. The consideration was based on fear of influence of these technological devises which could have a significant influence on the naturality of the class. I wanted to maintain the naturalistic character of the qualitative paradigm (Merriam, 1998; Creswell, 1998). The weakness resulting from this decision related to loss of critical data in the form of talk. Of course my decision had risks. Audio recording was purely voluntary and yet it was

supposed to provide critical data. This is the dilemma with which I was faced. While this is ethically correct, the success of the study relied on successful audio recording. The weaknesses have been addressed by the SAMPS system of Discourse analysis in that where there is no talk other aspects, such as activity aspect, were taken to be crucial in highlighting the constructed meaning.

Person-to-person interviews were not conducted. I differentiate between person-to-person interview and group interview (Merriam, 1998). The interviews lacking, and therefore a weakness on the part of data collection, are the person-to-person interviews. I have to agree with Merriam (1998:72) that

> Interviewing is necessary when we cannot observe behavior, feelings, or how people interpret the world around them. It is also necessary to interview when we are interested in past events that are impossible to replicate.

There are interesting cases in this study that I feel I needed more data about. Kabi volunteered at almost every stage to do whatever needed a volunteer. The question is why was he so *cooperative?* He also appeared to dominate discussions at group level, Why? Thabiso is another interesting case. He always presented in Sesotho, Why? Because talk is central in this study, students' interpretation of their talk should have been considered important. The weakness caused by not using this type of interviews resulted in lack of students' interpretation of activities and therefore of claims that I make thereof. Given another chance, I would have person – to – person interviews with actors such as Kabi and Thabiso.

Another dilemma was between the teacher vs the researcher interests. There was no time during any lesson to act like a researcher because the interests of a teacher would supersede. Because of this, mistakes that affected weaknesses or strength of the study can be observed. A classical example is the depth of the Journal notes. If journal notes were produced by the researcher at the time of occurrence, their richness would be far better than what they are now.

10.3 The Findings

In this section I discuss the main findings of the study. I approach this by discussing the research questions stated in Chapter 1. These research questions are:

- What strategies can be employed to enable access students construct meaning through discourse of science when learning about electromagnetism?,
- Which elements of the strategies enable or constrain the students' use of the language of science?, and
- What is the effect of mediation strategies on the students' learning?

In the next sub-sections I argue that meaning – making strategies employed in the intervention enabled Lerotholi Polytechnic's access students to construct meaning of many concepts of electromagnetism. I further show elements of the strategy that enabled students' use of the language of science.

In precise terms the following are the core answers to the research questions investigated.

- The strategy to enculturate Lerotholi Polytechnic's access students into scientific community has helped them to construct meaning of the concept of interaction of magnetic field patterns. The central concept in enculturating students included offering students opportunity to progressively use Discourses of science.

- Communicative approaches and discourse patterns, practising of Discourses of science, and the language of teaching and learning enabled and/or disabled students to use the language of science.

- As elaborated later, the intervention implemented in this study proved to be beneficial in enhancing the sharing of meaning among students and in general encouraging talk which otherwise would have not taken place.

10.3.1 The Strategies

I show in my brief answer to the research questions above that enculturation into the scientific community enabled construction of meaning of electromagnetism concepts. The fundamental tenet of enculturation concept, as viewed in this study, is a sociocultural and situated cognition theories. The two theories influenced my perception of learning

science as the process of meaning – making of historical and social activities. In particular, I view meaning – making as a discursive process and a social practice (Mercer *et al.,* 2004; Driver *et al.,* 2000) in which the role of language is crucial (Lemke, 1982; Rollnick, 2000; Leach and Scott, 2003; Wells, 1995; Rahm, 2004). In a context of second language learning and within a sociocultural perspective where language is a central tool, I view effective teaching strategies as those that are framed and put the centrality of language (Duran *et al*., 1998; Moje, 1995; Scott, 1998) and "other stuff" Discourses of science into practice (Lemke, 1990; Gee, 1999; Gee and Green, 1998).

