PERCEPTIONS OF LANGUAGE TEACHING IN SCIENCE FROM STUDENT AND TEACHER DISCOURSE

THESIS

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ABSTRACT

The research was concerned with perceptions of language and physics in three strata of participants in a writing across the curriculum teaching course at an intermediate college. The participants were: a language teacher, two physics teachers and a class of twenty physics students - the students were studying in order to enter the Engineering Faculty at the University of Cape Town.

The predominant understanding of the teachers was that of a limited interpenetration between the discourse of physics and language teaching. Physics teachers thought that language teachers would experience difficulties with both the concepts and language of physics. In actual practice however, students and the language teacher managed physics knowledge with some degree of success in the language classroom.

Some students understood writing as helping them to understand physics. However, the dominant understanding of language was that of knowing the appropriate language of physics for their teachers. An appropriate language understanding was seen as potentially problematic in that it could encourage an unquestioning or monodimensional approach to physics knowledge. As a way around this problem, it was suggested that language teachers teach students to recognise and to use particular genres within science, and to develop their voice within these constraints.

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CONTENTS

GLOSSARY OF ACRONYMS

DET The department of education and training. This is the education department responsible for black education in South Africa.

EAP English for academic purposes. Traditionally EAP is the label given to language support courses for DET students at English speaking universities.

L2 Second language. This refers to people for whom English is second language.

LAC Language across the curriculum i.e. language taught in subject disciplines.

LEAF Leadership Education Advancement Foundation.

UCT The University of Cape Town.

INTRODUCTION

0.1 THE RESEARCH GOALS

The general research goal was to investigate the following question:

> * **What is the relationship between teaching language and teaching scientific knowledge?**

The particular branch of science I was concerned with was physics. Thus my more specific goals included investigating the nature of this discipline. In addition I was interested in how different individuals constructed a relationship between language and science teaching.

My more specific goals are thus the following:

> * **What are physics' teachers understandings of physics?**
>
> * **How do physics' teachers relate these understandings to language teaching?**
>
> * **How do language teachers understand language teaching within a physics context?**
>
> * **How do learners understand language teaching within a physics context?**

0.2 THE RESEARCH PARADIGM

My approach to this research was within a social constructivist paradigm (Guba, 1990; Beach et al, 1992). Researchers who have a social constructivist world view maintain that there are multiple representations of the world which are context dependent, rather than some form of unitary, objective reality; by context they mean both the

situation itself and the individuals involved in this situation.

Within such a paradigm a research goal such as "what is the relationship between teaching language and teaching scientific knowledge" is not answerable in terms of generalisable, objective answers. Rather I have described how language teachers, science teachers and students understand this language/science relationship within their particular teaching and learning context.

My role as researcher was to interpret these understandings to form a context-specific construction of the relationship between language teaching and science. My hope is that language practitioners can judge the usefulness of this construction within their own teaching contexts (Greene, 1990).

The role of the researcher in social constructivist research is that of a subjective interpreter of events as he/she understands them. I have thus preferred to preface my descriptions and understandings with the pronoun "I" rather than with some other form of address.

0.3 THE RESEARCH CONTEXT

0.3.1 An experiential perspective on the research

Language across the curriculum (LAC) work in science classrooms is often a formidable task for language teachers. Teachers, usually from non-science backgrounds, feel baffled by science content and find themselves positioned outside of science.

As a science teacher myself, and a student of language across the curriculum, I am interested in how language teachers construct their teaching, and how this teaching becomes constructed in the minds of students. Furthermore, I

am interested in what implications these constructions might have for students' learning within the discipline. The following narrative, based on my experience as a language in science teacher, raised some interesting issues which helped me frame my research.

I worked for six years as a course developer and teacher on university language support programmes in a science faculty. These courses were aimed at bridging a perceived gap between the language African students bring with them from their schools, and the demands of the university.

The courses were not well-received by either students or faculty staff, and staff turnover was extremely high, compared to parallel courses in the arts and social sciences. One science teacher on an integrated foundation science course (biology + geology + language) went so far as to suggest herself, rather than a language teacher, as the most competent person to teach language. What this suggests is that the science teacher, rather than the language teacher, is in the best position to teach language within her subject.

A somewhat different, though linked event occurred during a geology lecture on the same integrated foundation science course. In one lecture on vulcanism, the lecturer began to digress into some of the disasters, in human terms, which had resulted from explosive volcanic eruptions such as Krakatoa. She then turned to me and said "this is something which you might like to follow up in the language classes".

The obvious reason why she had done this was that it had human interest, was broadly about geology and was likely to be suitable for some form of extended writing task. However what interested me was that this knowledge was not mainstream geological knowledge and was not likely, in any direct way, to further students' geological knowledge. To use a term borrowed from Dowling (1992: 26), this task concerned the "public" knowledge of geology, that which is

of everyday interest and concern. It did not necessarily engage with the "esoteric" aspects of the discipline i.e. canononical knowledge on which that discipline is structured.

Dowling's framework of esoteric and public knowledge was devised within the context of school mathematics. However I think it is useful in describing science knowledge. Dowling further describes esoteric knowledge as the dominant discourse of mathematics, since it allows learners to explore further within the confines of that discipline. Public knowledge, on the other hand, has limited value for learning about this dominant discourse.

These two narratives raise the issue of conceptual distance between language teachers' knowledge and the disciplines of the sciences - this same issue arose in the teaching of language in physics in section 3.3.1.

Furthermore many students who are studying science do not see the relevance of English for Academic Purposes (EAP) courses to their science studies. Students often feel that they know enough about language from school, or that writing is not relevant to science studies. The following quote, taken from a science students' evaluation of the EAP course mentioned above, is fairly typical:

> *There are a lot of essays done in arts compared to us here in science. In my courses I do not do essays or lots of reading. So for the other students it is helpful but for us it is not.*

My research was thus concerned with how scientists conceptualized language teaching within their disciplines, how language teachers understood this as happening and finally what students understood as the importance (or lack of importance) of language teaching in the sciences.

0.3.2 Discourse analysis and discourses

In order to get at understandings of language in science I used the method of "discourse analysis". But, as Burman (1992) and Fairclough (1992b) point out, there is no clear cut approach to discourse analysis - how you analyse discourse depends on which sort of product you wish to derive from it.

For example, Sinclair and Coulthard (1975) attempted to develop a classificatory system which typified classroom discourse. They devised units of descending rank, such as lesson > transaction > transactional moves and so on. Each of these could be further sub-divided into categories; for example "moves" consisted of categories such as "teacher elicitation", "teacher directive" and "student bid".

Ideally, any classroom discourse could be thus analysed and then compared to discourse in other classrooms. However as Fairclough (1992b) notes, this is a fairly rigid and limited system which furthermore does not sufficiently interpret or critique why certain interactional forms are dominant.

A similar form of discourse analysis is that of conversational analysis (Garfinkel, 1967) in which systems of "rules" for inter-peer conversations, for example turn-taking rules, are categorised; how these rules determine what speakers can or cannot say are then analysed.

Fairclough's (1992b) system of discourse analysis involves an articulation of social theory with linguistic forms. Essentially this involves the deconstruction of discourse so as to expose its ideologic base. Furthermore certain discourses use language in particular ways to instantiate certain power relations and social identities of readers or listeners; the role of analysis is to expose these often

hidden social relations so as to "empower" learners to resist and possibly change them (Fairclough, 1992b: 240).

In my own analysis I was interested in the understandings of language in science which teachers and students expressed in conversation. I was not concerned with types of interaction, nor with a deconstruction of language use. Such a form of discourse analysis is that favoured by social psychologists such as Potter and Wetherell (1987) and Burman (1992).

A further issue that needs clarification is that of the difference between discourse analysis, which concerns the analysis of stretches of language, and "discourses" which are akin to language varieties.

The importance of the concept of "discourses" is that it provides a bridge between the world of language and that of subject disciplines.

For the moment my working definition for a discourse is:

> Any stretch of language which we can identify as different from other stretches of language through what it talks about, how it talks about this content and who is involved in the interaction.

The concept of discourses will be picked up again in section 1.2.

0.3.3 Voices

Related to the notion of discourses is the concept of "voices". Wertsch (1991: 135) proposes the existence of an abstract language in school science called the "voice of official science". This voice reflects the typical ways the language of teachers and texts reflect the concepts of school science - such a concept of voice is similar to the concept of discourses discussed above.

However the abstract quantity "official voice" is very different from voice in use. When students talk or write they often appropriate some of the official voice and mix it with other understandings from previous experience and present perceptions; their utterances are thus multivoiced (Ibid: 138).

As with discourse, voice is more thoroughly discussed and related to my research project in section 1.2.4 of the theory section.

0.3.4 The research institution

The research was conducted at a university feeder college, The Leadership Education and Advancement Foundation (LEAF) college. The college is a two year intermediate college which prepares mainly African English second language (L2) matriculants for study at university or technikons. After two years they write the first year exams of these institutions and they may gain entry into the second year.

Students study either commerce or engineering subjects. They are also separated further into technikon and university streams.

I worked with the first year university engineering stream, all of whom were studying physics. The particular topic these students were studying in physics was that of mechanics. First-year engineers do the same first-year physics as other students, however their exam is different. At the time of writing it consisted entirely of calculation and multiple choice questions.

These students have four communications classes per week. Much of the course centres around oral and written communication, for instance report writing and presentation. I worked with them at the end of the first semester; this was their first taste of LAC involving physics.

I did no teaching but was deeply involved in planning how we could integrate ~~the two~~ subjects with the language and physics teachers. I chose paragraph writing as the unit of study as this was large enough to include the complex articulation of ideas in writing, yet small enough to be manageable.

CHAPTER ONE

THEORETICAL BACKGROUND TO THE RESEARCH

1.1 INTRODUCTION TO THE THEORY CHAPTER

The structure of this chapter is as follows. Firstly I have described my theoretical model of language instruction and how this differs from other models. Then I have suggested that writing coherently is bound up with knowledge of the discipline and the typical ways it is expressed; this I have called the "discourse" of the discipline. Furthermore I have described how there is often unequal access to these discourses because of the different socialisation of students. This is followed by a discussion of the relationship between disciplinary discourses, language and language teaching, with particular reference to typical modes of expression or genres. I have used the concepts of "appropriacy" and "voice" to critique an inflexible approach to teaching language within discourses and genres.

Lastly I have discussed the teaching framework which was used to teach the writing of explanation in physics. At each stage I have highlighted links between information structure in English and disciplinary discourses.

1.1.1 Some models for language instruction

The thesis is concerned with what happened during the planning and teaching of a language in science course and, furthermore, how students understood language in this context. I have thus devoted much of this chapter to describing the LAC teaching model used in this research.

This model provided a frame of reference against which teacher and student perceptions of language could be indexed. I was at no point evaluating this model against other possible language teaching models. What I did do, though, was to make recommendations about LAC courses in science (section 6.2.3 - 6.2.5 in the conclusion), but these have to be understand within the framework of my teaching model.

The teaching model which was used was one which concerned the integration of language teaching with the discourse of physics, and particularly the genres associated with this discourse. This teaching model itself derives from a social constructivist world view i.e. that learning is an interaction of individual subjective experience with the conventions of the social world (Ernest, 1993). (See also section 0.2 for the research paradigm).

The method of analysis, discourse analysis, was also based on this social constructivist world view (see sections 0.3.2 of the introduction, 2.2.3 and 2.2.4 of the methods section and 3.1.1 - 3.1.3 of the data analysis for more information on discourse analysis).

The particular teaching method used, that of close co-operation between language and subject teachers, seems to be the preferred method in tertiary science education today. For instance in South Africa Starfield (1990) and Kotecha and Rutherford (1991) recommend this method. More generally the method of content-based language instruction has been put forward by, amongst others, Snow and Brinton (1988) and Snow et al (1989).

However I find these language approaches broadly lacking in that they fail to take cognizance of the social construction of disciplines and students' individual interpretations. Rather they favour a more cognitive approach to content-

based language learning, loosely based on Cummins' (1981) concept of cognitive academic language proficiency.

Perhaps slightly closer to my model are the recent genre approaches to writing in science, for instance Veel (1992) in Australia and Robinson (1993) in Botswana. However the genre they chose (laboratory reports) does not necessarily reflect what I have referred to as the "dominant discourse" (section 0.3.1) of disciplines - nor do they make reference to the voice of the learner within the genre.

1.1.2 Language and cognition

My model for language teaching is concerned with content and cognition, but in a different way to the authors cited above.

I think that Nightingale (1988: 81), in discussing problems in student writing within tertiary disciplines, is right when she states:

> At points where language and cognition intersect the learner is capable of articulation of the knowledge.

Similar conclusions have been drawn from tertiary science writing in South Africa. For example Inglis (1993) observed that students' language broke down when they were asked to explain complex phenomena, though their language was satisfactory elsewhere.

I think that tied up with cognition here is knowledge of the **context** of the discipline, the whole enterprise of the subject matter, its umbrella understandings (Perkins, 1991: 79). For Perkins this cradle of understanding is woven with content and routine procedural abilities, proficiency in explaining and justifying content matter and "knowledge and know how concerning the way results are challenged and new knowledge constructed".

Thus the sorts of questions which interested me in this research were those concerned with the interaction of language and the knowledge of the subject discipline. In particular I was interested in teacher and student perceptions about this interaction. I hoped that these perceptions could provide some pointers for curriculum development in language in science teaching.

1.1.3 Discourses and the relevance of this research

The particular relevance of this research for second language learners comes from the theoretical construction of discourses. According to this construction people are constituted as subjects within multiple and often conflicting discourses. However the discourses available to subjects are not evenly distributed. The groundwork for the dominant discourses, i.e. those of dominant institutions such as schools and businesses, tend to be acquired by the dominant classes in their socialisation. Less dominant groupings, such as women, blacks and workers, often do not have this kickstart into dominant institutional discourses.

Gee (1990) describes this kickstart notion in terms of primary discourses into which children are socialised at home, and the secondary discourses of teaching institutions. Sometimes elements of the secondary discourses of the school are introduced by parents into the primary home discourse, thus easing the transition between home and school.

Some indirect evidence for the relationship between primary discourse, secondary discourse and school success comes from Morais (1993). Morais worked with senior primary science students in Portugal. Her interest was in the effects of class, race and gender on, broadly, academic success in science.

Morais relies on Bernstein's (1990) large and complex project which attempts to understand how language in education perpetuates power relations along class lines. She

uses Bernstein's concepts of "recognition rules" (Ibid: 29) of what does and what does not count as school knowledge, and "realisation rules", the ability to produce the contextually appropriate voice.

In order to test for recognition rules children had to give an explanation for the question "why does perspiration cool us down?". They had to choose a correct answer for the question from three choices, which ranged from simple definition to the correct application of the laws of evaporation to cooling our skin. Another task, this time testing for realisation rules, involved constructing an answer to the same question.

Morais concluded that "social class is strongly correlated with recognition rules and it is also strongly related to the most complex tasks of realisation" (Morais, 1993: 266). Also that "family socialisation is crucial in developing the elaborated orientation, institutionalised in the school and required for developing "U" competencies (use of knowledge in new situations)."

Morais' work is also interesting because it promotes the idea that school teaching with a strong emphasis on recognition and realisation rules offsets the disadvantages of socialisation. Gee (1990) promotes a similar argument in terms of the acquisition and learning of discourses in school. Acquisition, that which happens unconsciously through "practice within social groups" (Ibid: 146), can be augmented by the teaching of "conscious reflection" through "explanation and analysis". However, for Gee, acquisition has to precede learning. Learners need to be apprenticed to the practice of a discipline before they can analyse it into its component parts. This is the nature of the project which students were engaged in this study - both apprenticeship and analysis - which provided the framework from which I analysed teachers' and learners' "interpretative repertoires". Broadly speaking, the physics class provided

the apprenticeship to the discipline and the language class the analysis.

Up to this point I have alluded to the idea of subject discourses in education and how some learners, through their socialisation, gain a headstart in acquiring these discourses. I will now discuss the concept of discourses in education more generally. I have tried to weave discourse in with language and language teaching, with particular reference to the role of language teachers in helping students acquire subject discourses.

1.2 DISCOURSE

In section 0.3.2 of the introduction I distinguished between doing discourse analysis and the notion of discourse itself. Analysis is dealt with more fully in sections 2.2.4 - 5 and 3.1.2 - 3 in the method and analysis chapters respectively.

