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Stalking Science: A Microlinguistic Analysis of an Irish Classroom

A thesis submitted in fulfilment of the requirements for the degree of PhD.

For

Trinity College, Dublin
School of Education

May 2011

Brian Michael Donovan
Declaration

I, Brian Michael Donovan, declare that this thesis has not been submitted as an exercise for a degree at this, or any other, university. It is entirely my own work and I agree that the library may lend, or copy, the thesis, upon request.
Summary

This research project sought to investigate the language of school science from a linguistic perspective. Research into classroom discourse in Ireland is quite sparse, and it was hoped this research could contribute to learning more about the English language used in classrooms between teachers and students.

The research method was to video/audio-tape classroom sessions in Junior Certificate science with content selected by the teacher. One school was selected for analysis based upon the transcription of the classroom discourse culminating in 1632 separate clauses to analyse and interpret.

The framework for analysis was Systemic Functional Linguistics and the grammar associated with it. This led to an analysis at four discrete levels of meaning: Exchange (principally looking at labelling the meaning behind each utterance); Interpersonal (looking at meaning behind the semiotic relations between teacher and students); the Ideational (offering insight to the experience of meaning that is brought to bear in learning new content, particularly science); and the Textual (examining the clause-by-clause relationship to establish where meaning was, or was not, being made). The analysis led to assigning labels for each clause at each level accompanied by separate analysis of the labels. The software used was Systemics, specific to Systemic Functional research (with the grammar pre-configured into the software).

In interpreting the classroom data, sampling of excerpts of sequences from the classroom were chosen. The goal was to select exemplars of meaning (between teacher and students) in order to identify patterns of linguistic behaviour in the classroom activity.

The main findings relate to each level of analysis. At the level of exchange, the analysis showed the brokering of new content within science was a constant goal of the teacher. This brokering was between scientific/technical language and common-sense language. This was found to be both linguistic as well as cognitive (where the teacher exchanged common-sense language with students on their way of thinking differently about reality).

On the Interpersonal level, the examination of grammatical entities Subject and Complement (in functional terms) and the role of WH- and Y/N- Interrogatives in the classroom led to two findings. First, the analysis of Subject and Complement showed that students frequently answered in short (single word or small group) answers, lacking supporting evidence for much of what was said. For questions, the data suggested that students appeared to lack the ability to pose questions (of both types) to the teacher, despite the teacher being (in linguistic terms) the Primary Knower in the classroom.
At the Ideational level of meaning, the grammatical features of Process and Circumstance were explored. The results were that students did not seem to have acquired sufficient linguistic familiarity with completing full clauses in the class. With Process, it was found that the teacher continually used both Verbal (saying) and Mental (thinking) Process types, but students rarely did. With Circumstances, which help situate and buttress meaning within clauses, the students used very few of this grammatical resource in the classroom under investigation.

Finally, the Textual level analysed Theme and Rheme, allowing for an examination of Thematic Progression within two areas: teacher and student exchanges; and teacher monologues. The main finding was that the teacher seemed quite strong in her use of these grammatical resources, mostly subconsciously, but that students had to be forced into using Theme in their answers—again, returning to the brevity of the responses to the teacher’s questions, principally of science content.

It is hoped that future and continuing research using a functional linguistic approach will support this research and extend the direction of classroom pedagogy in future.
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...Science speaks the language of truth...More generally, the discourses of science are those that are concerned with the truth of propositions about how the world, including the human world, ‘is’ in some objective sense. (Lemke, 1995, 96)

1 Introductory Notes

1.1 Preamble

Science within education is a socially contentious arena. In the pursuit of ‘truth’ in some ‘objective sense’, students are taught science so they may better understand their world and interact within and on that world. One Irish curriculum document from the mid-1980s describes the knowledge of science as encompassing, ‘...humans and their environment and enables changes to be made in their relationship. Science is therefore a social force or influence and an essential part of culture.’ (Curriculum and Examinations Board, 1987, 13) There has been, and continues to be some doubt, however, about how well students in Irish schools are learning science.