Strictly speaking, learning science in a classroom or school laboratory can be equated to practising to participate in the community of scientists. I make this claim though cognisant of the need to understand the differences and similarities between the two communities (Bowen, 2005). The central thesis in the claim is the realisation that classrooms aught to offer opportunity to students to practice to become a participant within the scientific community. Bowen (2005) argues that social communities are characterised by, among others, standard practices, material resources and linguistic resources. Successful classrooms must provide the opportunity to practise these characteristics. Learning scientific concepts therefore, in particular learning Physics concepts, is a process of enculturation (Yackel and Cobb, 1996; Hodson, 1999; Roth, 2001; Bowen, 2005) in which novices, as in students, must be guided through social practices and be introduced to ways of engaging Discourses of that community. This study assumed ways of talking, and in general terms engaging Discourses, within a classroom setting as a significant element of enculturation into Discourse communities (Mercer *et al.,* 2004), and in particular into the scientific community. That is, students will have a better understanding of the concepts if they are given the opportunity to use Discourses of science rather than being told about scientific concepts (Bowen, 2005). This conclusion was made by Bowen (2005:130)

> [T]his research suggests that students need more than instruction on the mechanical aspect of constructing independent research and graphs, but need extensive experiences allowing them to translate between the real world and the inscriptional tools they are using to report their studies.

In particular the success of such usage must be accompanied by the understanding of ways of talking about a phenomenon that is characteristic to the aspired community. The strategies that enable access students to construct meaning of physics concepts in this study had to be enculturate them into the scientific community. The analysis chapters (6, 7, 8, and 9) underline the importance of the following issues during the process of introduction and usage of the ways of engaging scientific Discourses.

- Communicative approaches and discourse patterns,
- Practising of Discourses of science, and
- Language of learning and teaching vs Physics register.

Communicative Approaches and Discourse patterns

This study shows that construction of meaning, within a strategy where engagement of Discourses is pivotal, is related to communicative approaches and discourse patterns that students engage. I have shown, in section 4.2.2.1, that the concept of communicative approach indicates how communicators take turns and mutually participate to reach intersubjectivity. The analysis chapters, namely Chapters 7, 8 and 9, have highlighted how access students at LP communicated at interpersonal level. Four possible discourse patterns were identified and discussed in Chapter 4. The patterns took the form of Statement – Answer – Statement, Statement – Question – Statement, Explanation – Answer – Explanation, and Explanation – Question – Explanation (see Table 4.2). Consequently two communicative approaches were identified as students are engaged in interpersonal communication. Thus the four patterns are used to define two communicative approaches. The surface and deep dialogue communicative approaches are hereafter referred to as surface and deep dialogue. Even though these communicative approaches have been systematically defined and identified, the demarcation line between them is sometimes too thin to draw. However, the results show the following:

Surface Dialogue: Surface dialogue refers to communication between two, or more, people where communicators are engaged in *Statement – Accept – Statement* or *Explanation – Accept – Explanation* patterns. Communicators engaged in surface dialogue reflect a shallow discussion of their ideas. The results in this study put to the

fore primary characteristic of surface dialogue. Firstly, communicators engaging surface dialogue, hardly negotiate suggested ideas. Rather, when one communicator makes a statement, the other simply accepts it. The discussions in episodes 8.3 and 9.5 highlight this characteristic. In episode 8.3, for example, Tsepo is accepting Bohlale's utterance even though Bohlale does not offer explanations. Similarly, in episode 9.5 Mahlomola accepts Sello's utterance. Secondly, during surface dialogue, a suggested claim is hardly backed by a justification. For example, in episode 9.5 Sello, turn 1, does not justify the utterance "**I think that, indeed I don't think this thing will go to both**. **I think it can only manage to go to one**." neither does Mahlomola, turn 4, justify his utterance "in other word they are like poles". When such incidences are subjected to the Toulmin's framework (see diagrams 8.4 and 9.13) they show lack of necessary justifications. In other words, surface dialogue is characterised by a student involved in interpersonal talk, making a statement, which often has no backing, and the second student simply accepting the idea. Consideration of what influences surface dialogue leads me to conclude that during surface dialogue, talk is over shadowed by the assumption: *the other understands what I mean* and/or *I know what the other means*.

Deep Dialogue: Deep dialogue communicative approach refers to an interpersonal communication between two, or more, people engaging one of the following discourse patterns: *Statement – Question – Statement* or *Explanation – Question – Explanation* pattern. The patterns above broadly reflect a situation in which communicators negotiate meaning of a suggested idea. Deep dialogue is therefore characterised by intersubjectivities arrived at after discussion of different aspects of an input. Conclusions drawn, in episode 7.4 and 9.7 for example, converge to a simple contention, that the deep communicative approach results in enriched Discourse with improved products and therefore with a possibility of an improved intramental product.