In section 0.3.2 of the introduction I gave this working definition for discourse:

> Discourse is any stretch of language which we can identify as different from other stretches of language through what it talks about, how it talks about this content and who is involved in the interaction.

The first point to note is that my understanding of discourse is not that of spoken or written stretches of language alone. Rather it is that language in use can be divided into different discourses which reflect, broadly, understandings or intentions on the part of the producer.

I have used the ideas of Gee (1990) on discourses and social literacies, Foucault (1972) on knowledge, power and discourses and Swales (1990) on discourse communities to pin down the concept of discourses. However I found this concept alone to be too deterministic to account for learners'

language and I have thus included a section on discourses and voices.

Discourses are interpretative repertoires (Burman, 1992) through which we as subjects are constructed in the world. Gee (1990: 142) refers to discourses as "identity kits ... which come with the appropriate costume and instructions on how to act, talk and often write, so as to take on a particular social role others will recognise".

According to discourse theory, we draw on different discourses in different situations depending on our interpretation of what is needed. For instance the patient to doctor discourse we choose to use can vary according to which functions we want our language to perform. We might choose to come over as someone who looks after themselves or alternatively someone who needs a lot of care and advice. Which way we come across may depend on our assessment of the doctor, our self-image and medical need. However these are not transient states but rather constitute what we actually are; when we project ourselves through a competent discourse, we simultaneously bind ourselves into this discourse (Parker, 1989).

In effect, then, when we use language we are not simply referring to events outside of ourselves but we are actively constructing these events, in accordance with the discourses available to us. This is partly what is meant by a "social constructivist" approach to language mentioned in section 0.2 of the introduction.

In Foucault's terms (Parker, 1989: 61) discourses exert a form of covert discipline over our possible actions; freedom of choice is somewhat of an illusion. For instance the repressive sexual discourse of the Victorian age has gradually been replaced by more "free thinking" discourses of sexual liberation. However these discourses have created "an arsenal of categories and labels with which sexual minorities are typified against the norm".

In this respect discourses are conservative influences which tend to maintain the current power relations in society. To some extent these power relations are reflected in education through "dominant" and "subordinate" discourses of science and mathematics discussed in section 0.3.1 of the introduction.

1.2.1 The discourses of subject disciplines

Swales (1990) provides a useful account of disciplinary discourse through the idea of discourse community. For Swales the academic world is broadly divided into academic discourse communities which limit and define knowledge in particular disciplines and sub-disciplines. For instance ethologists define what constitutes animal behaviour knowledge, and what belongs in related disciplines such as physiology. These differences include certain central and powerful concepts peculiar to disciplines (Prawat, 1992). These powerful concepts of a discipline would be what enable learners to explore further within the discipline, and are thus generative; they provide access to the "dominant discourse" (Dowling, 1992: 5) of the discipline. Furthermore discourses define what counts as research, appropriate modes of analysis and representation of knowledge within a subject. How, though, does teaching fit in with this idea of discourse? As Prawat (1992) notes:

> many of the activities students undertake are simply not the activities of practitioners and would not be endorsed by the cultures to which they are attributed. At best school is a culture implicitly framed by one culture ¡the school¿ but attributed explicitly to another ¡how the discipline is practised¿ (Brown in Prawat, 1992: 377).

In this research I was initially unclear whether I was looking at the same discourse but from different perspectives and levels of expertise, or at two discourses,

education and the practice of the discipline, each possessing their own completeness.

A useful approach is to view a discourse in some sort of dynamic relationship with other discourses. For instance the discourse of physics in a predominantly teaching institution would be somehow reconceptualised in terms of discourses of teaching; in more research based organisations "physics" would be more defined by its relationship to discourses of research. Foucault (1972: 43) refers to these as different "orders of discourse". Some of the implications of physics within education are discussed below. Also I have used this useful concept of different orders of discourse to critique my analysis of interviews in section 6.1.2 of the conclusion.

1.2.2 Discourses and writing: the concept of genres

Discourse communities define particular types of purposeful writing, or genres, within their disciplines; for example reports, definitions, arguments and so on. Within particular discourse communities these would have particular structural features, tone and style and, above all, a clear communicative purpose which needs to be realised in order for the writing to qualify as part of a genre (Swales, 1990).

Thus genres do not necessarily cut across discourses but are overarched by the terms of reference of the particular discourse community. Studies of first-year essay writing have shown this to be very much the case, where the genre conventions of argument in one discipline are judged unsuitable by lecturers in other disciplines (Taylor, 1988).

Like Taylor, I think that genre has little value outside of the message it is communicating. We do not think about knowledge then squeeze it into a suitable genre which can then be emptied out of its content and re-used elsewhere. I agree with Mike Rose (1983: 122) when he states:

> Organisational patterns should not be thought of or taught as "modes" of discourse or as rigid frameworks but simultaneously as strategies by which one explores information and structures by which one organises it ... the two most natural ways to assimilate or learn these patterns are by reading a good deal of the discourse containing them and experiencing the need for them as one encounters barriers while writing.

The above description of "exposure" and "problem solving" was the predominant teaching method used to teach writing to students on this research project. As discussed in section 2.1.2, the language teacher modelled the writing of explanations using content and styles from the physics class. Students then had to do written exercises in which the teacher encouraged them to use the conventions of the genre of "science explanation" as an effective way to solve the problem.

Students, in engaging with the genre of explanation in science, are forced to confront their conceptual misunderstandings; the quotes in 5.4.1 confirm that this occurs. Thus I think that genre teaching enables students to expand their knowledge of physics rather than being simply restrictive. According to Hanne Bock (1988: 33):

> While particular discourse structures force restrictions on students, they also habituate disciplined thinking. Therefore essay writing tends to become easier practice with practice. Familiar modes allow familiar analytical processes to take place and ease the process of structuring and sequencing the writing. New genres are difficult exactly because of the interaction of analysis and structure. They force the student to develop different analytical cutting lines into their material and hence to develop different perspectives on it.

I think the ideas of "disciplined thinking" and "analytical cutting lines" are important here. This is because such thinking and analysis is concerned (at least within the genre of explanation) with the application of theory to events: the nature of explanation is discussed below in section 1.3.1. Interestingly, being able to apply theory to events was how one of the physics teachers perceived understanding in physics (section 3.2.1).

Applying theory for understanding is surely about using and refining one's knowledge of the "powerful concepts" of a discipline. In being taught to use a genre such as explanation, students are thus potentially developing generative knowledge about the discourse they are engaged with.

There was, however, a difference of opinion between myself and the language teacher as to how she went about doing this. This quote from the planning gives a sense of this difference (l is the language teacher, m the physics teacher and j is myself):

> *l. We need to get students to state the theory in the first paragraph and then to apply it in the second paragraph. This is the way m has done it in his model answer for "coffee capers".*
> *j. We could also ask them to integrate the two so that you continually cross refer to the theory but do not actually state it at the beginning as something separate.*

What l is promoting here is, quite correctly, the genre conventions as outlined by the physics teacher. My problem however was with a deterministic understanding of how to write in physics, that there is one way to write which is appropriate for that discourse.

1.2.3 Appropriacy and discourses

The first problem with a deterministic understanding of language relates to recent research in secondary school science in the United States. Students tended to understand science as "received wisdom" with the following implications for language and science learning:

> The students tended to repeat and confirm information provided by their teachers rather than construct meanings for themselves, and they tended to practise and regurgitate their teachers' formal science vocabulary in a relatively meaningless way. Indeed they were so adept at this that it actually acted as a disguise for their lack of any real understanding of the concept involved (Parker, 1992: 30).

Parker's ideas are backed up by those of Swales (1990: 12), but this time with reference to tertiary, English second language speakers. Swales believes there is a danger that such students tend to adopt a "monodimensional" approach to the language of their subjects.

Furthermore, a strong component of students' understanding of language in science in this study was that of using an appropriate language for their physics teachers (section 5.3.1).

If language teaching is going to engage with meaningful learning of science, rather than rote-learning, then teachers have to deal seriously with such notions of appropriate language from students. I have put forward some ideas on how language teachers can engage with appropriate language and learning physics in section 6.2.3 of the conclusion.

Fairclough (1992a: 43) criticises the notion of appropriacy in two main ways. Firstly he questions the idea that there

is some identifiable appropriate form of language to a particular situation. He describes this assertion thus:

> What image of language variation do appropriateness models give? In one sentence it is, I think, an image of clearly distinguished language varieties being used in clearly distinguished contexts, according to clear cut conventions, which hold for all members of what is to be assumed to be a homogeneous speech community.

He then goes on to describe how an apparent clearly defined "language variety", that of the doctor/patient interview, is in fact variable depending on "his or her view of medicine, conception of patients and so forth" (Ibid: 45).

Fairclough (1992a: 51) also criticises appropriacy in terms of the power relations involved in reproducing it in that it privileges the "sociolinguistic order of the dominant social group". Appropriateness, in this view, is not a natural phenomenon but one which replaces possible variation with a monodimensional approach; there are clear similarities here between Fairclough's concerns and those of Parker and Swales above.

However there is a tension between Fairclough's criticisms of appropriacy and apprenticeship into a discipline.

I think to celebrate alternate conceptualisations, or forms of presentation, is to do a disservice to learners entering into an apprenticeship within that discipline. The disservice is on two levels. Firstly, how learners package their information for the hearer signals membership or nonmembership of a discipline and "signals a world within which the text makes sense and finds its grounding" (Gee, 1990: 109). Or, as Wertsch (1991: 59 - 60) notes, utterances take on meaning within the social world when speakers speak through, or "ventriloquate", the appropriate social language; social languages and discourses are similar concepts.

Secondly, the learner engaged in some form of alternate conceptualization of a discourse is not necessarily using and experimenting with the powerful concepts on which disciplinary knowledge is founded. Nor are they necessarily using forms and concepts for creative problem solving and exploring knowledge within that discipline. They are possibly not engaging with the "dominant discourses" of subject knowledge.

I think that one way to resolve the tension between problems of appropriacy and the constraints of the discipline is through the concept of "voice" and through allowing some variation as to how learners can represent genres.

1.2.4 Voice and discourse

Finding one's voice within academic writing is particularly difficult because of the standardised conventions attached to such discourse. However learners can develop a personal voice of sorts within these constraints by making choices from the standardised repertoire. Such a voice is thus constituted by being a "unique mix" from this repertoire which the learner finds most suitable for what it is they want to say (Ivanic and Simpson, 1992: 142).

Cazden (1992: 193) describes voice in terms of it being "the speaking consciousness" of a person which is simultaneously expressing what they want to say, particular value systems and a sense of what the listener or reader might judge as appropriate. She also describes the tension between the newness of the individual's construction and the limits of the discourse thus:

> While speech is structured ... it is also emergent. There is an intrinsic tension between constraint and choice, between the given of tradition and the new of responsiveness (Ibid: 195).

Cazden is concerned with encouraging minority students to use the standard language of academic writing, so as to introduce new (and often personally important) terminology and types of knowledge into it. In this way learners undergo apprenticeship to disciplines, not simply through reflecting the dominant norms, but also through reconceptualising these norms.

Intuitively I feel there is much more chance of this occurring in the arts and social sciences than in the natural sciences. This is partly because of the extremely condensed nature of scientific writing (Lemke, 1987), in which the original voices are left out, as well as its more rigidly adhered to genres of writing.

However, students writing in science do use their personal voice as indicated by these two answers to the question "why is it easier to drink a cup of coffee in a plane flying at constant velocity than in a car traveling along lower main road?"

1.

Yes it is easier to drink a cup of coffee in an aeroplane that is flying at constant speed. The reason being Newton's first law of motion which states; a body is at rest or in constant motion unless acted on by an unbalanced force. This law is also called the law of inertia. In a plane when holding cup of coffee in your hand the cup is moving with the same constant motion as the plane. So if there could be any change in motion on the plane, the cup will want to continue moving in the same direction as before (inertia). Therefore, the plane experiences no inertia, because it is moving at a constant speed, and the cup will continue moving also with constant speed. But on the car the cup experiences a lot of inertia so it will be hard to drink coffee in the car.

2.

Because the plane is moving at constant speed, this will mean that all the external forces that are acting on the plane are in equilibrium. This could be taken as though the plane is stationary on the ground even though it is not so. Therefore it is easy to drink a cup of coffee. When it comes to the car, when it accelerates and you are still holding the cup in front of you the cup will resist the motion and you will feel its force on your lips. The coffee inside will also resist this motion. So when the car moves forward this will mean that the cup and the coffee inside are left behind and in this way the coffee will spill. This is because of the inertia of the cup and its contents.

These two pieces of writing were taken from students on the research project. Both texts work within the constraints of the genre of explanation within physics - they explain by relating a general law to the specific events and use some of the appropriate terminology of physics, though sometimes incorrectly. However they each have their own individual creative stamp within these constraints; the most obvious difference being that the second writer chooses to diffuse the general law through his text without explicitly stating it.

Returning to the difference of opinion discussed in section 1.2.2, a more open teaching approach to the discourse allows for more individual variation from the learners as to how they write. It also, hopefully, allows for some ownership of the concepts within the discourse of physics.

What I have discussed so far has been largely within the framework of "language in discourse". This framework has involved teacher modelling of discourse, but in such a way that there is space for students to express their own voice in their writing. What has not however been discussed is the role of language teachers within this framework.

1.2.5 Language teachers and physics discourse

To what extent can language teachers hope to model the complexities of discourse genres such as explanation in physics? Ruth Spack (1988: 38) takes a dim view of the ability of language teachers to deal with disciplinary knowledge:

> It seems that only the rare teacher can learn another discipline, for each discipline offers a different system for examining experience, a different angle for looking at subject matter, a different kind of thinking ... the teaching of writing in a discipline involves even more specialised skills than does the teaching of the subject matter itself.

Language teachers could, however, rely on physics students to supply content knowledge and appropriate terminology in the language classroom. The language teacher's role would then be to provide knowledge on information structure in English. But students themselves might not be sufficiently knowledgeable about subject discourses to articulate them meaningfully.

For example, students are unlikely to understand register as theory-generated unless they have been explicitly taught this (and, of course, exposed to such register in the content classes). What language teachers could do, however, is to supply in close conjunction with the subject teacher, a scaffold for making more informed decisions about discourse. For instance, with respect to checking one's text for discourse-appropriate register, language teachers could pose the following questions: What are the central theoretical concepts involved here? What sub-concepts are typically associated with them? How do these concepts and sub-concepts usually relate to each other (e.g. sequentially, cause and effect, as evidence for, predictively and so on). As Swales (1990: 218) puts it, language teachers can teach their students to become

"ethnographers" of the various scientific disciplines in which they are engaged.

Furthermore language teachers can utilize their skills in process writing to encourage the notion of personal voice within the constraints of the discourse genres. Such a process would involve students' constant awareness of the "fit" between what they want to write and the limits of the genres.

This sort of process could be seen as one of recontextualisation (Cazden, 1988: 113); the role of the language teacher is to help students structure their own understandings and preferred ways of expressing within the limits of the discipline discussed above.

From here on I move into the particular genre of writing in science, explanation, which myself and the teachers focussed on in planning our teaching. I was conscious throughout of trying to integrate what is typically known as information structure in English with the discourse of science.

1.3 THE TEACHING FRAMEWORK

As outlined in the introduction, I was engaged in planning a language across the curriculum (LAC) two-week course at LEAF College. The course which we planned had the following five components: general and specific information in paragraphs, explanation, register, given and new structures and cohesion. The teachers' and students' perceptions of language in science were collected during the planning and teaching of these components.

The teaching method we used was that of content-based language instruction which included what Snow et al (1989: 206) call "content obligatory and content compatible" language items. For Snow content obligatory items would

include essential words and structures required to express certain scientific concepts. Content compatible items can be taught within the concepts but are not essential for their mastery; these are mainly items from the second language teaching curriculum (for example information structuring in English such as paragraphing, cause and effect, listing and so on which is a similar idea to "how sub-concepts usually relate to each other" in section 1.2.5).

We could identify Snow et al's obligatory items with the genre of scientific explanation and register described here, and their compatible items with given and new sentence organisation and cohesion. However my understanding of the relationship between language and content would differ in two main ways. Firstly a genre such as explanation cuts across many concepts and is related to the way the discourse is typically represented, rather than related to particular concepts. Secondly, in connected writing, using an item such as cohesion may be essential to master the content, rather than being peripheral to it.