In a document published in 1999, for instance, the Irish Council for Science, Technology and Innovation (ICSTI) suggested that among other ‘causes of concern’ in relation to science education are, ‘...above average proportions of lower grades in some science subjects’ (Irish Council for Science Technology and Innovation, 1999, 3). Two recommendations made by the ICSTI were, ‘a system of rolling reviews of all science, technology and mathematics subjects...’ and, ‘subject choices [in science, technology and mathematics] and the factors influencing them should be monitored in an international comparative framework, and periodic surveys of pupils’ mathematical and scientific competences should be conducted using internationally comparable
methods...’ (ICTSI, 1999, 3-4). In fact, such an ‘internationally comparative framework’ has been put in place, within which Ireland as a country, has participated, and is described below.

In late 2002 and early 2003, there were two significant statements into how students were doing, or not doing, in school science in Ireland. The first was the publication from the Economic and Social Research Institute (ESRI) titled, *Who chooses science? Subject take-up in second-level schools*, which suggested there are differences in how male and female students perform in science, and levels of progression in science for Irish post-primary and secondary students. In particular, the book states that while, ‘The vast majority of students study Science for the Junior Certificate...girls, lower ability students and those allocated to the lowest classes within streamed schools are less likely to take Science than other students.’ (Smyth & Hannon, 2002, xiv)

The second declaration was by Mr. Sean Dorgan, then Chief Executive Officer of the Irish Development Authority (IDA), stating in a public forum that, ‘...we face the problem of reducing numbers of second level students.’ Mr. Dorgan proposed that, ‘...we must broaden access to and understanding of technology and science, not to make everyone a scientist but, in the course of everyone’s education, to give a basic understanding of the language of science.’ (Dorgan, 2003, n.p.)

These latter two analyses differ from another piece of research. This in-depth study into Irish students’ performance in science investigated as part of the Organisation for Economic and Co-operation and Development (OECD) research into educational standards as part of the Programme for International Student Assessment (PISA). The initial PISA report was initially published in late 2001 and given some media attention. This report, international in scope, and looking at Maths and English in addition to Science, suggests that Irish students are doing quite well, indeed.
A key area of this research related to science literacy, which sought to measure, '...students’ ability to use scientific knowledge (understanding of scientific concepts), to recognise scientific questions and to identify what is involved in scientific investigations (understanding of the nature of scientific investigations), to relate scientific data to claims and conclusions (using scientific evidence), and to communicate these aspects of science'. (Shiel, Cosgrove, Sofroniou & Kelly, 2001, 46) Irish students, whose age (15 years) would have placed the majority of those being researched at Junior Certificate level, scored, '...significantly higher then the OECD country average...' in science. (Shiel, Cosgrove, Sofroniou & Kelly, 2001, 47) In addition, the PISA report states that, 'correlations between the grades of students on the Junior Certificate Examinations...and their scores on the PISA assessment domains are moderately strong.' (Shiel, Cosgrove, Sofroniou & Kelly, 2001, xviii-xix)

The three reports noted above look at three distinct issues: gender performance in relation to students in science; an economic or commercial view of increasing performance in science through a better understanding of the language of science; and research into comparative performance between Irish students in the literacy of science and other international students. One might find it interesting that two of these focal points are language based. This thesis will explore the language of school science by entering into one Irish post-primary classroom to analyse the language used by Irish teachers and received (in the classroom) by Irish students, and look at how this language contributes to, or inhibits, the learning of science content. One key research question will be answered by looking at this issue.

In doing this specific task, a linguistic lens in looking at classroom discourse will be used. Classroom-based research has been continuing for a number of decades, with a particular focus on the specific discourse in the classroom having been firmly established in Sinclair and Coulthard’s work in the early 1970s. While such research did
not actually begin with this work, it is arguable that rigour and a more direct focus on language were offered by Sinclair and Coulthard. Time, of course, has pushed this research ahead internationally, but woefully little research has been done within Irish educational circles into classroom discourse (either inside or outside of science).

The comments that open this Introduction should be sufficient reason to begin such a piece of research based in Irish schools. However, it is also important to consider that, due to social changes over the past few decades, many people refer to what is called the ‘Information Society’ or ‘Knowledge Economy.’ Such terms are used in public with very little question in contemporary Western society, including Ireland. The bulk of such referencing is due to ever-evolving systems of technology, based on advances within science that drive such technologies. This can be seen clearly in the current revision of Junior Certificate Science Guidelines for Teachers, where it states that the syllabus is, ‘aimed at facilitating students in the development of skills, knowledge, understanding and attitudes that are appropriate in a society increasingly influenced by science and technology.’ (NCCA, 2006, 16)

Perhaps an additional reason to explore the language of school science in Ireland is the notion that, ‘...children in school know very well that there is a “language of science.” They may not be able to say how they know it; but when they are faced with [extract from school chemistry textbook] they have no trouble in recognizing it...’ (Halliday and Martin, 1993, 2) With virtually no research into the English used in Irish schools, never mind the specific language of school science, can one be sure of the above statement in an Irish context?