Though deep dialogue approach occurred throughout the four stages of the intervention it is observed that the occurrence improved in Conceptual Formulation and Conceptual Application stages. Interestingly, and probably as might be expected, deep dialogue incidences were scarce during Conceptual Initiation. As reflected in Chapters 6 and 8,

most of the learning at this stage involved lower cognitive demands such as observing and drawing. Thus talk at this stage involved less argument. On the other hand, talk which occurred in Conceptual Formulation and Conceptual Application stages required more argument. Inevitably during these two stages students had to support their ideas. Episodes 9.7 and 9.8 show communicators engaged in talk that attempts to understand a phenomenon and coming up with explanations. Such a talk therefore had to be deep dialogue. This is important because it highlights the potential that students in Lesotho's secondary education level, if given chance to talk, regardless of the background reiterated above, can engage discussions with colossal learning potential. Though I accept other science educators' position, e.g. Simon *et al.* (2006), that argumentation needs to be taught, the findings in this study suggest that the nature of the activity is also crucial in influencing the depth of argumenting.

Two important lessons are observed about communicative approaches and discourse patterns that help to understand strategies enabling the practice of Discourses of science. Firstly the classification of students' interpersonal talk into deep and surface dialogue is a pertinent conclusion insofar as talking, of course coupled with other stuff Discourses, is taken as a critical step in enculturation. Students in this access programme could engage in surface or deep dialogue regardless of the level of sophistication of the required talk and of the language actors used. The critical lesson about knowledge of communicative approaches and Discourse patterns, as social interactions between students occurring at group level, is that they reflect how LP access students engaged talk to construct systems of meaning (Chapman, 1993). A typical example is a discussion in episode 9.7 where Sello and Mahlomola are discussing the feasibility of an electric bell model operating as claimed (see appendix 2). Their discussion centered on the consideration of possibilities and resulted in some kind of conclusions. In turns 6 and 7 this is how the discussion proceeded:

Mahlomola:	**let me say this is** north, **isn't it? It will be** the, **yes it goes this way**. **It will be** repulsion. **That side** it ehh **it will be** attraction **this side**. **You see**? So **you understand it will go to one side?**
Sello:	**Yes**. **But this thing is the same thing here** …

Mahlomola is arguing a possibility of interaction of magnetic field lines leading to "repulsion" on one side and "attraction" on the other. He concludes that the result of this interaction will be a motion of the conductor towards one of the bar magnets. Sello disagrees. Sello is arguing rather that there exists same kind of repulsion on both sides. Clearly a negotiation of a shared understanding, e.g. a diagram of magnetic field patterns, was evident. I make a point that in situations where an issue is discussed, and indeed a nature of scientific learning, students internalise a concept, such as interaction of magnetic field lines in this case, easily. I underline the need for students to make arguments as a meaningful way of learning science and agree with Erduran *et al.* (2004:917) that

> …arguments concerning the appropriateness of experimental design, the interpretation of evidence, and the validity of knowledge claims are at the heart of science, and are central to the everyday discourse of scientists. Scientists engage in argumentation and it is through this process of argumentation within the scientific community that quality control in science is maintained…

The classification of talk into the communicative approaches and discourse patterns is therefore critical in understanding the nature of arguments and argumentation between students.

Many studies reported in the literature tend to concentrate on talk between the teacher and students (Scott, 1998; Mortimer and Scott, 2003; Erduran *et al.*, 2004). Though I agree with Rahm (2004; 225) that

> …knowledge is *collaboratively* constructed among students and teachers as they engage in activities they are committed to and deem valuable, and that make possible the exploration of new understandings of the world.

I make a point that such collaboration between students, especially at access programme level or at tertiary level in general, is as fruitful as the one between teachers and students. I view talk between students as critical insofar as implementation of the Vygotskian concept of ZPD is concerned. This position does not underestimate the role of the teacher as suggested in ZPD and elaborated by Rahm (2004). Rather, the subcategories of emergent category, Supporting Exploration, highlight the critical role that the teacher

plays in mediating learning. The point I make is that talk between and among students has proofed to be beneficial in supporting learning.

From these results, the process of enculturation of access students in which they are influenced to use talk as a learning strategy, is further clarified. Questions can be asked though about surface and deep dialogues. For instance;

- how is engagement of these patterns related to use of LoLT?, and
- how is engagement of these patterns related to issues of power within a group?

Ideally an expected scenario would be the dominance of deep dialogue, more so in Conceptual Formulation and Conceptual Application stages. Such a position is influenced by an understanding that during these stages ventriloquation is diminishing and students, from Conceptual Formulation onwards, begin to use their Physics register to express their learning fluently. An argument is made, in this study though, that the complex relationship between factors related to the use of LoLT is important. In particular, the issue of proficiency of language of learning and/or teaching, which is noted at different stages, cannot be underestimated. Surface dialogue's demand of proficiency of LoLT is lower compared to the demand of deep dialogue. Deep dialogue incidents (see episodes 7.4, 8.5, 9.7, and 9.8) clearly show dominance of the use of Sesotho, accompanied by different code switching categories (Rollnick and Rutherford 1996; Khati, 1992).