The content we used in the language classes was that which was currently being taught in the physics classes. The advantage of this approach is that students carry over authentic understandings and problems they are busy solving directly from the physics to the language class. Conversely, any changes in understanding or problem resolution which occurs in the language class can be carried back and tried out in the physics class.

1.3.1 Explanation

The genre of explanation in science seemed ideal for LAC teaching. Firstly explanation, as it was understood here, involves using theory, and is thus as much about learning important or generative physics knowledge as it is about learning language. Secondly, I thought explanation would be authentic for students, not only in terms of learning

physics in general, but also as something physics teachers spend a lot of their time doing in class.

The sort of explanation I was concerned with in this research was what Leinhardt (1993: 47) calls "discipline based". Such explanations are centrally concerned with the discourse of a discipline in that they need to answer these sorts of questions:

> What constitutes evidence? What may be assumed? What is the knowledge agenda for the discipline? What findings are valued for progress within the discipline? These discipline-based explanations have unique rules that focus on helping to construct new knowledge or reformulate old knowledge.

At this point I move towards a more full description of explanation, and particularly the form it takes in science. Explanation was the starting point for what we actually taught the students. Following on from explanation are the language conventions of paragraph writing which we taught to the students.

Linguistically, explanation of an event involves a statement of the circumstances under which it occurred or its immediate causality; this is known as the **antecedent**. Secondly it involves the situating of the event and antecedent within some broader theory, known as the **lemma** of the explanation (Shi-Xu, 1992).

For Hempel (1965: 246) scientific explanation always involves the two kinds of statement described by Shi-Xu, those concerned with the conditions before and concomitant to the event, and those concerned with general laws related to the event:

> The question why does a phenomenon occur is constructed as meaning according to what general laws and by virtue of what antecedent conditions does the phenomenon occur.

Some philosophers have criticised this construction of explanation in science by citing "the bridge fell down because the bomb exploded next to it" as being an adequate explanation, in which no law is mentioned. However Hempel (discussed in Losee, 1980) maintained that for the statement to count as scientific explanation it must, at least, presuppose some generalisable law, for instance something to do with explosive forces, strains on the bridge structure and so on, which would be likely to occur under these conditions.

Central to explanation is some form of abstraction from the event itself to some other imagined or real situation, the theory, with points of similarity to the event. Explanation thus has much in common with metaphor in that it is saying that **A** is, in some ways, like **B**.

Joan Solomon (1986) refers to the distance between the event, (A), and what it is compared to, (B), as semantic distance. Where this distance is small then the explanation is likely to be tautological and unsuccessful. For example in answer to the task "why does a cold room preserve foods" many children answer "because it stops them going bad" (Ibid: 44).

For Solomon what is peculiar about scientific explanation is that the theory part of it, (or B), is itself often a metaphor which explains "real" events. An example of this is the elastic balls-as-molecules metaphor, which is used to explain the kinetic behaviour of gases. These theory-metaphors are often elaborate tools scientists use to make sense of their disciplines. They are thus a far cry from the notion of science as about objective reality; if students understand them as real, then this can adversely affect

their ability to explain effectively. For instance learners often cannot "work" the ball/molecule metaphor because they equate "ballness" unreservedly with "moleculness"; there are however many things balls do which molecules do not.

Knowledge of explanation as a genre within a discourse alone, is not sufficient knowledge to actually create explanation. Learners also "need to bring ... considerable resources drawn from ... the metafunctional system of modern English" (Halliday and Hasan, 1985: 49). As I have tried to show, however, these aspects of language never fully separate out from the discipline they are working within.

The first of these language structures, consistent with the idea of theory/event in scientific explanation, is that of the general/specific structure of paragraphs.

1.3.2 Paragraph structure

Chaplen (1970) describes paragraphs as consisting of a controlling idea, usually in a topic sentence, main ideas and subsidiary ideas, which are hierarchically related to each other. Controlling, main and subsidiary ideas are illustrated in this paragraph:

> A body in fluid receives upthrust equal to the amount of fluid it displaces. A body can sink or float, the degree of which depends on the relationship between the specific gravities of the two mediums. If it sinks then its specific gravity is greater than that of the medium. On the other hand if it floats then ...

The idea of upthrust on the body is in a hyponymous relationship to the effect of specific gravity, which is again superordinate to the examples of what actually happens when a body is placed in a medium of different density. This sort of linear hierarchic relationship of ideas in paragraphs is also described by Flower (1981) in which she envisages the "shape" of ideas as

a sort of upside-down pyramid; the controlling idea has to be more inclusive than the main idea and is thus "larger", as represented by the pyramid base.

The unfolding of information in a hierarchic linear fashion from a clearly defined topic is tacitly based on reader expectation as to how knowledge is structured (Swales, 1990). However expectations may vary depending on different discourse communities and genres within these. In terms of scientific explanation, reader expectation would probably involve a hierarchy from the generalisable law or theory to the specific event. It would, though, be possible for this structure to be non-linear and to still make perfect sense to a reader (for example, the explanations in 1.2.4).

Weissberg (1984), in analysing science texts, claimed that most paragraphs exhibited an ongoing relationship between already given and new propositions, as the paragraph developed. Given and new was a more inclusive structure with which to describe these paragraphs than a linear hierarchic structure. For instance the "body in the fluid" paragraph shows repetition of "body", the old information, in successive sentences, and its attachment to new propositions.

1.3.3 Paragraph structure: given and new relationships between sentences.

This given/new contract is based on a theory of text analysis which shows that most textual sentences can be divided into a topic and a comment, which Halliday and Hasan (1976) refer to as theme and rheme. This sort of analysis is concerned more with the type of information presented in the sentence than with its grammatical sub-division, for instance into noun phrase, verb phrase and prepositional phrase. Furthermore one part of the sentence is usually more recoverable than the rest, in that it refers to previously expressed information or to a reader's schemata. In English texts the recoverable information is usually in the topic

and less recoverable or "newer information" in the comment. Seemingly, comprehension of text is enhanced when the given/new contract is adhered to (Weissberg, 1984).

The given/new contract can be represented through linear anaphoric reference, in which the comment of preceding sentences is taken up by the topic of subsequent sentences. Here follows an illustration of linear anaphoric reference:

> Evolution occurs through natural selection of individuals. Selection is a function of the environment. The environment is more likely to favour individuals with characteristics suitable to that environment.

Other types of given/new contracts are where each new sentence shares a portion of the initial topic in the first sentence, or where the initial sentence provides a "hypertheme" for the following sentences. It is this given/new progression which supplies overall paragraph cohesion which is instantiated through cohesive ties, as described by Halliday and Hasan (1976).

1.3.4 Cohesion

For Halliday and Hasan (1976) cohesion occurs where the interpretation of some textual element is dependent on that of another presupposed element; it is this relationship which partly constitutes a piece of writing as text. The instantiation of this relationship is usually through the use of ties, which are modes of reference, between elements. Pronominal reference, lexical repetition or synonymy and ellipsis are all examples of ties.

Likewise superordinate/subordinate and given/new relationships are also concerned with connections between elements in order to create a cohesive paragraph. The two may intersect, as with linear anaphoric reference and lexical repetition, or the cohesive ties may overlay and

accentuate the structural and semantic relationships between sentences in a paragraph.

For Halliday and Hasan (1976) an added component necessary to create functional texts is that of situational knowledge. They sees this knowledge as having the following hierarchic components.

> **Field**: the total language event with some overall purpose.
>
> **Mode**: The functional purpose of the particular piece of text and how it is to be communicated.
>
> **Tenor**: the relationship between the writer and the audience.

These three components define the particular register through which the knowledge is to be appropriately represented. Without appropriate register the writing "fails as text", even though "it may be beautifully cohesive" (Halliday and Hasan, 1976: 23). By register they mean particular types of lexis and syntax that are appropriate to the situation.

1.3.5 Register

Within Halliday and Hasan's definition, most practitioners in science view register as a problem for all students entering these domains. Scientific register is likely to be a particular problem for second language students because much of register derives from a root in everyday English; English second language students may not be familiar with these roots.

Perceptions of the problem vary. For instance Cassels and Johnstone (1980) concentrate on the particular way everyday terms are used in sciences - words such as "spontaneous, partial, convergent" and so on. They recommend careful

teaching of these words through texts and in the classroom. Swales (1971) highlights the syntactical peculiarities of scientific writing - nominalisations, passives , definitive statements and so on. Swales (1990) and Baker (1988) examine particular co-locations of lexis and syntax which accomplish some rhetorical purpose. For instance posing and supporting a hypothesis or defining an object or a process. This is a genre approach to register. Cazden (1988) views register as a way of marking off teachers from pupils and maintaining the power relations in a classroom.

My own view is that register is closely associated with particular genres in disciplines. Moreover I would understand the purposeful nature of register, at least in terms of explanation, as reflecting the generative concepts of a discipline (Prawat, 1992) or "the knowledge agenda and assumptions and what counts as evidence" (Leinhardt, 1993: 470). In other words, that the register reflects the disciplinary discourse.

I am more concerned here with register in terms of appropriate lexical items to a particular situation, than with how connected language is used for a particular effect, which I discussed under genres above. As Swales (1990: 41) notes, genres impose constraints at the level of discourse structure, whereas register is more concerned with constraints at the level of vocabulary (and syntax). However as Halliday and Hasan (1976) pointed out above, texts, and by association genres, fail to "work" unless appropriate register is used.

For example a classic experiment in ethology is that of training animals to learn that there will be a food reward in one arm of a "T" maze. After a number of trials, animals learn to favour the arm containing the food. Now a commonsensical explanation for this event could be: "the animal remembered that it found food in the left arm and therefore continued to return to this arm to get more food".

However such explanation does not count in this particular discourse community; a writer would have to refer to central theoretical concepts, such as "trial and error learning" and "positive reinforcement", and the appropriate lexical items associated with them.

Lemke (1987), though writing about technical discourse, gives a parallel understanding of word meaning in subject discourses to that of my own:

> Lexical items have a wide range of potential meanings in relation to other lexical items but their actual use-meanings in a text depend more directly on their place in a particular thematic formation, i.e. their field-specific semantic valences. Thus "weak" and "inconsistent" also have such field specific meanings and it is familiarity with the thematic formations of statistical research methodology that enable us to read "weak associations" as "statistical correlation coefficients in the range 0.0 to about 0.4" (Ibid: 441).

1.4 SUMMARY

The focus of the research is to describe teachers' and learners' perspectives of language in science, in the light of the theoretical issues and approach to language teaching discussed in this chapter.

Language teaching in LAC work often deals with the subordinate aspects of subject teaching. Viewing LAC teaching from a subject discourse perspective positions language as essential to the dominant discourse of that subject. However if we wish students to gain an understanding of the discourse of physics through writing, then we need to allow for and develop student voice within the discourse and genre constraints; this is a role which language teachers can engage in without necessarily having to learn the disciplinary discourse.

Writing explanations engages learners in this dominant discourse. It is thus ideal as a focus for language across the curriculum teaching. However we need also to teach the English language conventions for relating ideas to each other in connected writing.

Lastly, I think I need to pull together the various strands of discourse from Foucault, Dowling, Gee, Parker, Prawat, Rose and Swales which I have drawn on in this chapter, into my own account of "disciplinary discourse", as this is how I have used the term in the rest of the thesis.

A disciplinary discourse is a body of knowledge which can be separated off from other similar bodies by the theoretical knowledge it privileges and how this knowledge is typically produced, evaluated and otherwise represented. Production, evaluation and representation make use of particular genres and theory-driven lexical items for their verbal instantiation.

Discourses can be reconceptualised in certain context-specific ways with other discourses, for instance the discourse of physics with discourses of education or social issues. At least in terms of the latter, such reconceptualisation may not adequately engage with the central generative concepts of the discourse, and may thus be a subordinate form of the discourse.

CHAPTER TWO

RESEARCH METHODS

2.1 STAGES IN THE RESEARCH

There were three stages of data gathering in the research, each of which was approached with slightly different methods: planning the teaching of language closely linked to physics; teaching in the language and physics classes; and interviews with the students. At each stage my concern was with the participants' understandings of language within the context of science teaching.

2.1.1 Planning.

Planning involved myself, two language teachers, two physics teachers and, on one occasion, the language coordinator from the Science Foundation Programme at the University of Natal, Pietermaritzburg. Attendance was uneven owing to other commitments, absenteeism and so on. For instance only one of the physics teachers lasted the whole process.

Planning took place over fourteen meetings of between one and two hours each, over a period of approximately six weeks. These were mostly taped and transcribed, but some field notes were also taken.

The discussions were initially based on a draft of my theory chapter, chapter one, in which I described my understandings of writing in science. This involved deciding on an appropriate physics content and how this could be moulded into language across the curriculum materials, as well as making decisions on the actual teaching methods to be used. Thus the planning was one of group negotiation and expert

refereeing of understandings of language and materials development (Kandaswamy, 1980).

2.1.2 Teaching.

I observed all the language and physics classes over the two week period in which "writing explanatory paragraphs in physics was taught" in the language class. This occurred with one group of twenty students. I observed a total of seven language classes and four physics classes.

My method varied between taping the class as a whole and taking field notes (see section 2.2.2 on questionnaires, field notes and transcripts below).

The physics classes proceeded as normal, nothing was changed to overtly dovetail with the language classes. However the language teacher knew the problems that would be discussed, and made use of these as a content base for writing.

In the language classes the teacher had a "rolling explanatory paragraph" which she modelled with help from the students. This was initially a rough draft. As she taught each component of writing explanatory paragraphs in successive lessons, she rewrote the paragraph accordingly. This rewriting was in terms of using the theory to explain the event, using appropriate register, and ensuring cohesion and topic development.

At each stage of the development of the model paragraph, the students also had to write and develop a paragraph on another topic. This was assessed by me for its "fit" with the skills taught in the model paragraph, and returned daily for rewriting. At two stages students were asked to write fresh paragraphs using what they had learnt at that stage. Also students wrote an explanatory paragraph at the start of the course, and again one at the end of the course. The purpose of this was to provide some yardstick as to how their writing had changed during the teaching process. The

teaching outline, handouts and physics problems are given in the appendix.

In appendix b (page two) I have given the question, "the misguided horse" for which students and teachers developed an answer over the two week teaching period. The other main question we dealt with was the "coffee capers" question in appendix d (page nine). Students developed an answer to this question on their own but in parallel to their horse answer.

As outlined in the introduction, my research focus was directed at students' understandings of language in science, not at their competence as writers. Thus I have only indirectly used examples of students' writing to back up my claims made about genres and discourse in section 1.2.4 above.

2.1.3 The interviews.

Six students were interviewed about their perceptions of language in science. I chose two good students, two average students and two poor students, based on my assessment of their writing abilities. These interviews were taped and transcribed. My initial plan was to use the first interview as a pilot, then to alter the schedule to cope with any problems which arose. However I found that the initial interview was adequate and continued to use this unaltered.

The interviewing schedule was fairly open-ended with room to probe specific areas concerned with perceptions of language teaching. This type of interview is similar to the "less structured focussed interview" described by Kidder and Judd (1986: 274). In this sort of interview the interviewer has hypotheses about what is important in the situation being examined. The role of the interviewer is to explore these hypotheses through "ascertaining their (the interviewees) definitions of the situation" (Ibid, 275).

This form of interviewing was useful in that it allowed the generation of often conflicting themes about students' understanding of language as we taught it. For instance, in answering a question about the relevance of trying to explain something about physics, but not concerned with current teaching, the following answer emerged (the question was about explaining velocity changes in a falling raindrop):

> *And the moment they struck him, feel that you do not really know physics. They show you, that one, somehow the inside. .... I do not think it is wrong to discuss such a thing because it gives us at least some idea of how we should approach our books later if you are going to read, especially if it is not in physics, in communication or something.*

The student is initially expressing his understanding that using language, as in discussion, helps him to understand physics. He then moves straight on to some more general understanding of the role of language in understanding "books". A highly structured and closed style of interviewing would be more likely to reveal only one of these understandings.

I tried to give the students a sense of the value of their own expertise. For instance, I prefaced the interview with comment about how their responses in the interview would be used to criticise and reconstruct the same course in the following year. Also I tried to overtly value what students were telling me by using comments like "that was really interesting" or "this is very helpful for me". Much of the time these comments were not contrived but genuine responses to students' input. This approach to interviewing, in which the interviewer attempts to position the interviewee as an "expert" or as someone with "privileged knowledge" are characteristic of ethnographic interviewing (Burman, 1992).

2.1.4 The interviewing schedule

The topic of the interviews was about students understandings of language and physics during the two week test period.