Within the science classroom, an exploration of the language used can have two distinct focal points. First, are the pedagogical exchanges, which are an inherent part of teaching and learning at second level schooling, and includes the dialogue between teacher and students within the classroom. However, there is also a focus on the science
itself, and how language is used in the teaching, and learning of, science. In looking at both exchange and content, it is hoped such research will prompt future work in other Irish classrooms.

One point argued in this thesis is the view that when analysing language, a linguistic framework is the most appropriate approach. The framework used in this research is based on a ‘functional’ view of language in use, and has been applied to science (and other school disciplines) as well as classroom discourse (both in and outside of science) over the past 40 years. Using a functional linguistic framework, and one whose grammar accounts explicitly for both exchange as well as content, allows for an explication of what happens in the classroom, from the perspective of the language used, at multiple levels.

These opening comments lead directly to the specific research foci of this thesis, which will be presented in the form of a set of questions this thesis will seek to address.

1.2 Research Questions of This Thesis

Having stated the rationale for this thesis, it is appropriate here to state explicitly the questions this thesis will seek to answer, and then elaborate on those questions as a guide through the thesis:

- How much, and what, is known about the language used to teach and learn science in secondary schools?;
- Are there identifiable language patterns used in secondary school science classrooms that could add to Irish students’ learning of science?;
- How would the use of a detailed linguistic theory illuminate such language patterns used in teaching science?;
- How might the use of such detailed theory be applied in practice in both curricular work and teacher practice?

Before continuing, allow for an elaboration of each question. The first question seeks to illustrate the key question underpinning this thesis: what is known about the language of teaching and learning science in Irish secondary schools? It may be important here to distinguish between what is known via research internationally (though limiting this
scope to the English-speaking world) and what is known via Irish research into the
topic. This topic will be explored and detailed in the third chapter of this thesis, a look
at the literature on the subject matter.

The second question probes a bit further, and more specifically, into what
happens within Irish secondary school science classrooms. The hope here is that,
through a detailed investigation into the language used by teacher and students within
an Irish classroom, any such language patterns that could be specific to science (as
detailed in the literature review) will be identified. This investigation requires a
framework of analysis to underpin such a search. In looking at language, it was decided
to use an approach that has been involved in educational theory and practice for some
decades.

The third question above inquires into the value of a detailed linguistic theory in
the illumination of patterns of language used by teacher and students in the science
classroom. The proposed framework for use in this thesis is Systemic Functional
Linguistics (hereafter, SFL) and its associated grammar (hereafter, SFG). This linguistic
theory accounts for language at the level of lexicogrammar (refuting the notion that
lexis [or words on their own] and grammar [commonly referred to as ‘syntax’] work
independently of each other), as well as at the larger discourse, or text, level.

In the former instance, the tri-stratal analysis of SFG allows for looking at
content (the Experiential or Ideational level); interlocutor relations (the Interpersonal
level); and linguistic structure (the Textual level). This lexicogrammatical analysis will
focus on individual words and groups within each identified clause, or single unit of
analysis at each of these specific levels, which will be elaborated in the chapter on
research design. In addition, this analysis will look at the broader linguistic level, that of
exchange, and explore how specific clauses work to construe meaning. This means
looking at *primary* and *secondary knowers*\(^1\) in the classroom, as well as the linguistic functions at the level of exchange. However, clauses also work together to establish cohesive flow towards the construing of meaning. One goal of the analyses of this thesis will be the identification of clear patterns of language in use at the level of the lexicogrammar, and in the exchange between teacher and students from beginning to end of class and from class to class.

Such a goal will have as its purpose the improvement of classroom discourse towards enhanced learning of science in future. The fourth research question looks at linking this detailed linguistic research into the policy and practice of teaching in the classroom. The research, as such, will be orientated to practicing teachers and curriculum developers with the goal of improving practice. While this means using the language of Systemic Functional theory in the analysis, it is not expected that teachers and curriculum developers necessarily be Systemic linguists. The analysis and discussion chapters will be written in a way that seeks to make such theory, and specific academic language, accessible to such policy-makers and practitioners.