The second consideration about the two communicative approaches relates to the nature of intersubjectivities reached by actors at the end of such communication. This is a critical aspect to any teacher since it immediately highlights the degree of success of the mediating strategy. Intersubjectivities, and the resulting knowledge, has been discussed thoroughly in the literature (see Lerman, 1996; Wertsch, 1990; Musotov, 1996). This study suggests considerations therefore which a teacher needs to do concerning the nature of intersubjectivities reached (Wertsch, 1990; Musotov, 1996). Strictly speaking communicative approaches which students engage indicate the degree of engagement of talk. During surface dialogue, for example, it is hardly clear what students are agreeing on. For instance in episode 8.3 students Bohlale and Tsebo engaged a surface dialogue

when they were comparing magnetic field patterns between like and unlike poles of two magnets. In turns 2 to 4, reproduced below, they agree that

Tsebo	They are the same in the middle
Bohlale	In the middle they are still in circles,
Tsebo	Umm **(Yes)**

It is not absolutely clear what Tsebo refers to by "They are the same…" and "…in the middle" and also it is not clear what Bohlale means by "…they are still in circles". The intersubjectivity formed in the above extract possesses a possibility of long term knowledge. But what is their agreement? How detrimental is it to knowledge making? The point I make is when students engage surface dialogue, rather than deep dialogue, there may be a threat on the intramental product formed. Any strategy therefore that a teacher employs must not leave him/her wondering whether s/he succeeded or not. This leads to the next element of engaging Discourses of science.

Practising Discourses of Science

The second critical element reflected in this study, which gives meaning to the process of enculturation, is the notion of practising to use Discourses of science. By practising of Discourses of science I incorporate an action of engaging Discourses of a community and offering of opportunities to engage those Discourses. This notion of practising of Discourses of science acknowledges differences between the classroom setting and scientific setting (Bowen, 2005). I view the Lave and Wenger's (1991) notion of participation to encompass practising. The core understanding in practising of Discourses of science is that in classrooms members of the setting, in this case students, participate by practising of Discourses of a different, but aspired, community of scientists. Then they use Discourses of the aspired community. That is, practising should be viewed as participation before the actual participation. This study identified three primary emergent categories of activities in which practising to use Discourses of science is engaged, namely exploration, ventriloquation, and cross pollination. Crucially, about these categories of activities, students practised talking about scientific phenomena and using "other stuff" Discourses for further understanding of the phenomena.

The following characteristics, related to practising of Discourses, have emerged significant about the categories of activities:

Exploration: The emergent category shows students engaged in the process of meaning making of a scientific phenomenon. The process was initially characterised by learning how to use Discourses of science and relating them to the scientific phenomenon under study. These involved, for example, portraying magnetic field patterns using iron filings, magnet and a plain paper (see diagram 8.1 to 8.3). As students drew these diagrams they were being introduced to ways of talking about the phenomenon, interaction of magnetic field. It is pertinent to note that episodes 8.1 and 8.2 highlight practising of talk that is coupled with introduction of ways of talking about the phenomenon. The critical issue about the exploration is the notion that students are introduced to ways of using Discourses of science and the scientific phenomenon. Importantly, I concluded in chapter 6 that the activities grouped into exploration reflect a process of transformation of external actions into internal mental functions.

Ventriloquating: In section 6.6.3 I defined ventriloquation as mimicking of Discourses of a community. Characteristics of mimicking are highlighted in episode 9.1, a portion of which is reproduced below.

Sello	**Remember, remember those three things which we were doing yesterday**. **Those ones we were doing** … **we drew our, our** field**s .. these ones**. A wire carrying a current in a magnets … Ok! *Silence* **Isn't it they say** a wire carrying a current has a field around it?
Mahlomola	**Yes!**
Sello	**Then, they say** direction of field … Ok! **I wanted** … **which they say** a solenoid and bar magnets produces the same field.

In this discussion Sello wants to make his point but uses the phrase "…**they say** …" to indicate ownership of ideas. The critical issue about ventriloquation, insofar as practising of Discourses is concerned, is the notion that students use Discourses to express views partly assumed to belong to the aspired community and partly assumed to be that of students.