There were four main questions, each of which included a number of probing questions. The interviews, however, did not necessarily follow this order. For instance a student might answer question four while talking about question one. Also I often had to match questions to the student narratives rather than follow my schedule. All the questions were, however, asked at some point or other in the course of the interview.

QUESTION ONE.
Many students have problems with the relevance of language work to their science courses, for instance something like writing. How did you find this writing course?

QUESTION TWO
Do you think your writing has improved during this course?

Probes
- Which areas of writing did you find hard? Which were easy?
- Is writing different to talking, for example writing and talking about physics issues? Why do you think this is so?

QUESTION THREE
What other sorts of writing have you done or learnt about at school or here at LEAF?

Probes
- Was writing explanations in science new to you?
- Was writing explanations in physics different from other sorts of academic writing in history or in English? Why do you think they may be different?

- Is writing explanations in science different from explaining something to your little brother or to explaining something about soccer? Why are they different?

QUESTION FOUR
What did you think about the content we used for this writing course? We dealt mainly with Newton's laws and with problems from the physics classes.

Probes
- What did you do in your writing when you were unsure about the physics content?
- Do you think that content knowledge affected your ability to write? How did it influence your ability to write?

2.2 RESEARCH METHODS

2.2.1 Research into attitudes

The goal of the research was the description and investigation of teacher and student understandings of language teaching in science (section 0.1). Investigating understandings falls within the ambit of "attitudinal style research". According to Potter and Wetherell (1987: 43) attitudes involve "speaking or acting people taking some idea or object of interest and giving it a position in an evaluative hierarchy". However Potter and Wetherell's research in social psychology reveals that attitudes are not fixed but are context variable.

For instance in interviewing white New Zealanders on their attitudes to Polynesian immigrants and Maoris they found these types of contradictory attitudes of individuals typical:

> *... bring Polynesians into New Zealand, right, and train them and encourage them to go back again.*

and later from the same person:

> *... if we encouraged more Polynesians and Maoris to be skilled people they would stay here ... they are not as nomadic as New Zealanders ... that would be better (Ibid: 49).*

This recognition of people holding contradictory attitudes is typical of a discourse analyst's perspective on the world. It is also a difference between discourse analysis and other qualitative methods of analysis, as discussed in section 2.2.4.

I think that the word "attitudes" is too closely linked to the idea of fixed or unitary attitudes. I have thus preferentially used the words "understandings" or "perceptions" to refer to teachers' and students' sometimes differing views on language teaching and science.

These understandings were represented in the discourse of the participants in the research, in planning, in the classroom and in interviews. Furthermore understandings can be linked to socially constructed bodies of knowledge with particular belief systems, content and characteristic modes of expression. In chapter one, section 1.2, I called these constructions "discourses".

The aim of the description was to cross-match understandings from teachers and students and, where possible, to match understandings to established discourses. I was thus aiming to form a context-specific construction about understandings of language teaching and physics teaching, as was described in the research paradigm, section 0.2.

There are various methods in the research literature about how to gather data on attitudes or "understandings". For example data can be gathered through questionnaires, field notes and transcriptions. I have outlined these methods

below, and given reasons as to why I favoured using taped transcriptions where possible.

2.2.2 Questionnaires, field notes and transcriptions

Questionnaires are an accepted form of gathering attitudinal data. However, attitudinal questionnaires are difficult to construct because, as Kidder an Judd (1986: 239) put it:

> ... attitudes are complex and multidimensional. A person may not have a single overall attitude towards abortion, but may favour it in some circumstances and reject it in others.

A specific question, however, may encourage a respondent to answer in one way or another, or, in the case of a general question about attitudes to abortion, to gloss over "inconsistent" views.

Through altering the contexts in which respondents have to answer questions, it should be possible to pick up these sorts of variation. For a discourse analyst, such variation would reflect the different interpretative repertoires available to people, and would be an important data source.

I thought that taped planning meetings with teachers and taped interviews with students would provide me with a richer pool of information than the other methods mentioned. In the planning meetings we were concerned with negotiating our understandings of language and physics. In so doing, I gained a lot of insights which I could not have foreseen and asked about through a questionnaire. In the interviews students could interrogate the questions to some extent, or "go off on a tangent", both of which increased the breadth of my information.

As indicated, my information was largely taped. However, I did have to use field notes in some instances: both my recorders malfunctioned sometimes; on one occasion classroom

interaction was drowned out by an unsilenced lawnmower and on another by complex shunting manoeuvers in the nearby railway yards.

However it is extremely hard to make verbatim field notes - interactions are often very rapid. I had to make snap decisions about relevance, or attempt on the spot interpretation so as to cope with the amount of information. This is problematic because it fixes decisions "in stone" before there can be a holistic analysis. I found that my interpretations changed as the research progressed and I accumulated more insights, for instance the recursive nature of my categorizations of discourse, discussed in chapters 3 and 4. With tapes I was able to go back and reinterpret my information, something which was difficult to do with field notes.

For instance in one of my interviews I was delighted and excited to hear and transcribe one student talking about "the importance of discourse ...". I had to listen to the tape two more times before I realised he was actually saying "this horse .. ", from the cart and horse problem they were discussing in physics.

2.2.3 Quantitative and qualitative research

The data I was concerned with in this research were those of perceptions or understandings of language in the sciences. I thus favoured a qualitative rather than a quantitative research method.

It is possible, however, to quantify attitudinal-type data. For example, Kerlinger (1986: 481) discusses how field notes on parents' attitudes to weaning may be classified as "permissive" and, presumably, strict. The relative frequencies of responses can then be compared to give an overall view of which category has the most common occurrence. To some extent I have done this in chapter four,

but only to accentuate the predominant discourse expressed by students and not as a topic for analysis.

In discourse analysis the quotes themselves are the topic and are not some sort of initial rough "readings" which can be quantified into a more meaningful form at some later stage (Potter and Wetherell, 1987: 173). Furthermore quantification tends to iron out individual difference in favour of a sort of blanket of sameness which then becomes the topic for analysis. Eisner (1985: 89) describes this tendency thus:

> The uniqueness of the particular is considered noise in the search for general tendencies and main effects. This, in turn, leads to oversimplification of the particular through a process of reductionism that aspires toward the characteristic of complexity by a single set of scores. Quality becomes converted to quantity and then summed up and averaged as a way of standing for the particular quality from which the quantities were originally derived ..... the single numerical test score is used to symbolise a universe of particulars in spite of the fact that the number symbol itself possesses no inherent quality that expresses the quality of the particular it is intended to represent.

2.2.4 Qualitative research and discourse analysis

On the face of it discourse analysis is not very different from other forms of qualitative research. For instance in qualitative research one gathers ethnographic data, such as interviews, observations and written work within a naturalistic setting (for example a classroom). This data is then categorised or "pattern searched" (Seliger and Shohamy, 1989: 122) into more manageable chunks for analysis; in the process of categorisation some data is disregarded. The same process is followed in discourse analysis.

Again, like qualitative research, discourse analysis does not begin with firm questions and end up with definite conclusions. Research questions and categorisations of data may change as the researcher accumulates knowledge about the research situation. Also the object is not to come up with firm conclusions or proven hypotheses, however tentative these may be, as is the case with correlational research. Rather the aim is to increase the reader's knowledge of some object of research, and to pose more, possibly finer, research questions (see 0.2 and 6.2.5).

Differences in approach, however, reside in the discourse analyst's theoretical paradigm of knowledge as a socially constructed phenomenon, as discussed in section 0.2. When people use language they are constructing reality within the ambit of the particular situation. We are probably all aware of the different accounts of why we crashed into a tree, given to a traffic officer and a best friend. A discourse analyst's interpretation of the crash accounts, however, is not just one of contextual variation, it is also one in which the talk is performing certain actions (Potter and Wetherell, 1987), such as claiming innocence or sobriety to the policemen, and camaraderie with a best friend.

Speakers may also "act with" their talk to claim membership of certain groupings or "discourses" (Gee, 1990: 109) as discussed in section 1.2.3. Claiming membership is particularly likely to occur within institutions, such as educational institutions, where such membership is seen to be advantageous. For example, I think that students' understandings of using "the appropriate language for physics" in section 5.3.1 could be linked to claiming membership of the "official voice of science". There are, too, other examples of discourse, as in talk, performing actions that make claims for the participants in chapters three, four and five.

Thus central questions in discourse analysis are not concerned with "what people really mean" or the "truth" but

why they "choose" certain understandings, and not others, and what the consequences of these actions are. For instance:

> ... people are using their language to construct versions of the social world. The principal tenet of discourse analysis is that function involves construction of versions, and is demonstrated by language variation. The term "construction" is apposite for three reasons. First it reminds us that accounts of events are built out of a variety of pre-existing linguistic resources ..... Second, construction involves active selection: some resources are included, some omitted. Finally the notion of construction emphasises the potent, consequential nature of accounts. Much of social interaction is based around dealings with events and people which are experienced only in terms of specific linguistic versions. In a profound sense accounts construct reality (Potter and Wetherell, 1987: 33).

If we accept this version of people constructing reality in their discourse, and that there is often variable representation of reality within one individual, then methods such as triangulation are largely redundant. Triangulation methods aim to pinpoint, as closely as possible, people's real understandings of a situation (Cohen and Manion, 1980). Discourse analysis, on the other hand, exposes the variability of understandings of any one situation.

However a lack of triangulation does not mean that discourse analysis lacks validity, rather it gains its validity from pursuing a coherent object (understandings of language teaching in science) across a variety of natural settings, and through its posing of new problems and its fruitfulness for other practitioners (Burman, 1992).

Although there are differences between what I have referred to as qualitative research and research methods using discourse analysis, one strand of qualitative research, phenomenological research, has close connections with discourse analysis.

2.2.5 Discourse analysis and phenomenological research

In phenomenological research interviewing techniques, there is a focus on the individual's conceptions of the events they are engaged in, the understanding being that learners encounter events in qualitatively different ways. However utterances can usually be selected according to their relevance to the research questions, and subsequently placed into a number of limited categories (Marton, 1988). It is these categorised quotes from individuals which provide a pool of meaning. As with my research, it is this pool of meaning which is used as the data base.

A useful metaphor for phenomenological data gathering is that of a biologist entering an undiscovered rain forest for the first time. She brings with her a knowledge of Species classification and generally what counts as an important classificatory feature. However she cannot exactly predict the plants and animals she will encounter, nor how she will eventually categorise their features as constitutive of a particular Species. This she can only do once she has examined the forest organisms. Thus she uses elements of her connoisseurship to construct her classification within the complete context of the forest (Ross, 1988).

Connoisseurship is a term first coined by the educational researcher E.W. Eisner. For Eisner (1985) connoisseurship involves an appreciation or awareness of the whole event in a classroom, in other words a "thick" appreciation (Ibid: 112). Connoisseurship is complemented by the ability to represent the situation to someone not in possession of this knowledge. This ability he calls "educational criticism" which is a "form of linguistic artistry replete with

metaphor, contrast, redundancy, and emphasis that captures some quality of educational life" (Ibid: 111).

What is interesting is the similarity between Eisner's idea of connoisseurship, in which researchers intuitively know what is important in the research context, and the ability to do discourse analysis. As Potter and Wetherell (1987: 175) state, discourse analysis relies on "craft skills and tacit knowledge" of the research context.

There is, however, a danger of researchers being conscious seekers of the contextually meaningful discourse within a classroom. They can, for instance, interpret talk according to their own subjective world view. An example of this phenomenon is given in section 3.2.2 where there are two possible interpretations of a single quote. Burman (1992) suggests that the categorisation and interpretation of talk should be done by a group of researchers. In this way different "subjective interpretations" can be discussed and compared within the group and a measure of validity in interpretation achieved. This has occurred to a limited extent in this research. However the time constraints of a half-thesis prevented my engaging in group analysis.

Researchers may also fail to appreciate the significance of learners' comments that appear to be unimportant or unrelated to the educational context; learners may be privileging "different orders of discourse" (1.2.1) from those of the researcher. This problem is further discussed in section 6.1.2 of the conclusion.

Some of the examples Eisner gives of educational life from his own research students are vivid and often moving accounts of classroom life. There is however too much "thickness" in his criticism. In order to represent the wholeness and richness of the classroom the critic has to bring in enormous amounts of data; such research thus often has a strong narrative component. This is particularly a problem for data-laden research such as my own, which has to

be selectively culled to be comprehensible. Thus my methods of research, and those of Eisner diverge at the level of data representation and analysis.

2.2.6 SUMMARY

There were three stages of data gathering in the research: planning, teaching and student interviews. My aim was to use this data so as to gain my own view of teacher and student understandings of language teaching in science.

The method of analysis was that of discourse analysis. Although this falls broadly within the ambit of "qualitative research methods" it differs in that there is an understanding that people actively signal varying positions through their use of talk. Sometimes this positioning is determined by the institutional discourses available to the speakers.

CHAPTER THREE

ANALYSING THE PLANNING DATA.

Three types of data were analysed in the research: data obtained from the lesson planning; data obtained from the lesson delivery; and data from student interviews. This chapter deals with the data from lesson planning.

As the research progressed, and I was engaged in typing up and reading my data, I became conscious that I had a lengthy and seemingly jumbled array of data. I needed to locate what Yin (1984: 36) refers to as a "chain of evidence" through the data. What constituted this chain was all information concerned with understandings of physics discourse and any information which related to its interaction with language.

3.1.1 Selective culling of the data

The process of culling (or coding) was a cyclical one "of moving between analysis and coding" rather than a more straightforward once-off affair (Potter and Wetherell, 1987: 167). I had to repeatedly re-read my original data to ensure I had captured all relevant information. Some data was clearly irrelevant for my purposes, for instance data about using diagrams for solving particular types of physics problems.

At this stage I had a body of selected data from the whole corpus of data, which I put together in a single document. My next step was to search for patterns in the data, to squeeze it into more manageable chunks which I could then use as a basis for a more detailed analysis, each chunk becoming a category. Again, Potter and Wetherell (1987)

describes a similar process in their description of discourse analysis in social psychology. As each category was quite lengthy, I further divided them into sub-categories (a - d) for easier analysis.

As with the initial culling, the categories reflect my research interest in disciplinary discourses. In particular, the tensions between the discourses of language teaching and those of physics. However my category choices are also those that other researchers show interest in.

3.1.2 Categories in the selected data

1. The discourse of physics.

If we want to teach language with close ties to a discipline, then we need to know something about the discourse of this discipline (Spack, 1988; Raimes, 1991). How physicists understand physics is thus important for understanding where and how language teaching can occur.

2. Language and physics discourse.

There does seem to be a discourse associated with academic language skills. By virtue of being a discourse it is a separate entity from various subject discourses; thus following an academic discourse approach will not necessarily be useful for learning subject discourses such as physics (Gee, 1990: 145).

3. Register

Register is concerned with the whole situation of an interaction, including what we are talking about, how we are talking about it and to whom (Halliday and Hasan, 1985). Register concerns making meaning through using the appropriate language for a situation from the available linguistic resources of the producer. As was pointed out in

section 1.3.4 of the theory chapter, register is given prominence in texts on language in science such as those of

Swales (1971), Cassels and Johnstone (1980) and Baker (1988). I have used register in the more restricted sense of situational or appropriate terminology, as this was the predominant understanding reflected in the planning sessions.

These categories were not entirely insulated, some quotes appear in more than one category. Some categories are apparent because of their juxtaposition to other categories. Thus the larger context of the quote needed to be included.

Other quotes seem to belong equally well in two categories. For instance a lot of the quotes in "register" could be in "the interface between academic and physics language". But, I felt I would be suppressing interesting information by using a single category. Potter and Wetherell (1987) refer to overcategorisation in a similar way where researchers go into analysis with fixed category labels, such that they ignore variation.

3.1.3 Analysing the categories

It was at this stage, once I had my data in a more manageable "packaged" form, that I could begin the analysis proper. I studied each category and asked myself the following questions about the data. What understandings are being presented here? How do these understandings relate to each other?

My purpose here has not been to pin particular understandings to particular people. Nor has it been to relate my findings to the full range of possible understandings and discourses; this would be far too large a project. Rather, it has been to describe the range of understandings which unfolded during the research.