These four questions will be returned to throughout the thesis, specifically in order to focus the thesis content on a hoped-for practice-orientated goal: improving the teaching and learning of science in Irish secondary schools.

At this stage, it is perhaps salient to suggest a look at how the remainder of the thesis will be structured chapter-by-chapter. Such a structuring should help guide the reader into, through, and beyond the thesis as a whole.

### 1.3 Structure of Thesis

The second chapter will look at science as it is taught in Irish post-primary, or secondary, schools at Junior Cycle. Junior Cycle refers to the first three years of

\(^{1}\) Linguistic terminology will be defined at appropriate points in the design methodology and the illustrative exemplar chapters.
secondary schooling, terminating in an exam referred to as the Junior Certificate. The chapter traces the development of science through to its contemporary incarnation and does so to orientate the reader to what is being examined in later chapters. The focus in this chapter will be to explore the context of school science in Ireland’s Junior Cycle, and what commentary there has been from within Irish academic research.

Chapter three will be a review of the existing literatures in the areas of classroom discourse, as well the language of school science. The reason to refer to such a review of the ‘literatures’ is that there are multiple ways of seeing both phenomena. The language of school science and the language of classroom discourse can be (and have been) researched from within both educational/pedagogical perspectives, as well as linguistic frameworks. It is important to note that the use of varying perspectives will see the same phenomenon in different ways depending on the lens used. It is hoped that by looking across disciplines, and valuing contributions from each, will allow for consideration to be made into why any analysis of language must take linguistics (the discipline of the study of language) into account. This comment does not intend to suggest that the linguistic framework used in this thesis must be used in all language education research. It is meant to agree with one linguist who, stressing the importance of grammar in understanding how language works, comments that:

A discourse analysis that is not based on grammar is not an analysis at all, but simply a running commentary on a text: either it has to be made to some set of non-linguistic conventions, or to some linguistic features that are trivial enough to be accessible without a grammar, like the number of words per sentence (and even the objectivity of these is often illusory); or else the exercise remains a private one in which one explanation is as good or as bad as another. (Halliday, 1994, xvi-xvii)

This review chapter explores the relevant academic literatures and highlights the use of grammar in explicating the language of school science and the language of the classroom. Of particular importance here will be the contrast in the level of analysis.
provided by Systemic Functional theory with other approaches, and how this specific linguistic theory sheds light on features of language that others tend to limit. It is hoped that this contrast will establish the validity of SF theory in the context of the wider thesis and the goal of improved pedagogy in the science classroom.

This review will be in the form of a critical synthesis of a wide range of literatures bringing in three discrete domains of research: 1) classroom discourse; 2) language of school science; and 3) the language of the secondary science classroom. The first literature focuses on exchanges between teacher and students in classrooms. The second looks at a specific range of features of science in the classroom, from views that tend to conflate spoken and written language, to those that contrast different forms of communicating science. The third looks at detailed research, from varying theoretical frameworks, to explore science content and exchange in the classroom. The combination of these three literatures should help to highlight specific features of the language of school science that have been identified, and how such research is relevant to pedagogy today. At the same time, the four research questions, posed and detailed above, should begin to be answered.

The fourth chapter looks at the design of the research and seeks to justify the motives, approaches, analyses, and interpretations which follow. The chapter looks at why the specific classroom, teacher, and students were selected for analysis. It looks at how data was collected in the classrooms, problems encountered and resolved in that data collection as well as how the data was transcribed the way it was. Also presented here is the software packages used for transcription, and the subsequent analyses of those transcripts. Finally, there will be a brief description of the linguistic framework used in the analysis and interpretation of the data collected. The reason for this description is to prepare the reader for the subsequent chapter.
Chapter five precedes the linguistic analysis which forms the main parts of this thesis by offering an introduction to the analysis at various levels. It will begin by looking at one clause, the opening piece of the first class session, and will provide the reader with details of the approach used in the thesis analysis: the software and presentation of that software analysing the data; the levels of linguistic analysis which will follow in succeeding chapters; and ways into understanding language in use from the Systemic Functional perspective. Featured herein will be snapshots of computer screens for each level of the analysis so the reader can begin working with the complete analysis (the entire compilation of analyses is contained in full in the appendices, along with significant sections drawn from the analysis chapters).