Cross pollination: I used cross pollination to connote activities in which there is an exchange of opinion, thus a "transfer" of understanding, between two, or more people. The discussion below, extracted from episode 9.8, characterises talk at cross pollination stage.

Kabi: as current flows **that thing gets** magnetised
Thabiso: **What gets** magnetised **here is, is** this coil. **What we are** concerned **about is the** movement of the coil. **When this coil goes upwards, that means**…
Kabi: **which** Coil **are you talking about?...**
Thabiso: **Here is a** coil **that**
Kabi: Oh! this one.

In this discussion Kabi and Thabiso are discussing "magnetisation of a coil". The discussion shows the two students making claims without reference to some authority elsewhere. I am making a point that talk during cross pollination reflects students' ideas. The three stages therefore reflect a progressive degree of practising of Discourses that starts from a situation where ideas were external to a situation where students express their own ideas.

Interestingly practising the use of Discourses of science in this study has been reflected as a progressive process which concurs with Mortimer and Scott's (2003) conceptualisation of Bakhtin's (1934) suggestion about appropriation of meaning by students. In Diagram 10.1 below I compare Mortimer and Scott's (2003) interpretation and the above emergent categories. Of particular interest in the comparison is the view of practising of Discourses of science by access students. Mortimer and Scott (2003) in this representation, highlights the students' view of knowledge which firstly starts as an external construct and later develops ownership of the process. In this study, practising of Discourses of science starts from mimicking of teacher's choice of Discourses. This initial process therefore characterises initial practising of Discourses as practicing of external construct. Then the process develops until students are able to engage their choice of Discourses.