The letters l, k, j, mg, m and d refer to comments made by different individuals in the planning process. l, k, are the language teachers and j is myself. m and d are the physics' teachers. mg is a language teacher on a science foundation programme elsewhere to whom we presented our plans for teaching explanation in science at a late stage in the planning. The bold letters a - d are sub-categories

3.2 THE DISCOURSE OF PHYSICS

3.2.1 Quotes on the discourse of physics

a.

m. You can tell a physicist by the way he talks. Physicists work in the domain of esoteric academic language .... this esoteric academic language is about signs taking on particular meanings which are different to the meanings in the public domain, e.g. motion in physics and in life ... language teachers simply do not know this ...

b.

d. The work we are doing at the moment does not lend itself to a great deal of interpretation. Essentially it is a set of equations which describe something that is happening, a mathematical description involving notations and conditions under which they apply, there is not much beyond that. When we get beyond mechanics to electricity there is lots we can do with language. As I say at this level I am anti-language.

d. We can divide physics into initial mechanical knowledge which provides a springboard into later more conceptual knowledge. Language is better suited to these later conceptual areas where you can begin to relate, for instance, gravitational and energy

potential .... electromagnetic forces (in year two) are absolutely suitable to verbal engagement.

mg. Physicists do tend to separate out their subject into the more conceptual and the more mechanistic aspects. They are also encouraged to find the right answer over anything else. Being able to explain, though, is a useful check on acceptability of the answer.

c.

d. Theory is dynamic depending on the level been dealt with, hence explanation too differs. Learners at year one level need to be aware of this dynamism, but they are not sufficiently skilled to deal adequately with it.

d. Physics is concerned with why things are the way they are, not the pursuit of truth. Physics is a sense making device, like others in the world. So long as the explanation works for some limited and generalisable class of events, it is adequate. However some theory is not necessarily adequate as the learners move into new domains of knowledge or as their cumulative knowledge becomes too complex to be explained through earlier understandings. .... Physics differs from other academic pursuits in that there is usually one agreed upon explanation for events, unlike in say, psychology or sociology in which there can be a variety of explanations.

m. Knowing in physics is applying what you learn in the physics class to everyday situations. It is a question of transferability of knowledge, whether it is inside the discipline or outside it. For instance .... you need them to understand other concepts in physics, like work, force etc. That is what I meant, the applicability of theory.

d.

m. *Explanation is about linking up different areas of knowledge ... for instance when students are asked to explain projectile motion they have to use horizontal and vertical motion. The tools of analysis (Horizontal and vertical motion) are not what is actually happening. Students often describe a projectiles moving one unit horizontally and two units vertically. This "works", however the projectile is actually moving in an arc. Students often understand the simultaneity of the components (of motion) but cannot explain it.*

3.2.2 Discussion of the discourse of physics

The quotes I have here are obviously only a small part of what teachers might have to say about physics. The quotes emerged as part of the process of planning the language of scientific explanation into physics teaching; they must thus be seen through this filter and not as representative of these teachers' full understanding of the discourse of physics.

Firstly **a**, the notion of physics as a "*system of signs which have taken on meaning*", directly links knowledge in physics to language; the routinised way in which physicists talk about their domain reflects what constitutes that knowledge. This esoteric view of knowledge in language is very close to what Gee (1990: 145) refers to as the "dominant discourse".

This second category of quotes **b** reflects, I think, what I referred to in the theory as the reconceptualisation of physics within educational discourse (section 1.2.1). One aspect of teaching discourse could be that of proceeding from basics (such as mathematical manipulations) to more complex and integrated subject matter.

As mg points out, however, it is the more integrated conceptual understanding which enables learners to check the correctness of their mechanical mathematical work.

c. For me there are different understandings of the discourse of physics emerging here. For instance physics as "not about the truth" and "dynamic" suggest a certain post-modern sense of uncertainty about knowledge. Such a view on the nature of physics probably stems from recent advances in analysing complex systems in biology and physics. In these systems changes are not necessarily describable using linear mathematics, nor can the effects of changes be accurately predicted (Doll, 1989):

> through post-modern science we are developing a new dialogue with nature, one wherein our vision of nature is undergoing a radical change toward the multiple, the temporal, and the complex and conversely, away from the universal, the stable and the simple which Newton's system posited (Ibid: 244).

However as d puts it "*learners (at the intermediate level) need to be aware of this dynamism but lack the skills to deal adequately with it*". The informants here seem to be moving more towards what I earlier described as reconceptualising physics within educational discourse.

In this system physics is something which "works", which we fully "*understand when we can apply it to the world*". Such a world would have to be explainable in some way hence there is "*generally agreement about what explains what event at different levels*".

Furthermore I think that d is signalling membership of the powerful esoteric world of physics through his talk. His subsequent talk or discourse then acts to position him quite differently as a teacher teaching physics within an educational institution. In other words he is signalling his membership to educational discourses. This idea of discourse, as in talk, signalling membership to discourses, was discussed in section 2.2.4 of the method chapter.

One reader of these quotes pointed out a possible alternative interpretation of the quote in c concerning physics not being about the "*pursuit of truth*". She understood this to mean that physics was not about some academic pursuit of social knowledge but concerned with how real objects behave in the world.

This illustrates how my own subjectivity may frame my interpretation of teacher talk. Reference is made to this problem in section 2.2.5 of the method section.

d. In this case the motion of the projectile (the event) can be explained through reference to the theoretical construct of horizontal and vertical components of motion. The projectile itself does not undergo these two types of motion, rather the components are a form of explanatory theory/metaphor. The idea of theory/metaphor in explanation in science was discussed with reference to the work of Solomon (1986), and forms parts of scientific discourses.

3.3 LANGUAGE AND PHYSICS DISCOURSE

3.3.1 Quotes on language and physics discourse.

a.

> *m. Writing is a powerful force in cognition. It is about the thinking procedures concerned with what one is writing ..... So this art of writing, giving out explanation, that process is learning ..... when you want to explain, theoretical explanations, in physics, there is a relationship where you want to explain one part then you explain the other part, you want to find some intersection between the two, ... where you cannot see the intersection you say that the explanation is disjointed. The ability to link up, this goes far in physics ..... where you talk about the relationship between certain types of theory, between electrical and magnetic theory .... you find a*

situation where you are able to explain one and then the other ..... how could you link them? And that needs the necessity of understanding what one means to the other because in most texts information is not clearly linked, you have to guess these links.

d. We could ask for general causes that are interesting for discussion but still the work (mechanics) doesn't lend itself to a great deal of interpretation, essentially it is a set of equations which describes something ..... as I say at this level I am almost anti-language.

b.

j. Ya ...., mmm .... what I would like to do is to pick up on a few explanatory style questions in kinematics, I have seen some in the texts.
d. I've got one for you! If an aircraft is flying in a certain direction and a wind is blowing at an angle to the aircraft why does the aeroplane have to fly in a certain direction, why does the pilot not just fly due north? But this is totally trivial! Look I will have to think about this.

d. m is more interested in the way language moulds scientific thinking, its political aspects.
Try practical work (as a source for explanation).

c.

m. We could use something like "what is gravity, why does it change with height and when is it different".
We could start right away with writing.
Some examples of why questions: why do we choose only external forces acting on a body? Why is acceleration not always in the direction of motion?

d.

l. Theory/event in physics explanation should be situated within the larger academic discourse of general/specific. For instance paragraph writing usually proceeds from general to specific.

l. I should deal more with language and m should deal more with the nature of explanation and its content. So I could do the work on topic development and cohesion. Then we can mark each paragraph separately for both physics and language and m can do the physics marking.

e.

d. It is very hard if not impossible for language teachers to make sense of physics.

m. .... this esoteric language of physics is about signs taking on certain meanings in physics which are different to meanings in the public domain .... language teachers simply do not know this.

3.3.2 Discussing language and physics discourse.

Here I have judged academic language to be the more general **written** discourse of LEAF college. This is, to my mind, writing that is communicatively acceptable, for instance with a clear development of ideas, cohesion and some acceptable level of coherence. This, then, is the stuff of communications and EAP courses, "a discourse connected with academic practices like essayist writing-talking-and-thinking, or other school based practices" (Gee, 1990; 145).

However essayist discourse is not physics discourse. Furthermore it is difficult to assess to what extent such a general discourse actually helps students in learning about and communicating within the discourse of physics, as opposed to some more general enculturation to institutional life.

The first respondent in a clearly sees a role for writing explanation in the learning of physics. It is actually enabling understanding of physics; writing here is physics discourse. However it is interesting that the example used to illustrate the importance of explanation in tapping physics discourse, is not that of the current teaching topics, kinematics and forces, but of electricity, a later topic.

d states that "*mechanics does not really lend itself to explanation*". Earlier, in the category The discourse of physics, he had also stated that "electricity is suitable for verbal engagement."

Thus, although written explanation is useful in physics teaching, it seems more useful as a link or organiser at later more conceptually complex levels of knowledge.

In b d is describing possible roles for writing outside of kinematics. Writing here is seen as possibly occurring within the more subordinate ambit of physics discourse (politics, practical write-ups and offbeat problems) rather than within the dominant discourse of the mainstream teaching programme. This understanding has echoes of the geology writing assignment suggested by the science teacher in section 0.3.1 of the introduction.

In c the teacher m sees a role for explanatory writing within the current teaching topics. He seems to take the idea of scientific explanation as "using relevant theory to explain an event" to a different level than that previously expressed, to one more deeply embedded in the esoteric discourse of physics, i.e. using theory or some other generalisation to explain another abstract generalisation.

It is almost as if the imaginary world of trains, carts and cars is stripped away, leaving only the bare bones of theory, physics discourse in its most esoteric and meaningful form.

This sort of discourse is similar to what Gallimore and Tharpe (1991: 193) call "schooled discourse" in which "the student's attention shifts from sign-object relationships to sign-sign relationships". The discourse begins to describe itself in terms of itself. Thus acceleration becomes defined as change in velocity (speeding up, slowing down or changing direction), where velocity itself is an abstract value, rather than as something more rooted in experience such as a car speeding up. Or electricity becomes defined in terms of magnetism and vice versa.

d.

The two discourses, academic language and physics, are being separated here. Like **b** language has little to do with understanding physics, but exists as some sort of separate stream.

e.

> *It is hard if not impossible for language teachers to make sense of physics .....*

This quotes here indicate that language teachers do not have access to the domain of physics by virtue of not being physicists. By inference what happens in physics and what counts as physics discourse is insulated from what counts as academic language discourse. As indicated in section 0.3.1 of the introduction, such an understanding can relegate language teachers to a subordinate role in the teaching of physics discourse.

3.4 REGISTER

3.4.1 Quotes on Register

> *d. Language teachers tend to concentrate on groups of words and not see the significance of individual words in physics, which can introduce a whole new equation into a problem.*

j. Words in physics, though, are like homonyms in ordinary language use; their meaning is highly context dependent so we have to teach meaning within context, not as some separate linguistic item.
My idea of register is that it is identified by a particular discourse community. Also within this community there could be different registers depending on the different content areas being dealt with. Word meanings come in webs.

m. Learners know the meaning of words in the public domain of life but not the esoteric one of physicists; the signs take on different myths in this domain .... Well it is like using motion not movement. Motion indicates that a body has certain theoretical properties, like....

3.4.2 Discussing register.

There are three main views on register being discussed here. Firstly there is that sort of register which involves precision in writing and understanding. This would seem to be a general feature of writing in physics. Such a focus eclipses what writing teachers usually do, which is more involved with connected stretches of writing, for instance paragraphs and essays. Secondly, the esoteric domain of physics gives meaning to "everyday" words. Thirdly, and related to the esoteric domain of physics, is that word meaning derives not so much from the whole of physics, but from the particular "part" of physics which is being discussed. These particular understandings relate to using "the appropriate language of scientific disciplines" discussed in section 1.3.4 on register. The problems of appropriacy in terms of its use encouraging a monodimensional approach to knowledge, were discussed in section 1.2.3 of the theory chapter.

3.5 SUMMARY

Physics becomes reconceptualised in teaching so that learners at an intermediary level can understand it. Learners at this level probably cannot cope with too much uncertainty and complexity. Furthermore it is initially divided into a non-verbal mechanical and more conceptual modes. There is, too, a special esoteric language of physics in which language takes on a particular field of meanings.

It is hard for language teachers to gain access to this esoteric language because they do not have in-depth conceptual knowledge of physics. Where language teachers are involved it is probably at a peripheral level; this is particularly the case with the mechanistic modes of physics. Generally, the understandings of language from language teachers are likely to be different from the way language is used in physics.

CHAPTER FOUR

ANALYSING CLASSROOM DISCOURSE

In the previous chapter the respondents were identifying aspects of their understandings of physics and language. In this chapter the focus shifts to what two of the teachers (m in physics and l in language) actually did in the classroom and how students responded to their teaching. Some of the understandings which arose in the first section, as expected, appear too in the classroom; others are absent, or are different from those in the previous chapter.

As I was concerned with linking discourse from teaching with what had occurred in the planning, I did not categorise the student and teacher talk. The bold symbols, **a - d**, represent talk from different lessons, or topic shifts in one lesson.

4.1 THE PHYSICS CLASSES

4.1.1 Talk in the physics class.

These extracts are taken from the physics teacher m's classes only; there were four classes in all. Only two of these were taped; in the other classes I relied on handwritten notes only. These tended to give more of an outline of what was happening, rather than representing verbatim reporting. In one instance, too, I was struggling to take everything down in some comprehensible way so as to have as reliable a record as possible. Where the classes were taped I found most student and many lecturer comments unclear. Thus I had to rely mostly on my own notes.

As pointed out in section 2.2.2 of the method chapter, such field notes are not the most effective method for collecting classroom talk.

The transcripts given here represent about 20% of the total transcribed text. The rest of the transcriptions can be divided into: extended interactive questioning and teacher explanation, about 60% (i.e. what I have included here is a representative sample of this); individual and teacher demonstrated problem solving about 20%. m refers to the physics teacher and *s1, s2* etc to the students.

a.

m. Why does the acceleration of a falling body not depend on its weight?
s1. Because the force of gravity is constant.
s2. Because weight is proportional to mass times a constant.
m. What happens if you increase the acceleration of gravity?
s3. Weight increases.
s4. Weight decreases.
m. (with a textbook balanced on his forearm) *I push the book up what happens to its weight? I let my arm fall, what happens now?*
s5. (summing up a classroom interchange) *When you push up the weight is the upward acceleration plus the acceleration of gravity.*

Linked to the above is the theoretical aspects of this problem:

b.

m. A lamp hangs from a cord in a lift, what happens to its apparent weight as the lift accelerates up or down? The apparent weight will be equal to the sum of the forces on the lamp. At rest these are the weight of the lamp, its mass times the acceleration, and the upward force of the cord on it the tension, which cancel each

other out. T - W = 0. The sum of the forces here is 0. It is also equal to ma. so we can say that T - W = ma and from this derive equations for the T, or apparent weight, as the lift accelerates up or down. T - W = ma so T = ma + w but w is also equal to the acceleration of gravity multiplied by the mass of the body, or mg, so T = ma + mg and T = m(a + g).

Here follows the actual use of the formula derived in the previous section to "reason through" an imaginary problem.

c.

m. A lift has a lamp of 10Kg hanging from a cord. The tension on the cord is 89N as the lift decelerates downwards at 2 m.s-2. What is the tension as the lift accelerates up at 2 m.s-2? The tension is the same. ***Why*** *is this?*
s1. Because the acceleration is the same.
m. What effect does descending have on g, it subtracts so why do you say it is the same here?
s2. Because you say T = ma - mg. it is accelerating downwards so you subtract from the weight.
m. What do you subtract?
s2. The force
m. The force from the weight?
s2. Yes.
m. The elevator is decelerating downwards, not accelerating. The elevator goes down but acceleration is in the opposite direction, it is decelerating. But we have the elevator going up and acceleration is in the same direction as the motion, this is why the tension in the cord is the same.
s3. What if the elevator is accelerating downwards at 2 m.s-2?

At this point the teacher guides the students using the common sense notion or metaphor of the book discussed earlier, and the sum of forces acting on the lamp, to work out the tension. Part of the interchange went like this:

m. The tension, what is it?
s4. It is the weight.
m. Mg is the weight.
s4. It is an opposing force because of weight.
m. I am standing on the floor, exerting a force on the floor equal to my weight. What is the opposing force?
s5. Force applied by ground on you.
m. Which is equal to..
s5. Equal to your weight.
s3. It is the weight.