Chapters six, seven, eight, and nine will be sampled analyses of the classroom transcripts using the SFL perspective and SFG at multiple levels. Chapter six will look at the language of the science classroom at the level of the exchange of science—the focus in this chapter will be to analyse the interactions between teacher and students via language in the two class sessions. This will be done from within a Systemic Functional framework, drawn from work derived from Sinclair and Coulthard (1975), but seeking to apply and extend later work by Berry (1981, 1987) and Martin (1992). Here, the exchange will be orientated to teacher as Primary Knower, and student(s) as Secondary Knower(s), as well as segments of 'knowledge' that are being exchanged.

Chapter seven will shift the focus to a clausal analysis of the lexicogrammar and explore the Interpersonal level of meaning. This will entail looking at the grammatical resources of Questions (WH- and Y/N Interrogatives) as well as Subject/Complement usage by teacher and students in the teaching and learning of science. In some ways, this chapter will complement the previous chapter on exchange, but look in specific detail at the linguistic features that underpin, or 'realise', the Exchange moves in the classroom.
Chapter eight will continue this clausal focus, and look at Ideational meaning in order to begin looking at the some of the specific features of the language of school science. The key focal areas here will be the Process types used by teacher and students and the use of Circumstances (specifically those of Means and Quality) to extend meaning in the science class. In addition, a brief foray into the technical nature of school science will be done by comparing the relative use of technical and non-technical science terms in the classroom.

Chapter nine will move to the Textual level for its analysis and look at the relations between clauses. This will include sample excerpts between teacher and students as well as a longer monologue (mostly) from the teacher. The grammatical terminology here will be Theme (starting point for a clause which gives clauses focus), Rheme, and an exploration of Thematic Progression in the classroom discourse.

Contained within each of these analysis chapters will be sections exploring how the use of each specific level of detail contributes to a nuanced view of the language used by teacher and students in relation to science, and how that view can contribute to shifting a pedagogical focus to a more meaningful and dialogical exchange in the teaching and learning of science.

Chapter ten, the penultimate chapter, will seek to consolidate the entire thesis by highlighting findings from the analysis chapters, and discuss these in line with the literatures reviewed in chapter three. It hoped that there would be convergence as well as divergence in this discussion. The goal of this discussion is to move to a form of pedagogy where teachers have a better (or more detailed) understanding of the language of science (and point to future research in other subject content areas). This goal would be realised when the language of science is made available to all students to use both within the science content classroom, and within other future learning contexts.
The final chapter will be the conclusion of this thesis. It will review the entire thesis from science in Irish post-primary/secondary schooling, to the literatures of the language of science and school science. It will briefly re-state the work in chapters six to nine, and finish with comments on the value of the use of a linguistic lens in classroom discourse. This is particularly relevant in an Irish context, as so little has been done in this regard in relation to the English of the classroom. This conclusion will seek to be inclusive, and suggest that all research should be pushed beyond where it, itself, concludes: including this one. Perhaps an appropriate way for research to end by extending itself is in suggesting questions of the research itself as it is situated in the academic and wider world.

In this light, this conclusion will end with questions for consideration rather than with definitive answers. This will hopefully contribute to shifting educational research, more generally, into a direction of query, and re-query.
Each discipline (as a field) is defined by a particular *nomos*, a principle of vision and division, a principle of construction of objective reality irreducible to that of another discipline—in accordance with Saussure’s formula, ‘the point of view creates the object’ (the arbitrariness of the ‘disciplinary eye’ as a constitutive principle is seen in the fact that it is most often expressed in the form of tautologies, with, for example, in sociology, ‘explaining the social by the social’, in other words explaining social things sociologically). (Bourdieu, 2001/2004, 51)

2 Science At Junior Cycle in Irish Education

2.1 Introduction

The introductory chapter begins with several points of view in relation to science in contemporary Irish schooling. Taking those comments and linking them in with Bourdieu’s note above on academic disciplines, this chapter will seek to introduce the discipline being researched in this thesis. In some ways, this means exploring the ‘vision’ of the various curricula that have been part of Irish junior cycle teaching and learning, as well as explicating the ‘division’ which comprises the curricula and syllabi.