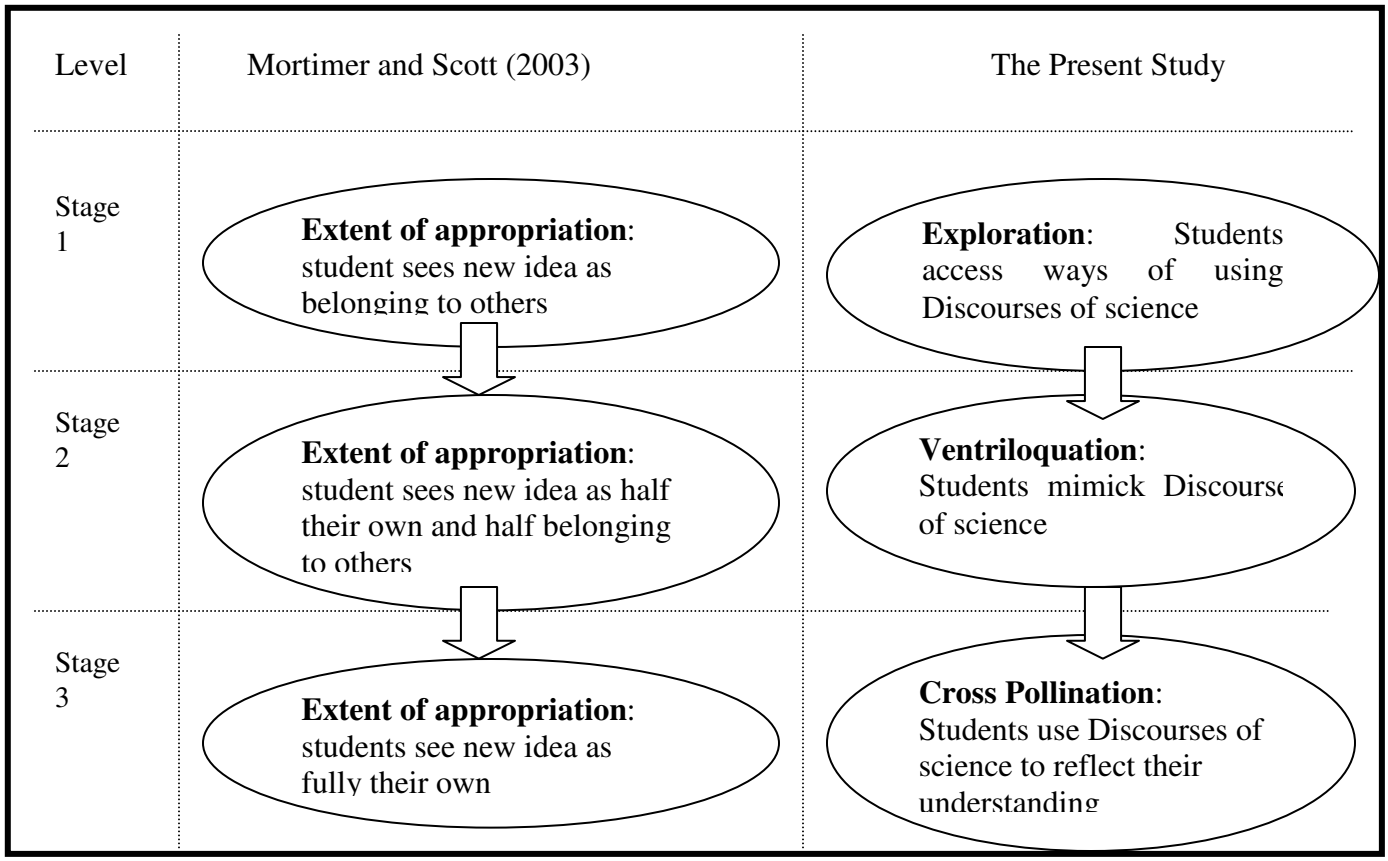


Diagram 10.1: Practicing of Discourses

It is pertinent to deal with the possibility of misinterpretation of Diagram 10.1. In this diagram enculturation is not necessarily displayed as a linear process. The incidence in Table 6.1, between the Teacher and the two ladies, Puleng and Karabo, adds an important perspective to the process of using and/or practising of Discourses. Though Puleng and Karabo in the earlier lesson had studied magnetic field patterns, of the form of Diagrams 8.1 to 8.3, they had to be helped to understand that work. Clearly Puleng and Karabo could not relate the previous work to what they were expected to do; assistance was necessary. The process is therefore not linear. At the least it can be said to be spiral. The responsibility of the teacher in supporting the practising of Discourses was crucial. The importance of Practising of Discourses is further strengthened by oral presentations in which other students and the teacher could contribute.

The importance of practising Discourses of science, as a theoretical definition of enculturation in a Discourse community, must not to be underestimated. The contention I

make here is that the meaning – making process was enhanced, and better guaranteed, by these three primary activities. Learning as a participation, as done in this study, has benefited students.

Language of learning and teaching vs Physics Register

The language of learning and teaching (LoLT) has surfaced as an element contributing negatively towards construction of meaning in many episodes in this study. The transparency of LoLT makes it unavoidable though the issue has been researched and reported thoroughly in the region in both science and mathematics education (see Setati *et al.*, 2002; Setati, 2005; Rollnick, 2000; Cleghorn and Rollnick, 2002). Proficiency of LoLT, in particular, has surfaced as an issue contributing negatively towards students' ability to effectively talk about scientific concepts. The problem of proficiency of LoLT was, in a complicated manner, compounded by lack of Physics Register. The relationship between deep dialogue incidences and the frequency of occurrence has been argued above. Two issues associated with this tendency must be noted; namely preference of using a certain language and depth of a discussion. I relate depth of discussion with freedom to talk at intermental plane which may result from proficiency of a language. I further relate the depth of a discussion with quality of talk and other stuff Discourses in the written text.

Various incidences, in different episodes and extracts discussed in the result chapters, reflect proficiency of both English language and Physics register. In Chapter 8 episode 8.2, for example, it is observed that students used the word "wana" to mean "**want**". The observation made is that in English language things do not "want". However, the Sesotho translations of the word allowed Bohlale to use the word the way he is using it in that phrase.

> They are going out, they don't wana (**want to)** touch each other like *inaudible* like it was doing with straight lines mane ha ke re? (**there isn't that so**?)

The use of the word therefore reflected the complexity of using LoLT which is not the students' mother tongue. But in the utterance Bohlale reflects magnetic field lines as a

living thing that can "touch" each other. Inevitably Bohlale's conception of magnetic field is also an issue in this utterance. Therefore in the same sentence both proficiency of LoLT and Physics register are reflected. Similarly, in episode 8.3 the choice of words that Bohlale and Tsebo make highlights this problem of proficiency of LoLT. Instead of using the word "between", Tsebo uses the word "near" in this episode

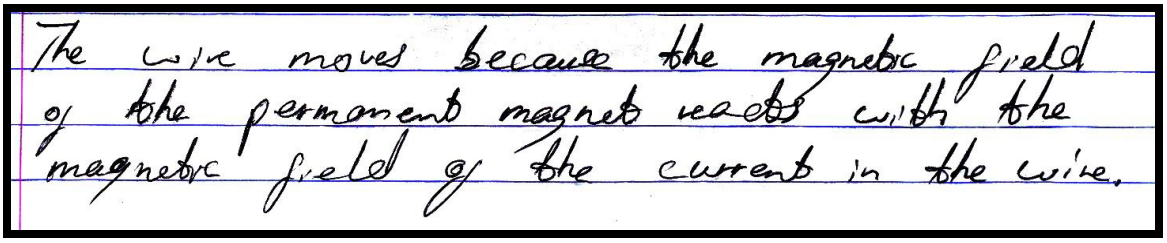
Bohlale Which means the field, fields lines
Tsebo The difference is where ehh near the, near this *inaudible* like poles