In this instance the teacher first explains a concept then applies it to understanding an event, in this case the problem of "how a horse manages to pull a cart".

d.

m. Friction is the force that tends to compensate for an external force. Friction increases with the external force which is applied to the body and eventually the body breaks away. The external force needed to keep the body moving at a constant velocity is now less than the force needed to start the body moving. Because of the breaking of static frictional forces this force is greater. When we apply a force to a body, eventually the force on the body exceeds this frictional force and the body moves. You have to increase this external force till it exceeds the force of friction. In the case of the cart the tension on the rope acts on the cart and the cart resists this tension. When the tension force exceeds the force of friction then the cart moves. Let us look at the horse and the cart. Tension on the rope acts on the cart and the cart resists tension on the rope. The cart is a system. When the tension exceeds frictional forces then the cart moves.
s1. If the horse was to pull the thing, it adds unbalanced force to the system.

m. The more force I exert on the cart the more it exerts on me.
s2. The static friction of the cart is exceeded.
m. Which law do we use when we have unbalanced forces? Let's look at all the forces acting on the horse and cart, name them all..... .

4.1.2 Analysis of the physics talk.

The question that I asked myself here was "to what extent do the understandings outlined in the planning section surface in teaching?"

The results were quite surprising. Firstly the division between the mechanical and more conceptual aspects of physics discourse is not evident. In these transcripts the mechanical (mathematical manipulation) is firmly interrelated with the conceptual. It would seem that explanation, and in many cases resorting to a theoretical generalisation, are commonplace in mechanical problem solving, particularly where student problems arise.

Obviously this focus is only a small section of teaching on one topic area (forces); there could well be a situation where the emphasis is much more clearly on mechanical skills alone. However the nature of the interaction between teacher and learner in these examples is such that theory or "big concepts" have to be brought in to explain the mechanical moves, for instance the concept of the sum of forces to explain the derivation of the formula T - W = ma. Such explanation seems to occur as a natural part of the teaching process.

Furthermore the teacher engages extensively with word definition, for instance words such as acceleration, tension and weight. These definitions are firmly rooted in locating meanings within the thematic field of physics discourse discussed in section 1.3.4 the theory chapter.

There is no hint of physics being about anything "dynamic" or "not about the truth", nor is physics expressed as a social semiotic; both these understandings were expressed by the teachers in the planning sessions in section 3.2.1. Students are clearly subjects solving problems in a defined world of esoteric physics. This may be a conscious decision on the part of the teacher or it may simply be that the subject matter is unsuited to more philosophical discussion.

One aspect of physics discourse which did not arise in the planning is that of the use of imaginary problems to illuminate a more canonised physics discourse. These sorts of problems show elements of a "serious exploration of knowledge which generates more knowledge within the system of canonised disciplinary knowledge" (Dowling, 1993). For instance the horse and the cart example illuminates the interplay between Newton's third law (each force has an equal and opposite reaction force) and second law concerning the sum of forces acting on a body.

4.2 THE LANGUAGE CLASSES

4.2.1 Talk in the language classes

A total of 6 language classes were attended and recorded on tape or in longhand; similar problems arose here to those experienced in the physics classes.

The quotes taken here are samples of the discourse used by the teacher and students, which involved about 60% of the classroom time. The rest of the classroom time was taken up with revision of previous days' work, presenting model explanations to illustrate what was being taught and writing assignments.

A lot of the talk was about language items which needed to be discussed, for instance planning writing, keywords and the concepts of register, cohesion and given and new

paragraph structure (see section 1.3 on teaching, and appendix c for the language notes given to students). The quotes I have focussed on are those which dealt with both language and physics, and not those concerned with language alone, as this was my predominant concern in this research.

a.

1. Writing explanations is an important skill when you do your design projects later on and more generally in your work as an engineer. Describing, defining and explaining are different approaches to writing about something. For instance when you describe the superposition of waves you say that the two waves cross over and interfere with each other, constructively or destructively. When you explain superposition you say why this interference actually happens. Similarly you can describe a raindrop reaching terminal velocity as it falls to the ground and you can explain why it does this. These two are different.

1. There are two types of explanation; general to specific explanation, in which you need to talk about an event and the theory or law behind it, and step by step explanation such as the procedures involved in baking a cake.

1. Planning your explanation is important, for instance using hierarchic or conceptual maps (the teacher goes on to illustrate these). *Each paragraph has a main idea. there should be three paragraphs; the first one states the theory, the second is the main body of content and the third is your conclusion.*

1. In the horse and cart example, the topic is about the horse, cart, forces between them and Newton's first law.

b.

s1. If somebody answers something and they understand it, what is being said, it is clear, but they are not using this language of physics, what is the difference?
s4. I think then you get marks for understanding but not for using the right words.
s1. I mean what I am trying to say is if you understand it, the main point is understanding.
s2. It is just like in maths, if you do not use intervals or sets you just say it is from ... to wherever, this to this, then you won't get marks, you must use the language.
s1. I know it is like that but what I am trying to say is why is it done like that.
1. One reason for using physics register is that you can be more precise than when you use everyday language. Another example is a mechanic in a workshop, he can't ask for a "v" shaped thing. When he says pass me the spanner, that is more precise.

1. You need to show the physics teacher that you know the theory even though you know he knows it. Register is the language you use which is appropriate to the situation. For instance if I introduced myself to the class with "howzit everyone", it would be inappropriate. You must show the lecturer that you know this register but you must not use it inappropriately.

Students gave the following comments when they were asked to examine an early explanation they had written for evidence of theory, cohesion and so on.

1. Check your explanation for theory, register and cohesion as we discussed them.
s1. I did not have any theory.
s2. I had no idea about register.
s3. Somewhere I used speed and you underlined it, why?
j. Is there not a fundamental difference between speed and velocity in physics?

s4. Yeah, velocity has both direction and magnitude.

c.

s1. I have a problem with the horse and cart problem. If the horse can move then it means it is exerting a greater force on the cart than ..... I do not know how to put this.
1. The body is at rest and remains so unless acted on by an external force.
s1. So as soon as it moves the cart ... so the horse is maybe right.
1. Explain.
s1. Newton's first law states that it (the cart) will remain at rest unless acted upon by an unbalanced force and the horse says it cannot apply an unbalanced force because the force the cart pulls will always pull it back with the same force.
1. The horse says it cannot but according to Newton's first law it can.
s2. If s1 is right then nothing could move.
1. Again a body will not move unless it is acted upon by an unbalanced force.

4.2.2 Analysis of the language class talk

In a the predominant discourse is that of academic language skills, or essayist discourse, defining, explaining and so on. Mostly, these genres do not directly tap physics discourse, i.e. they do not highlight important or generative knowledge of physics. Rather the teacher uses them as examples to illustrate language differences. To some extent the teacher "plunders" physics for its academic language discourse. This role of the language teacher as someone who applies structural formats onto physics knowledge was mentioned in section 1.2.5 of the theory chapter.

Similarly, *"writing explanation is an important skill in design project writing and work as an engineer"* is separate

from the actual processes of learning physics; for instance making sense of a problem in physics and connecting it, via generalisable theory, to other related problems.

"*In the horse and cart example, the topic is about the horse, cart and forces between them*" seems to be touching on the more esoteric field of physics discourse, in that it makes direct reference to "Newton's first law". It is, though, privileging "topic", which is part of academic discourse, through a physics example, rather than integrating with physics discourse.

I think there is a veneer of authenticity in using subject knowledge which often occurs in LAC classes. It fails to be authentic because the task, or learners' engagement with content, is about language and not about making sense of content or solving some problem in physics. Widdowson (1990) puts it this way:

> Authenticity in the language classroom is bound to be, to some extent, an illusion. This is because it does not depend on the source from which language as an object is drawn but on the learners' engagement with it (Ibid: 45).

In the superposition of waves example (*for instance when you describe the superposition of waves ...*), the language teacher runs into content problems. The superpositioning of waves is a model to explain, for example, the interference of light. Thus the "model" is the theory/metaphor which is used to explain real events. Explaining the behaviour of the model itself has little value within physics education.

In **b** the student is distinguishing between what he sees as academic language and physics. He sees language as a rather unnecessary overlay on "understanding the physics". S2 says this is the "way to get marks" and seems to be in some agreement with the teacher comments in the next quote about "showing the teacher that you know appropriate register".

The sense here is that there is a distance between physics content, or at least understanding this content, and the language used to represent it. This is an issue which I think has potentially serious consequences for learning in science (see section 1.2.3). It is also the dominant understanding of the role of language in physics expressed by students (5.3.1).

The idea of precision, which the language teacher brings up, also fits into an understanding of language as an overlay on the discourse of physics. However she also begins to suggest that the language of precision is not just appropriate but also necessary for successful communication (*"He can't ask for a V shaped thing"*). From this perspective language is concerned with what physicists habitually talk about and how they do this.

Quote c is illuminating in that the student, in trying to explain an event, is questioning his own understanding of the generalisable laws of force. It is as if the demand for explanation of this imaginary event has triggered an examination of his own understanding of esoteric physics. Linder (1992: 115) describes the role of verbal interpretation in a similar vein:

> To give verbal explanations of physics a student essentially needs to create a world ... which essentially involves exploring the essence of a conceptual idea, both from within oneself and the current physics theories, models and concepts.

As in a, the teacher again runs into content problems with the horse and cart problem. She does not seem to do anything "wrong" in this explanation, rather she lacks the depth of physics knowledge to be of help in the discussion. Compare, for example, the language teachers comments in this interaction to the physics teacher's explanation of why the cart can move above (section 4.1.1).

An important point here is how what was being discussed in the physics class, the horse and cart problem, crossed over directly into the language class. This is significant in shaping student understandings of the role of language in physics discussed in chapter five; students understood writing explanations as helping them to understand their physics.

4.3 SUMMARY OF CLASSROOM TALK

Much of the teacher talk in the physics class involved explanation, using theory, to explain events in physics, even though students were engaged in largely mathematical problem solving. Also the teacher concentrated on the meaning of words such as "acceleration" and "weight" within the thematic formation of kinematics and physics education.

In the language classes the most striking issue was the distance between understanding physics discourse and the language through which it was represented. Much of the reference to language and physics concerned using language appropriately for one's teacher, rather than some sort of integration of language and content knowledge. Some student talk, however, shows evidence of an evaluation of content knowledge through trying to explain an event in physics.

Where the teacher does talk about physics her understandings are not altogether wrong but, not surprisingly, do not match what a physics teacher could do.

CHAPTER FIVE

ANALYSING THE INTERVIEWS WITH SIX STUDENTS

5.1 SELECTING THE TEXT

Interviews involve responses to questions from the interviewer and are thus generally more directed than, for example, discussions about planning. In a structured interview situation it would thus be possible to categorise responses according to the types of question which were asked. However these interviews were fairly open ended (See the interview schedule in section 2.1.4), with the responses to questions not necessarily matching the questions asked. I thus categorised the discourse of students and analysed these categories, as was done with teacher and student talk in chapters three and four.

All the questions concerned probing student's understandings of language in science, with particular reference to the two week course they had just completed. The student responses were divided up into the following categories: essayist discourse, the appropriate language for physics, and writing as understanding physics. The category for the appropriate language for physics was quite lengthy and was thus further sub-divided.

C, F, FO, S, T and V are the students I interviewed. J is myself.

I had to restrict my analysis to talk concerned with both language and science as I had gathered a large amount of student talk during the interviews. Despite this restriction there are some quotes which concern language only, for

instance the essayist quotes. However these quotes were derived from questions which specifically asked about language and science, so I judged them as pertinent perceptions within the ambit of science and language.

I excluded the following sorts of talk which I thought were largely irrelevant to this project:

* Information concerning changes in understanding about different essayist genres. This often related to school/college differences, for example:

> *t. We wrote what we thought at school. The teacher would only take what was important.*
> *j. They did not teach you how to argue or discuss and so on, you just wrote everything in the same way. Did you think explain and discuss were the same thing?*
> *t. Yes, I would do the same thing.*
>
> *j. Are you more conscious now?*
> *t. Yes, of different ways to write*

* Ideas about talking/writing differences, for example:

> *c. You know I would say writing is like to test yourself but in a discussion really you are OK. The testing is not that much, someone comes to a point and you add something. But now in writing because you are all alone you do it all by yourself.*

* Comparative information from non-educational arenas concerning explanation, for example:

> *fo. Karate is like going to school ... they teach kata ... but when a person is fighting is different. I can teach you how to fight but when you are fighting you are on your own so it is different. Well there is theory because that person was supposed to use a kick because that person was far away from you, or that*

person was supposed to block the punch, things like that...

* Repetitive information.

5.2 ESSAYIST DISCOURSE

5.2.1 Quotes on essayist discourse

j. What about the relationship between the more language issues like given and new, cohesion etc. and physics.
t. Well I never knew what English was all about though I was good at English. I mean in writing English there are problems and maybe like you have to combine two sentences, which words to use when you are trying to say something.

f. ... maybe I understood the laws but when I write I just waffle. Now I can organise my writing, if I am solving a problem, I can make a plan about how to write it. And brainstorming, now you know what you are going to write about. After writing about it, you know this doesn't fit here, you put arrows in, and someone marking it ... (indistinct).

v. ... because I had a problem just writing everything haphazardly, everything I had been taught without any sequence. It is really different because in our minds if you ask us to explain something or discuss something it is the same thing but now it becomes more clearer. ... when I discuss things I think of in general, when I explain things ... I think of a particular set of things (indistinct).

s. Now we know the difference between explain, discuss, define, all those. We used to mix them all up, we do them other way round, whereas we are expected to do

something else ... it brings up all your ideas and you just write them down, then we made a pattern out of them, arranged them in order, that is how we write.

fo. Ya but I think they are important (topic, given and new etc.) *in the way that the language, even if you are doing physics, the language which you are communicating is English, so it may happen that you really understand science but if you do not understand English also it gives you a problem ...*

5.2.2 Analysis of the essayist quotes

All the students responded in this category. I differentiated this category from the others because students were understanding the language they were learning as being of a more generalist nature. For instance they understood language teaching as helping them be more "ordered" in their writing, but not necessarily concerned with doing or learning physics.

Students made little reference to essayist discourse in their interviews yet this discourse was highlighted in the language classes. I think this is important in that students seem to be quite focused on connecting current language teaching to some facet of science teaching. However it must be pointed out that the focus of questioning was on the relationship between language and science and not on the general usefulness of knowing academic English. So I would expect essayist discourse to be under-represented in these interviews.

On a slightly different note, the question in my first quote (*What about the relationship between ...*), could possibly only have been answered with respect to language alone. In retrospect I see that the task I presented the student with, to link information structure in English with physics discourse, was probably way beyond her level of understanding of language.

Student talk within essayist discourse probably derived from the early part of the language course which was concerned with using physics examples to teach different genres of writing (I use genre in a general sense here), and writing process skills such as brainstorming. For some students these were new ideas with which they could make sense of their writing. This tendency is evident in the above quotes as well as in the classroom talk in section 4.2.1, in which one student initially fails to discriminate between "description" and "explanation".

I am not sure if knowledge of essayist discourse is important in learning subject matter such as physics, or if it is just a general academic literacy skill. Gee (1990) believes it serves a gatekeeping role to academic institutions, but is not itself concerned with acquiring academic knowledge.

The only real way to ascertain if essayist discourse influences understanding in physics would be to examine student writing. A strong essayist effect should manifest itself in good representation of topic, cohesion and paragraphing, but not necessarily an adequate articulation of theory and event in the explanation. However, as Inglis (1993) points out when discussing black, second language learners writing in first-year biology, a lack of conceptual understanding may cause a deterioration in language. Students may exhibit an ability to write coherently where the concepts are fairly straightforward, but this coherence fails with more difficult concepts.