In fact, the Junior Certificate Science Curriculum has been reviewed by the National Council for Curriculum and Assessment (NCCA; the statutory agency established to determine curricula and assessment in the context of a national curriculum in Ireland). That body has undertaken a review, ‘...to address the concerns raised, to reflect best practice internationally and to support the provision of a science education for the 21st century.’ (NCCA, 2002, n.p.) Part of the rationale for the review was that, ‘science education in the post-primary junior cycle is concerned with the development of scientific literacy and the associated science process skills...’ (NCCA, 2002, 4) This is very much the NCCA’s ‘vision’ of science at junior cycle. The division,
of course, refers to the specific subject content of science that has been, and is currently presented to students as a lead-in to the Junior Certificate examination.

This chapter looks at the science taken by students in the immediate second-level context, referred to as the Junior Certificate (JC) Examination, or, more simply, the Junior Cycle. This chapter will also look at its immediate predecessor, the Intermediate Certificate, and a more practically-based alternative, the Integrated Science Curriculum Innovation Project (ISCIP); as well as the final draft of the recently revised JC Science Curriculum (which was introduced into second-level schools in the school year beginning Autumn 2004 in the middle period of this thesis being written).

The purpose of this chapter is to introduce the subject content area, which will allow the reader to understand better the context of contents of the next chapter, which looks at the language of science in the classroom, and begins an exploration of the classroom discourse of science. As well, this second chapter will also show how, or if, the issue of the language of science has been seen within the Irish JC Science Curriculum and Syllabus.

In relation to the research questions posed in the opening chapter, this chapter allows for a smooth entry into the questions by providing the context of the Junior Certificate classroom at the present time. As the previous paragraph states, this journey through the evolution of school science in Ireland will look at what, if any, role a study of the language of the science classroom has had on how the Junior Certificate Science curriculum changed over time.

2.2 Brief History of Junior Cycle Science in Ireland

Science has offered perhaps the most significant challenges to Irish, and international, education over the past century. Over that time, key scientific developments that have trickled down into public use include: flight (conflating both distance and time); popular media (including first, the radio; later, television and film;
and more recently, home video equipment); and communications (earlier the telephone; later, personal computer technology and the internet, and most recently, the mobile telephone). Each of these technologies was derived from scientific explorations and moved more and more into the public domain. Each has led to a world where many students are more advanced in the latest technology (and perhaps the science underpinning that technology) than educators in primary and secondary schools.

To contextualise the Irish second-level science classroom today, a brief history of science within Irish post-primary education will be given. Junior Certificate examinations at post-primary/secondary levels of education have only been assessed since 1992, so it is perhaps useful to proffer an overview of second-level schooling in Ireland, as well as the predecessor of the current curriculum/syllabus, the Intermediate Certificate.

Hyland writes that, 'State involvement in secondary education...dates back to 1878,' (Hyland, 1980, 31) with the passing of the Intermediate Education (Ireland) Act. This continued, with a focus on learning classics (i.e., in addition to English, Greek, Latin, etc.), giving secondary schools, 'a 'grammar school' or academic-type bias...which persisted until 1924 and which influenced the development of secondary education in the Free State until the 1960s.' (Hyland, 1988, 32) According to Hyland, 'The examination syllabi for these examinations...largely determined the curriculum of secondary schools and we have inherited this tradition of an exam-dominated curriculum.' (Hyland, 1988, 31)

Upon the creation of the Irish Free State, the Leaving Certificate (terminal examination for second-level schools) and the Intermediate Certificate (mid-term examination for second-level schools) were established. 'To obtain a pass in the Intermediate Certificate examination, a pupil had to pass five subjects which had to include the following: (1) Irish or English; (2) a language other than that taken at (1);
Mathematics or (for girls only) arithmetic with any one of science, domestic science or music; history and geography. From 1929 onwards pupils also had to pass Irish in order to pass the Intermediate Certificate. (Hyland, 1988, 32-33)

The Vocational Education Act (1930) established 'continuation education' which was intended, 'to continue and supplement education provided in elementary schools and to include general and practical training in preparation for employment in trades, etc.' (Hyland, 1988, 33). This was the schooling system in place into the mid-1940s, with the introduction of the Group Certificate, in 1947, which was, '...to be taken by pupils in Vocational Schools at the end of a two-year continuation course.' (Hyland, 1988, 34)