The result of this choice of words leads to the precision of meaning being compromised. The undertone in the episode is that of lack of competency of the LoLT. I interpret Bohlale's utterance, and other cases, with an observation though that

- usage of words and therefore their meanings are social and situated (Gee, 1999; Gee and Green, 1998), and
- "…discourse analysis is an analysis of social language, not an analysis of languages (like English) per se." (Gee and Green, 1998:142).

That is, if Bohlale's audience was the teacher, the meaning in the utterance in question could be different because he may have not used the word "wana".

Group A4's report, analysing the electric bell model, further supports the contention that the lack of competency of the LoLT and the influence of Sesotho contributed to lack of precision of meaning. Students in this group used the word "reacts" to imply the word "interaction".


The wire moves because the magnetic field of the permanent magnet reacts with the magnetic field of the current in the wire.

It is argued that the use of the word was influenced by Sesotho word with the same connotation. Thus, the problem of meaning, which is compromised, in this extract, is associated with use of LoLT and not necessarily conceptual. A critical look at other written reports suggests that the use of Sesotho has positively contributed towards meaning making.

The point I am making here is that enculturation is related to the proficiency of the LoLT. From the sociocultural perspective, language is a tool and as Adler (1999) argues it must not be visible to the extent that it makes learning invisible. According to Lave and Wenger's (1991) construct of transparency if language is visible then it becomes an epistemological obstacle (Moru, in press) to the process of enculturation.

10.3.2 Physics Concepts

The sections above made reference to students' Physics register and conceptions of some concepts. Though none of the research questions above directly led to discussion of students' conceptions, talking as an activity has highlighted conceptions that are worth noting. Chapter 3 discussed, from an individual's view of learning perspective (Leach and Scott, 2003), what literature informs us about what is known in relation to students' ideas of magnetic field. In this section I show that the contribution from this study suggests that access students at LP had a complex understanding of magnetic field patterns and the associated concept of direction of magnetic field lines. The following issues have surfaced in this study:

- LP's access students had initial situation definitions of the concept of magnetic field. The initial situation definitions include a complex network of the following;
  - magnetic field as lines that originate from one end of the magnet to another. An illustration of this conception is Diagram 7.12 in which students have drawn magnetic field lines, around a bar magnet, starting from one end of the magnet to another. These lines have direction to be specified from north to south pole of a magnet. Importantly too, Diagram 7.12 is divided into two distinct parts "N", for north pole, and "S", for south pole. A similar conception is expressed in an extract in section 6.5.1 that reflects collaboration between the two ladies Rethabile and Nthabeleng. It is reported that

    > Nthabeleng has divided her drawing of the magnet into two pieces and is still drawing. *(camera leaves 05:37:08)*

    Nthabeleng's drawing, referred to in the above extract, was similar to Diagram 7.12. It is important to notice that the extract refers to incidence during an

activity. None of the reports show this feature. What happened is evident. The interpersonal communication between the actors resulted in Nthabeleng changing her final drawing. This underlines the effectiveness of talk in addressing students' initial situation definitions at Conceptual Initiation. Finally I observe that none of students' diagrams, of magnetic field patterns, show a direct match with the Borges and Gilbert's (1998) model of magnetic field patterns. It is could not be established why this is the case.

- there is no direct relationship between magnetic field and application of force by magnets. This conclusion is based on the fact that students do not relate magnetic field to two common phrases; "unlike poles attract" and "like poles repel". If students do not relate magnetic field and application of force this has direct implication on their Physics register of the concept of force. Evidently such a register lacks coherence. The definition of force has two important components; namely a point of application of pull/push and what applies the pull/push. When there exists such a lack of coherence then the two phrases above are mere rhetorics. The situation had changed by the end of the intervention. Though Tau's presentation does not discuss interaction of magnetic field, it is clear from his diagram, Diagram 6.2, that their analysis considered them. That is, by the end of Conceptual Formulation students had realised the relationship. During Conceptual Application, as reflected by Diagrams 9.5 and 9.9, students' understanding of the relationship between magnetic field and application of force was clear.