5.3 THE APPROPRIATE LANGUAGE FOR PHYSICS

5.3.1 Quotes on the appropriate language for physics.

Structure

c. Sometimes we are asked a question and they say to explain an event but in physics. Then you know the

physics the whole thing but you don't really know how to answer it, you answer it as if you were talking to a friend ... but this lesson ... learnt about the theorem that explains the whole thing. Usually you take it for granted "no it is fine, I do not need to put this in, write the whole thing."

f. When you talk about a law we shouldn't put it in the way we understand it but as it is and I didn't know that. In matric we just put it down when we apply. Here we put it down then we apply as our understanding in solving a problem. But we have to state the law first.

v. The problem is we can do things the way we understand it but it is not the way others understand it. There has to be a uniform way.

v. It is very difficult to express in physics if you do not have the right ways. You might write a whole page for something which should have taken half a page. Maybe you are writing a lot of things which could have been summarized.

fo. Well it is one of the most important things we have done ..., you look at, you find a person, you know what a question is, you know you are right ... but because you can't just put what you know in order ... so that the person ... can see that you know the concept. It is very important on physics, many of us, especially those from DET, are having problems when it comes to like jotting things down. So it is important.

f. I take him as a lecturer in a tertiary institution so I can just put in inertia. Now I have learnt that you just repeat it even if you know he knows what you know, you just show him.

fo. Because if I, like, writing, answering questions for my lecturer. I know that this person knows about

what I am writing so I have to be brief and straight to the point an show him that I understand.

fo. For me it is good to use physics because I mean physics, I mean I think that, that if that someone has to be taught to answer questions and so forth, they must, to be able to teach that person, so that person can to understand, so that I know how to answer physics questions, if I am supposed to answer a certain subject, ... maybe I will get it from physics.

s. So I realised that you have to state it, and I realised that this is important, or especially when you are giving a law, you are giving an impression that you know this thing.
j. You mean that you are giving an impression to the lecturer that you know this?
s. Yeh, you also understand what Newton 1 is.

s. What is important is to show that you know it. Not that he knows. So you try to show that you know the law. Because if you do not show him that you know the law, maybe I just think Newton one ... so he knows which law I am using ... makes marking easier.

Register

j. What do you think about particular language you use for Mr Gibe, for instance, you brought it up you said it is different to talking to a friend.
c. When talking to Mr. Gibe you have to be correct, use appropriate terminology. At least we know how to write. ... "wants" is too human. Now "tends to" is more appropriate.

fo. *Like we have got an idea, like just like ... from now on if I get a question like "why is that" or "how" I have got an idea of how to tackle it. I think that maybe now I have forgot it ... things like using the right tense, you may know the right words but because you are not taught to use them, simply lose marks for*

the question. The first words that come to mind you put them down, like velocity and speed. I was arguing that in that, velocity, putting speed would be OK, but not right for the question ...

f. It was important, it does help, maybe you just know language, it doesn't mean you can talk the language of scientists. You need to know the terms.

j. So do you see the way people write in physics, explanation in physics, as different from explanation at home?
s. Yes it is different, the thing is register. Register will be different. Because when you are at home you explain something you explain so that the next person to understand what you are explaining, but you are just using ordinary language and that is acceptable language of explanation at home. So that language is not acceptable in physics. In physics you cannot use that language, you have to use physics language, that is the difference ... each and every thing has its own words for writing.

s. ... everything has its own register, for instance in physics, I am just writing and writing and writing everything. When I am corrected and this thing is wrong I try to find a word. I try to think which word can I use, a physics word, which word can I use for this thing. ... Ya, when I am looking I look at the word I used, I look at the word I wanted to say, then I look at can I say according to physics, or how can I name this with the physics, or which physics word can I fit in with the word I've written. So I look at those terms.

s. Yeh, you state the law, if you want to use this law you state the law, what it is. Then you state how does this law apply to what you asked, you link the law to the question "according to this law, this and this".

j. I am interested in the physics class, was what we were doing in the language class helpful or matched what you did in physics classes?
v. Yes because we were doing the same things, the language we used was similar.
j. Like register?
v. Yeh.

Levels of appropriate language

J. What happens if you don't give your reader theory for e.g. in the block problem, if you just said there is more force horizontally, why would that not be satisfactory?
c. It is too light and its not satisfactory.
j. Too ordinary and not satisfactory for Mr. Gibe?
c. Ya, it is OK for std. 6 or 7. It is saying the obvious.

Holistic approaches to appropriate language

f. If you meet lawyers, maybe people doing commerce, they have their own language, you can't communicate properly with them, you won't feel relaxed. Now we also in engineering also need our own language when we speak about things.

f. ... in 2 years we will be at UCT. We are going to face the problems in a project when you present your things you have to put the logistics of science, use the right language. If we are going to talk about other things, out of science it will be a waste of time for us.

Mixed approaches

j. So do you think there is more to English than being fluent and grammar? Do you think the way we use English in physics is different to the way we talk to a friend? Are there special ways of writing in physics you do not use in everyday life, scientific explanation is that different to explanation in everyday life?

t. We use words like motion. Explain using a graph say for a car and its velocity, writing it down I would use the way we did it in communications. With a friend you would just talk.

j. What is the difference between knowing and understanding?
t. I knew the law, I didn't understand what it really said. So when I explained it was not right, what the teacher wanted.

5.3.2 Analysis of the appropriate language for physics

All the respondents understood the language they were learning on the course as being in some way appropriate to their physics course.

The predominant views in this category were those of students recognising that there are particular ways of structuring their writing in physics, and that they need to use an appropriate terminology. Some of the respondents see this as essentially translating what you already know into this appropriate language "for the physics lecturer" or "to get marks".

There is an essential separation being made here between the language one applies to physics and the physics knowledge itself. This is not surprising as it was the dominant understanding expressed by the language teacher in the language lessons in chapter four.

Furthermore I think that students often gain an understanding of the appropriate words to use in science from their school experience, though they do not necessarily integrate this understanding with the discourse of science. For instance one can detect elements of the need to use the appropriate language from this student talk in a standard eight DET classroom (Clarke, 1993: 176):

Question: Why do you think the textbook has these big words?
Mfundo: I think it is to differentiate the laboratory English from the normal English.
Thomazama: I think science is science and English is English, so we can't mix the words of science and English.
Question: Why do scientists talk in a certain way?
Mfundo: It is part of being a learned person.
Question: Why do we use such words (like decant in science)?
Xolile: I think ..... in my own words it is made so that it .... people can identify that this is science and that it is not like any other subject.

The appropriate language of science is similar to Wertsch's (1991: 135) concept of the "official language of science" discussed in section 0.3.3 on voice. Students seem to understand a need to talk through this official language in writing about science. This tendency and some of the problems associated with it were discussed in section 1.2.3. of the theory chapter. Furthermore, how appropriate language use can be more integrated within the discourse of physics is discussed in section 6.2.3 of the conclusion.

5.4 WRITING AS UNDERSTANDING PHYSICS

5.4.1 Quotes on writing as understanding physics

c. I think just knowing it to say you just know it, you don't know, until you have to explain it. Usually you talk to friends but this ... (indistinct). *I think writing it you really know deep.*
j. So do you think that writing is something different from talking about or simply knowing in your head?
c. I think just knowing it to say you just know it, you don't know, until you have to explain it. Usually you

talk to friends but this ... (indistinct). *I think writing it you really know deep.*

j. What are your feelings about the links between the language course and physics? Has it helped you see physics in different ways?
t. You have to know the physics to explain it so I have to go and study physics to explain it. So I think at the same time as I am studying it I am learning to explain it. I knew Newton's first law but didn't understand what it was about.

f. Just looking at my previous script and the script I wrote afterwards ... like the thing ... like I did not, when I answered the question, like the lamp hanging on the lift, I did not think about laws, I just talked about weight, that weight, I did not go deep down to it, but if it was an exam question, ...

j. What about raindrops which was not being dealt with then, which you did not actually do in physics was it OK or would you rather do things like Newton's laws?
v. Certain things we do them. We pass them and still we do not understand them, so that is what is happening most of the time. What I found ... I tend to understand more when we discuss although I can do a whole problem and still do not have an understanding.
j. Does writing help understanding?
v. Yes it helps you to gain understanding and to remember. Immediately you write something which does not make sense, you know because it is written down, you start thinking, unlike just saying it.

fo. For me it is good to use physics (in language learning) *because I mean physics, I mean I think that if that someone has to be taught to answer questions and so forth, they must, to be able to teach that person, so that person can to understand, so that I know how to answer physics questions, if I am supposed*

to answer a certain subject, ... maybe I will get it from physics.

5.4.2 Analysis of writing as understanding Physics

In this category five out of six students commented on writing explanation as a way of understanding physics. Writing enabled them to *"really know deep"*, *"see the inside of"* or *"start thinking about"* the physics content.

Such an understanding of language is one which extends the idea of translation into appropriate form and terminology to that of learning physics; these were the same students who commented on appropriacy of language in the previous category. Using language to understand physics is a generative view of language, that language can be used to generate understanding within the subject discourse.

This sort of understanding is likely to occur where problems encountered in the physics class cross over directly into the language class, as took place between the language and physics teaching during the research period (see section 4.2.1).

I think a genre approach to teaching writing encourages students to evaluate their knowledge. As Bock (1988: 33) described in section 1.2.2, a genre approach encourages "disciplined thinking" within the discourse. However not all genres will necessarily play this role. For instance giving a description of a process or outlining experimental procedures would be less likely than explanation to engage students in evaluating their knowledge.

5.5 SUMMARY

There were three main understandings of language as it was taught expressed by the students.

Firstly they expressed a discourse concerned with genres in general and other ways to structure language. This was also a discourse expressed by the language teacher which I called "essayist discourse".

Secondly, students referred to the correct language to use in physics, what I called "appropriate language". This was by far the most frequently expressed understanding of language in science. The appropriate language for physics was highlighted in the language classes and this is probably where this understanding originated from.

Lastly, students talked about how writing actually helped them to understand physics. This seemed to derive from a cross-over between the content of the physics and language classes, particularly in terms of genres and content.

CHAPTER SIX

CONCLUSIONS.

This chapter is divided into two main sections. The first is a critique of the research methods used, that of discourse analysis, in the planning and teaching sections and the student interviews.

The second section deals with the implications for language teaching of what teachers do in the language and physics class, and how students understand language in science.

6.1 METHODOLOGICAL CRITIQUES

6.1.1 Analysing teachers' language

The first problem that arises with a discourse analysis is the subjectivity of the researcher. Researchers may see what they want to see and disregard what seems to be outside of the ambit of their gaze. In discourse terms this involves a subjective "construction of reality" which is derived from what the researcher sees as important in the research situation.

For instance, I showed my analysis of "planning and teaching discourses" (chapters three and four) to the language teacher with whom I worked. She believed it to be a selective reading of what had actually occurred in the language classes, one which showed her in a negative light as a language teacher. I had, seemingly, concentrated on her problems with physics content in the language teaching and had thus suggested that she could not teach successfully in a LAC initiative. Furthermore she believed that I had not been open with her about what it was I was looking for, I

had basically used her for a critique of LAC teaching in science.

The teacher believed that what I was engaged in was some from of evaluative approach to the teaching of explanatory writing. Although I was throughout interested in teachers' and students' understandings of language teaching and physics, I did not know what sort of data would emerge nor how I could eventually use this data. My initial approach to the teachers at LEAF college was "let's try and work out a way of teaching written explanations in physics and see what happens", which could easily be understood as a straight evaluation of the teaching method.

I think part of the problem lies in the nature of social constructivist research and indeed much of what was discussed under "qualitative research" in sections 2.2.3 - 2.2.5.. The initial research questions one asks are often quite vague and are only later firmed up as the researcher gains an understanding of the research situation.

In the light of l's perception of my aims, which I think she was quite justified in holding, my analysis of her discourse appeared to be personally directed rather than about the whole process of teaching language across the curriculum. This was, too, a process in which I was involved yet it seemed to her that I had become a completely external observer.

It is important to inform teachers about which data one is using, and how one is interpreting this data, at each stage of the research progress. One suggestion, based on my problems with this research, is to have a form of "rolling minutes" consisting of regularly upgraded data and their interpretation. The teacher could then intervene and make suggestions at each stage of the research, thus ensuring that her "voice" and concerns are heard. Also such a process would be helpful in ensuring the validity of the data and some sort of reflection (from the researcher) as to why they

made a particular interpretation. The issue of validity was discussed in a similar way in section 2.2.4 of the method chapter.

What I have talked about as "subjectivity" could equally come under the heading ethics. That is the ethics of sharing your research process and your understandings with whoever you are researching. The research is not just about subjects or for them in some way (i.e. enhancing their practices), but is also with them (Cameron et al, 1993).

I think my research was "with" the teachers only to the extent that we co-planned the LAC course. However it was very much about "advocacy" (ibid: 83). The language teacher gained materials for a LAC teaching module and the students gained an enhanced understanding of language in use. Furthermore, part of the research resulted in a conference paper, written by the language teacher and myself and presented at the South African Academic Development conference in 1993. This was the first time the language teacher had presented at this sort of conference.

The second level of critique focus on problems with the possible framing of student answers in interviews.

6.1.2 The interviews with students.

The first problem that arises is the context in which the interviews occurred. They were being done in a classroom. I had been introduced to the students as a researcher. Also I had been present in the classes and had intervened with content problems and marked four of their scripts. Although I did not ask students how they viewed me, I think it would be safe to say that I was "institutional" and a "teacher".

One could thus suggest that whatever students had to say would be framed in terms of the institutional and educational discourses in which we were situated, as well as towards my role as a language teacher.

Interviewees would be "signalling through their discourse system a particular identity appropriate to this occasion" (Gee, 1990: 112). Naturally, what students perceive the discourse situation to be is also going to influence my interpretations as researcher. As Fairclough (1989: 144) says:

> How participants interpret the situation determines which discourse types are drawn on and this in turn affects the nature of the interpretation procedures which are drawn on in textual interpretation. But we also need to refer to intertextual context: participants in any discourse operate on the basis of assumptions about which previous discourses the current one is connected to, and their assumptions determine what can be taken as given in the sense of part of common experience, what can be alluded to, disagreed with and so on.

I was not concerned here with some "internal state" or "consistency" (Potter and Wetherell, 1987: 164) which lay beneath the ideological understandings of educational institutions and social roles. What did, however, interest me was how students viewed language within these constraints. I wanted to know what their understandings of language would be within the classroom.

Secondly, related to the ideas about what students considered appropriate answers to questions, is the problem of "different social orders and orders of discourse" (Fairclough, 1989: 150) between myself and the students, which was first discussed in section 2.2.5. This problem manifests itself in interviewees giving apparently irrelevant answers to questions because their interpretative resources are differently structured to those of the interviewer. They privilege different knowledge. For instance Fairclough gives this example during a job interview for a position in a library:

I. What about the library interests you most?
R. Oh the children's books, because I have a child .... there's so many for them to read and little things that would interest them would interest me too.

In this case the interviewee is privileging a discourse concerned with "motherhood" whereas the interviewer, I presume, is more interested in some form of professionally orientated discourse.

Some of the students I interviewed seemed to also have this different order of discourse, for example:

j. Students often feel that language courses in science do not have much to do with what they are doing in science in this case physics. Did this feel relevant to you?
f. I did not know how to explain. I am improving.

j. Does something like given/new help you when you cannot understand content?
t. It looked easy when I (the teacher) did it but when it came to write it, it was tough.

In the first quote the student appears to be privileging an entirely essayist type of learning whereas the question concerns links between science and language. In the second quote T refers to the difficulty she experienced with given/new rather than whether or not this was helpful/unhelpful in understanding content.

In the introduction to the interviews I had used this second quote as a misunderstanding between myself and the student. It is still not absolutely clear to me whether this is a case of misunderstanding or different perceptions of the order of discourse. However, although different orders of discourse may be a problem for interviewees in a job

situation, I was again interested in what understandings of language students privileged.

Lastly, there was a problem of my questioning becoming closed and thus encouraging "yes or no" style answers, even though I had described my interviewing technique as open-ended in section 2.1.3. These examples of my questioning which illustrate this tendency are taken from section 5.3.1:

> *J. So do you think there is more to English than being fluent and grammar? Do you think the way we use English in physics is different to the way we talk to a friend? Are there special ways of writing in physics you do not use in everyday life, scientific explanation is that different to explanation in everyday life?*
>
> *J. Was what we were doing in the language class helpful or matched what you did in physics classes?*

On one or two occasions I found it difficult to avoid such directed questioning where students did not respond to multiple probing of their understandings, or where I felt our interview time was running out. Fortunately where I used directed questioning students tended to respond with extended, reasoned answers rather than just yes or no. However if I had received yes or no answers then I could have probed with an added "why?" question.

6.2 SOME IMPLICATIONS FOR LANGUAGE TEACHING FROM TEACHER AND STUDENT PERCEPTIONS.

6.2.1 A brief summation of the results

There was an understanding, from both the physics and language teachers, that language teachers have difficulty in understanding physics' concepts as well as the language which carries this meaning. There was also a sense that at

least some physics knowledge was more mathematically than verbally orientated (for example calculations in mechanics).