It is apposite to note that there was a very strong distinction made between secondary schools and Vocational or post-primary, schools. 'Until the late sixties, vocational school pupils followed a two-year course leading to the Day Group Certificate examination and secondary school pupils followed either a three or four year course leading to the Intermediate Certificate examination.' (Hyland, 1997, ix) Breathnach writes that, '...a dual system was established. Secondary schools were heavily academic; vocational schools emphasised practical studies.' (Breathnach, 1993, 1)

Over this time period there was on-going discussion and debate on education in Ireland. The Council of Education was established in 1950, reporting in 1960 that, '...the junior cycle curriculum should be planned as a unit in itself, since it completes the general education of a considerable number of those who attend secondary level education.' (Hyland, 1988, 34-35) This was followed by a key document, Investment in Education, which was published by the Government in 1966. Of this report, Hyland notes that, 'In a country which in the 1960s believed that investment in education was investment in the future of the country... [this report] found many shortcomings in the
curriculum at all levels.... In boys’ secondary schools, a considerable amount of time was devoted to Classics, with 95% of boys taking Latin for the Intermediate Certificate.’ (Hyland, 1988, 35) As the focus of this thesis is science at second-level schooling, perhaps it is relevant to highlight the relative absence of science from the curriculum/syllabus at this stage—something that changes in future Irish schooling.

A brief overview of science at that time can be seen by looking at an essay by Reidy published in 1985 titled, ‘Post-Primary Science: Education: Evolution or Degeneration’. (Reidy, 1985) This essay traces the history of science since the foundation of the Irish State in 1922. Reidy cites the Council of Education report in 1962, Report of Council of Education, which reported that:

The curriculum at present prescribed by the Department of Education for recognised secondary school is still on the lines of that adopted in 1924. (Reidy, 1985, 140)

Reidy describes school science in Ireland at that time as offering courses and assessment which, ‘…fell into three categories: (1) a preparatory course; (2) Intermediate Certificate; (3) Leaving Certificate.’ (Reidy, 140) Reidy details the Intermediate Certificate (which was predecessor to the Junior Certificate) as being further divided into four courses. These were listed as, ‘… (1) syllabus A; (2) syllabus B; (3) syllabus C (girls only); (4) syllabus D (non-experimental).’ (Reidy, 1985, 140)

Following the above-cited Council of Education Report, Reidy reports that:

...new science syllabi were introduced in 1966. While the recommendation of the council with regard to a single syllabus was not accepted the range of courses was cut to two, i.e. syllabus A which contained elements of physics, chemistry and biology and syllabus B which had a wider content covering areas of physics, chemistry and other material of a biological/geographical nature. These courses were in operation up to 1973 when syllabus A was revised to include more biology and syllabus B was replaced by syllabus E which became an elementary course in junior science. (Cited in Reidy, 1985, 142)

From this point, in 1973, what followed was the implementation of the Intermediate Certificate Science Syllabi, which will be detailed in the next section.
However, before embarking on that venture, it is worth quoting again from Reidy in 1985. In looking at the issue of costing education, which is a political issue at its core, Reidy wrote that, ‘The real test of the state’s commitment to science education will come when the finance to provide science for all junior pupils is requested.’(143) This is an issue to be explored when looking at the introduction of the Junior Certificate some years later, and the more recent evaluation and re-drawing of the Science Syllabus.

Between the Intermediate and the Junior Certificate science efforts, it is worth looking at one endeavour at opening up the scope for those who study and seek to understand science. This effort, known as the Integrated Science Curriculum Innovation Project (ISCIP), was devised by the City of Dublin Vocational Education Committee (CDVEC) Curriculum Development Unit (CDU). The CDU was established in 1972, ‘...to develop new teaching and learning programmes...intended for 12-15 year-old students...’ (Curriculum Development Unit, 1981, 5) ISCIP was drawn from Syllabus A, and will be seen as a link between the Intermediate and Junior Certificates, and, indeed, the new Junior Syllabus.

Arguably, the next significant movement in Irish secondary education was the establishment of an advisory agency in the mid-1980s. At that time, the Minister of Education, Gemma Hussey, established the Curriculum and Examinations Board (CEB), with one task being the adoption of, ‘...a suitable programme for all students, with a unified system for assessment and certification.’ (Breathnach, 1993, 2) The CEB published two consultation and discussion documents relating to the place and role of science in the secondary curriculum. These were:


These documents set the tone for science within the Junior Certificate, which evolved from the year 1986. The Junior Certificate was officially announced by then Minister for Education, Mary O’Rourke, in 1989, and pupils/students began sitting examinations in 1992. Details of science as defined and practiced in this curriculum will be detailed below.