- Students used the term "magnetic flux" rather than "magnetic field". The origin and/or the influence of use of the term "magnetic flux" could not be traced but the term is not mentioned in either COSC Physics syllabus or in most O'level books that students could have used. Regardless of how it was introduced, it is evident that the meaning that students attached to it was of "magnetic field".

- Students' understanding of direction of magnetic field lines had the following issues related to it:
    - The students' operational definition of the word "direction" seems to have the connotation of a physical movement. This definition, which conforms to Sesotho way of defining the corresponding phrases, signified an undertone that something moves from the north pole to the south pole.

    - Direction of magnetic field lines appears to have been a contributing factor towards the learning of, and/or talking about, magnetic field lines. In particular, the absence of labelling of poles, and hence of direction of magnetic field, contributed towards invisibility of interaction of magnetic field lines.

10.3.3 Effect of the Intervention

The effect of the intervention must be viewed as a qualitative construct rather than a quantitative one. A qualitative study, by definition, must result in a descriptive product. Merriam (1998) has noted that a qualitative research product has to be comprehensive, holistic, expansive and richly descriptive. The effect of the strategy therefore, on the students' learning, has been a positive one. As stated earlier, the purpose of the intervention was to introduce Discourses of science by way of emphasizing the language of science and associating talk with the phenomenon. The success of the strategy must be measured in the following:

- **Engaging talk:** Students' engagement of talk, whether taking the form surface or deep dialogue, is a success on its own. In section 10.1 above I recalled the background of students in this programme and maintain that such background must be noted when interpreting the results of this study. I must emphasise that what is important in this study is whether students were able to use language of science when engaging talk. The language of science is an academic social language with unique semantic patterns used by community of scientists (Lemke, 1990; Gee and Green, 1998; Gee, 2005). Any claim in this direction observes the undertone in Gee's (1999) definition of Discourses which encourages a holistic treatment of the issue.

- **Engaging "other stuff" Discourses:** I used the phrase *engaging "other stuff" Discourses* in a similar connotation to Lemke's (1990) meaning of "Talking Science". Lemke refer to Talking Science as:

  > "…observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing…" Lemke (1990:1)

  Engaging of "other stuff" Discourses is another element that shows success of the study. The result chapters show that

  - LP's access students used Discourses such as writing, discussing, agreeing, rearranging, and drawing to share their initial situation definitions of electromagnetism concepts,
  - LP's access students used Discourses such as identifying, matching, reading, agreeing, writing, and drawing to internalize the concept of interaction of magnetic field patterns,
  - LP's access students used Discourses such as drawing, identifying, agreeing, and writing to ventriloquate the meaning of the concept of interaction of magnetic field, and
  - LP's access students used Discourses such as identifying, naming, drawing, agreeing, and writing for cross pollination of application of concept of interaction of magnetic field in artifacts.

Students were therefore able to use Discourses of science by the end of the intervention. The use of everyday language was still observable even by the end of the intervention. This shows that although the study has been successful in other aspects, there was a longer way required in achieving total use of the language of science and abandonment of everyday language.

10.4 Recommendations

It is finally recommended that:

1 Improvement of learning strategies at Lerotholi Polytechnic (LP), and arguably even at Lesotho's secondary school level, is evidently critical. In particular, encouragement of discursive processes, which must be addressed during the access

programme, is highly needed. It is therefore recommended that students be trained on how to engage in scientific Discourses including how to talk about and use a scientific phenomenon.

2 A recommendation of encouragement of improved students' learning strategies must acknowledge teaching strategies and the training of teachers. It is therefore recommended that teacher training institutions, the National University of Lesotho and Lesotho College of Education, improve their training programmes to encourage teachers to promote the discursive process in their science classrooms.

3 It is acknowledged that language issues are also political (Setati, 2003). Discussions above have shown that there are issues that may affect learning that are purely language related. Lerotholi Polytechnic, the Government of Lesotho and other tertiary institutions which admit students such as those that are accepted at LP have to reconsider the LoLT policy.

10.5 Further Areas of Research

There are further areas of research which might be pursued to respond to the problems in Lesotho. Two of those areas are:

- Five years after the running of the intervention in this study, the sister programme Pre Entry Science Programme (PESP) at NUL is facing the problem of high intake. Believing that the idea of enculturation can work, the challenge becomes implementing it in a high intake environment.

- I was asked to help in the teaching of Physics at Sefika High School in 1999. The enrolment of the science class was 63 students in the Form 4 class. The situation was such that the classroom space was too small to allow movement of the teacher. There was only one laboratory to be shared by other streams. The challenge is practising enculturation within this kind of environment.

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