As I later found out however, verbal explanation was strongly represented in the physics classroom which I observed (section 4.1.1). Furthermore, where the content of the language classes was that of explanation of problems in physics, then this genre crossed over between the two subjects; students were engaged in trying to explain what had happened in their physics classes. Although the language teacher was not trained in physics she did manage to intervene to a limited extent, though this intervention was not always correct.

Student responses as to how they viewed language in physics were predominantly in two categories. Firstly, they understood writing as a means to understand and refine their own knowledge. Secondly, there was a strong awareness of the need to use appropriate language for their teachers when writing about physics.

In this last section I want to weave together these understandings, from both teachers and students, so as to provide some pointers for the role of language teachers in the teaching and learning of scientific discourse. My preferred point of departure for this is to review some of the discussion on language and knowledge.

6.2.2 Language and knowledge

In section 1.1.2 of the theory chapter I addressed the importance of the relationship of language and knowledge in teaching. This issue was further explored in section 1.3.1 on explanation.

Writing explanations encourages students to use the main concepts or theories of the discipline to explain why certain events occur. In so doing they are engaged in learning physics while they write. However what language

teachers can do that is both different from what physics teachers usually do, but is still within the ambit of teaching physics, needs to be addressed.

6.2.3 Language teachers and physics discourse

The problem for language seems to lie not so much with the closeness of fit between language and subject discourses, but whether or not the language teacher can actually cope with this knowledge. As Ruth Spack (1988) points out, such a mission is extremely difficult, especially for teachers with an arts or social science background. There is evidence of these difficulties in the transcripts of the language classes where the teacher tries to intervene in student discussion around physics issues (see section 4.2.1).

The obvious answer is for language teachers to have a strong working relationship with the science teachers. However, as pointed out above (section 0.3.1) it is possible for language teachers in this position to take on a relatively unimportant role in the teaching of the scientific discourse.

What I believe is needed is for language teachers to use their skills in language to mediate student learning in science. This mediation can best occur through attention to the notions of genre awareness and voice in student writing.

6.2.4 Genre awareness and voice

As pointed out in section 1.2.5 of the theory chapter, language teachers can ask questions such as "what are the main and sub-concepts pertinent to this problem and how do they typically relate to one another?" In other words they can use their knowledge of genre conventions and the need for appropriate register to raise students' consciousness as to how to write in physics.

This role, as I understand it, is one of alerting students to the need to write what they want to say within the constraints of the relevant genres. As Bhaktin (1981, 165) puts it:

> I can mean what I say but only indirectly, at a second remove, in the words I take and give back to the community according to the protocols it establishes. My voice can mean, but only with others.

Such a role for the language teacher requires a knowledge of the scientific genres they are dealing with, but does not necessitate an intimate knowledge of the subject itself; the role of the language teacher in raising genre awareness is that of training students to become ethnographers of their subjects (Swales, 1990. Section 1.2.5).

Furthermore, using the constraints of genres would allow the language teacher to more formally deal with the "writing as understanding" perceptions from students in chapter five.

For instance, understandings such as:

> *I think just knowing it you say you just know it, you don't know until you have to explain it. I think writing it you really know deep.*

could be reconceptualised in terms of working within the appropriate genre, which in turn aids understanding of the discourse of physics. As Swales (1990: 12) notes:

> Some of these ¡genre driven pedagogical activities¿ are primarily concerned with getting student apprentices to explore, reflect upon and better articulate the ethos of their particular discourse communities ...

The other main perception of language in science from students in chapter five was that of using the appropriate register and form for their teachers (but not necessarily as

a way to understand physics). I called this perception a reflection of the "official voice of science" (Wertsch, 1991: 135).

For instance this student had this to say about using appropriate language:

> *When I am corrected and this thing is wrong I try to find a word. I try to think which word can I use, a physics word, which word can I use for this thing. Ya, when I am looking I look at the word I used, I look at the word I wanted to say, then I look at can I say according to physics, or how can I say this according to physics, or how can I name this with the physics, or which physics word can I fit in with the word I have written. So I look at these terms.*

It is tempting to view this quote as just another example of a student reflecting the official voice of science as he has heard it in his lectures or read it in his texts. I did, in fact, interpret it as such in section 5.3.2. There is, however, another way to interpret the quote. What this student could also be doing is talking about trying to express his "voice" within the confines of the terminology of physics; he is trying on the "clothes" of the formal language of teachers and texts (Cazden, 1992: 190) in trying to express what it is that he wishes to communicate.

As was pointed out in the voice section (1.2.4), using the official voice of science does not mean that students can only write in one way. On the contrary, they continually mix the "official" terminology with their own understandings and language.

Language teachers can alert learners to official or appropriate terminology through raising questions such as "have you used terminology that is appropriate, in terms of texts and teacher talk, for the theories you have discussed?". At the same time they can both allow and

encourage personal voice, at least within the constraints of information structuring in English, and those of genre (see section 1.2.2 of the theory chapter).

Perhaps the best way to do this is for students to redraft their writing according to teacher input on genre and voice as suggested above. In other words for teachers to use a form of "process writing" in which the students' early attempts at writing, rather than being superficial, indicate their current stage of conceptual understanding of, for example, genre and register. The teacher can then, through careful questions and comments, lead the learner from naive to appropriate institutional conceptual understandings. In other words scaffold the learners' introduction to the discourse community through intervention at his or her level of register and genre understanding.

A process approach to writing has obvious similarities with Vygotsky's notion of teaching through the zone of proximal development (Hedegaard, 1991). The role of the teacher here is to advance learners' present relatively naive knowledge towards that of formal disciplines of schools; eventually this new knowledge should become internalised as part of the knowledge repertoire of the learner.

6.2.5. Some problems and research questions

The most obvious question generated by these language teaching suggestions is "how much physics would a language teacher need to know to successfully coach students in genre awareness and voice?". As pointed out above, I did experience some difficulties with physics content in the language classes.

I found the following talk after one of the language lessons illuminating in terms of I's physics knowledge:

> *J. You seem much more confident with physics than you were at the start.*

l. I have learnt a lot. Also having m's model answer for the "coffee capers" problem, I studied this. I picked up you had to state the theory, and in his explanation you had to mention the coffee was moving at the same speed as the aeroplane, so what was happening outside the plane did not really matter.

What helped l with her physics knowledge was m's model explanation of a typical physics problem (the problem itself is in appendix d, page 9 under "coffee capers"). If, as I pointed out in 1.3.1 and 5.4.2, explanation illuminates the discourse of physics for students, then it could play a similar role for language teachers.

Perhaps if physics teachers could be persuaded to write explanations for a number of conceptually important physics problems, then this would equip language teachers with an appropriate conceptual knowledge, structure and terminology, which they could then exploit to teach students about genre awareness and voice.

It would be important to see how such a relationship between the language and science teacher would function in practice in other institutions. The idea of "genre teaching" is gaining credibility as an approach to teaching language within the sciences (Veel, 1992; Robinson 1993). It would be important also to ascertain whether genre teaching in general provides access to the dominant discourse of physics, as explanation does, or whether it simply provides students with a template for appropriate presentation.

6.2.6 Concluding remarks

In conclusion this research has generated useful data about teachers' and students' perceptions of language in science classrooms. This data has furthermore provided pointers as to what language teachers can do to aid student learning in science. My final comment concerns the situation of these

recommendations within the theoretical framework of the research.

The notion of language teaching which I have been advocating has not been that of "transmission" of knowledge from teacher to learner. Nor has it been that of the unconstrained representation of the learners' experience of physics. Rather I viewed language teachers as mediating the interaction of individual subjective experience within the realm of the social (Ernest, 1993). In the context of this research the social refers to the established discourse of physics and the subjective to the individual's reading and representation of this discourse. Such an understanding is congruent with "social constructivism" which was the theoretical paradigm for this research (this paradigm was discussed in section 0.2).

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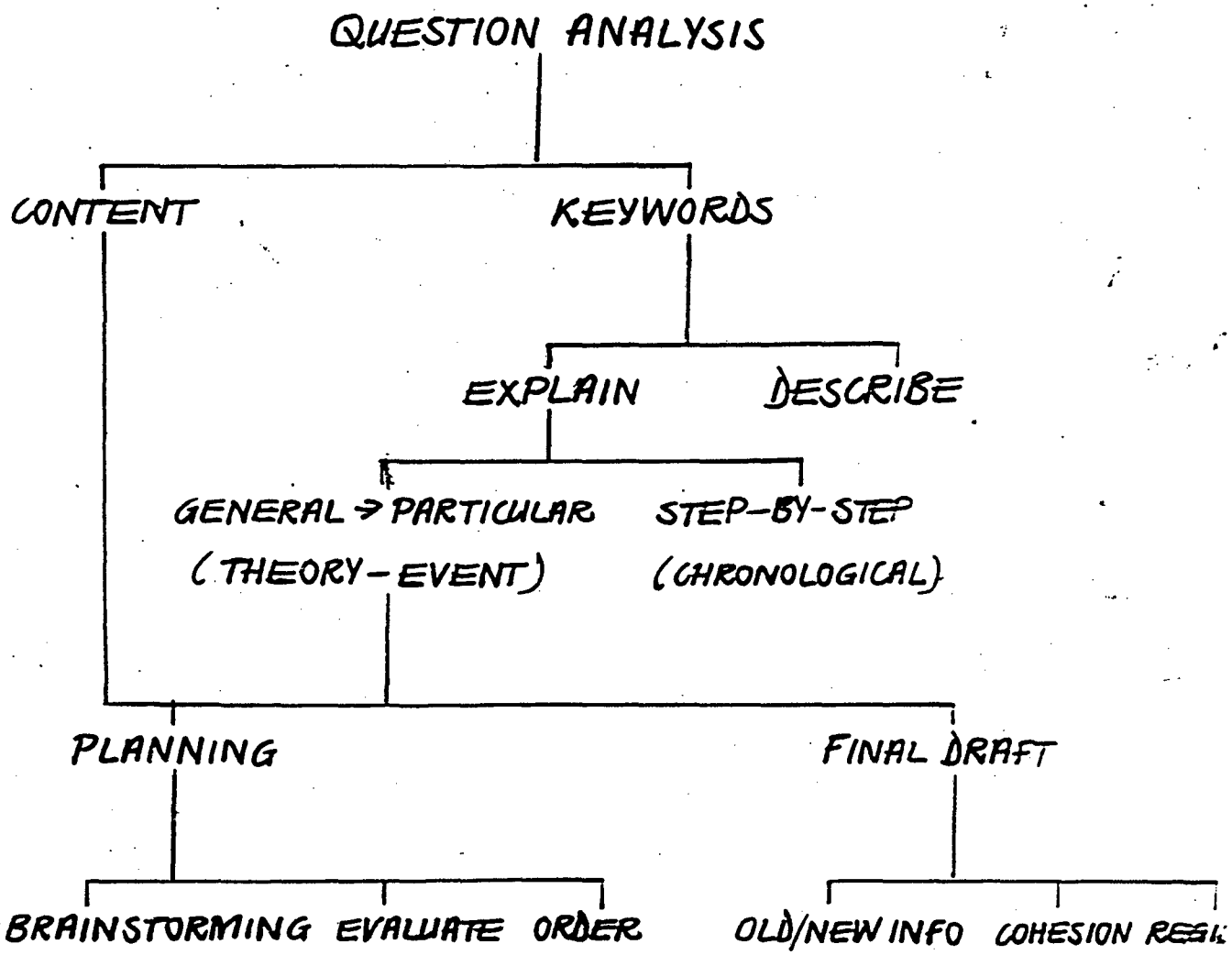
APPENDIX A

Appendix A TEACHING PLAN



Appendix B

Appendix B

Q1 MISGUIDED HORSE

A horse is urged to pull a wagon. The horse refuses, citing Newton's third law as a defence: The pull of the horse on the wagon is equal but opposite to the pull of the wagon on the horse. "I can never exert a greater force on the wagon than it exerts on me, therefore I can never start the wagon moving," the horse claims.

Why is the horse wrong?

Appendix C

THE MISGUIDED HORSE

exerts a force on exerts an equal and opposite force
The horse pulls the cart and the cart pulls the horse

The forces do not each other
with the same force. Nothing is cancelled out.

The action-reaction pair bodies
These forces act on opposite things. (Newton's

Third Law). Nothing moves because the weight

frictional force against the cart greater or eq
and roughness of the ground are different from

force the horse exerts
the strength with which the horse pulls. In accordanc

with Newton's First Law, which states that a body is

at rest or in constant motion unless acted on by

inertia.
unbalanced forces, the non-motion of the cart is

disturbed unbalanced
changed by the large forward force of the horse.

It is greater than the cart's frictional forces (weight and roughness).

There is motion.

CORRECT REGISTER

The horse exerts a force on the cart and the cart exerts an equal and opposite force on the horse. The forces do not cancel each other out. The action-reaction pair act on opposite bodies. (Newton's Third Law) Nothing moves because the weight and frictional force of the ground against the cart are greater than or equal to the force the horse exerts. In accordance with Newton's First Law, which states that a body is at rest or in constant motion unless acted on by an unbalanced force, the inertia of the cart is disturbed by the large unbalanced forward force of the horse. It is greater than the cart's frictional forces. There is motion.

REGISTER - What is it?

Register is the choice of language which shows that you understand theory and concepts. This understanding is revealed by words and phrases which are appropriate to Physics.

COHESION

Cohesion refers to the way a piece of writing "hangs together" i.e. how the ideas and sentences are linked. These links are made clear by: (a) topic development and (b) cohesive devices

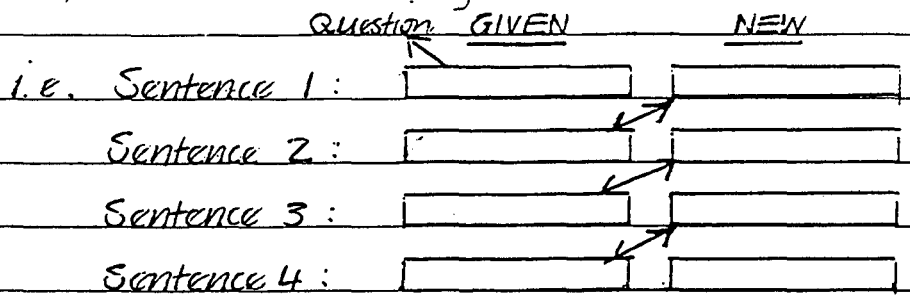
A TOPIC DEVELOPMENT

(1) Overall development

- the first part of the explanation should refer directly to the question i.e. the topic of the question
- the middle part (the longest part) should deal with different aspects of the topic i.e. explain in detail
- the last part should pull all the details together i.e. return to the overall topic

(2) Sentence development : given and new information

Most sentences should give some new information about the topic of the previous sentence (given information).



B COHESIVE DEVICES

Cohesive devices are words or phrases which:

(1) indicate structure eg two reasons ..... firstly ... secondly

(2) indicate how one idea is related another one (the next idea or previous idea)

eg because (x is the reason for y)

therefore (cause-effect, reason-result)

however (x is contrary to what the previous idea led us to expect)

(3) referring to a word/phrase mentioned earlier eg this, these, the (usually found in the "given" part of the sentence)

GIVEN AND NEW INFORMATION – TOPIC DEVELOPMENT

question

The horse is wrong for two reasons: firstly it has misapplied Newton's Third Law and secondly, it has not taken Newtons First Law into account.

Newton's Third Law states that for every force on one body there is an equal and opposite force on another body. Therefore the horse exerts a force on the cart and the cart exerts an equal and opposite force on the horse. These forces do not cancel each other out because the forces form an action-reaction pair on two different bodies. Therefore Newton's Law does not explain why the two bodies do not move. They do not move because the weight and frictional forces of the cart are greater than or equal to the force the horse exerts on the cart.

COHESIVE DEVICES

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The horse has not taken Newton's First Law into account. This law states that a body is at rest or in constant motion unless acted on by an unbalanced force. According to this law the inertia of the cart is disturbed by the large unbalanced forward force of the horse. This force is greater than the weight and frictional forces holding the cart in place and therefore the horse is able to move the cart.

introduction

The horse has not taken Newton's First Law into account. This law states that a body is at rest or in constant motion unless acted on by an unbalanced force. According to this law the inertia of the cart is disturbed by the large unbalanced forward force of the horse. This force is greater than the weight and frictional forces holding the cart in place and therefore the horse is able to move the cart.

Appendix d

Appendix d

Coffee Capers question

Explain why it is easier to drink a cup of coffee in an aeroplane which is flying at constant velocity than in a car which is travelling along a bumpy and winding road?