More recently, the NCCA review of science within the Junior Cycle has led to a Revised Science Syllabus. This revision refocuses on a more practical approach and is, at the time of writing, still to be introduced in schools in a broad scale. The details of this revision, and differences between it and the original Junior Certificate will follow later in this chapter.

This brief history is presented simply to provide a broad historical background. In the following sections, overviews of science in the Intermediate Certificate; the Integrated Science Curriculum Innovation Project; the initial Junior Certificate Curriculum; and the newly revised, more practically based, Junior Certificate Curriculum will be detailed. The chapter will conclude with a comparison of science as it was and is now taught to junior secondary students in Irish schools. Care will be taken to look at each effort in search of that which is similar, as well as that which are different, and to distinguish between the practical and theoretical orientations of the various curricular efforts.

2.3 Descriptions of Science in Intermediate to Junior Cert, with ISCIP between them, and the introduction to revised JC syllabus.

This section will offer a limited description of, and a short critique of, the content covered in the four aspects of secondary school science education in Ireland: Intermediate Certificate; ISCIP; Junior Certificate, and the more recently released revised Junior Certificate. The details for each of the curricular content and syllabus efforts will not be presented for two reasons. First, this thesis is not concerned with
science as much as with the language of school science; second, the data for this thesis is not the entire current curriculum/syllabus, but a section of the curriculum/syllabus covered at a given point in time to second-year students—one that was contained in each version of the syllabus. In addition, details of each of the four syllabi can be found in the reference materials cited within the text.

2.3.1 Intermediate Certificate Science

The Intermediate Certificate was the precursor to the current Junior Certificate and served the same age group (assessment at age 15-16). What was known colloquially as the ‘Inter-Cert’ was intended, ‘...to provide a well-balanced, general education suitable for pupils who leave full-time education at about 16 years of age or, alternatively, who wish to enter on more advanced courses of study.’ (12) The further course of study, of course, was the Leaving Certificate. In the 1987-88 document, the aims and purposes of the Leaving Certificate were described as, ‘...to prepare pupils for immediate entry into open society or for proceeding to further education.’ (15) The intended matriculation through the Irish school system can be seen in these two quotations.

As stated in the brief history earlier in this chapter, science in the Intermediate Certificate was broken into two syllabi: Syllabus A and Syllabus E. Syllabus A included modules in (1) Physics, (2) Chemistry and (3) Biology. These modules, and the modes of assessment, are detailed within the Rules and Programmes (126-130). There is no explicit goal or aim of Syllabus A, other than that stated in the previous paragraph in relation to the entire Intermediate Certificate. The brevity of the scope of details of the content was commented upon by Palmer as being, ‘...merely a list of science

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2 All references to the Intermediate Certificate are drawn from Rules and Programme of Secondary Schools, 1987-1988 (Dublin: Stationery Office). These documents were syllabus documentation for all post-primary/secondary schools until quite recently. While Rules and Programme is still published, NCCA documentation in all Junior Certificate and Leaving Certificate courses more completely describe all subject content areas.
knowledge that is examined at the Intermediate Certificate examination.’ (Palmer, 1990, 159)

Science Syllabus E was quite different. The preface to Syllabus E in the *Rules and Programmes* states that this syllabus was, ‘...intended as a coherent and integrated course in elementary science.’ (130) This course had three explicit aims, detailed as being:

1. to give pupils some understanding of man, of the environment, and of man’s place in the biosphere,
2. to provide pupils with copious opportunity for first-hand experience and appreciation of the methods of science—systematic, objective and quantitative observation; experimentation in accordance with age and ability; development of logical processes of thought, reasoning and communication,
3. to serve the pupils’ needs as citizens and, further, to serve as a foundation for further studies in scientific subjects at more advanced levels. (130)

Following these aims, the documentation then presents much more detail than in Syllabus A, and covers 16 pages (131-146). The preface to the details says that, ‘The relevance of this subject to the pupils’ interests and needs in everyday life will depend in large measure of the ingenuity and attractiveness of methods used in presenting it.’ (p. 130). Stress is given here to a ‘...coherent and integrated course.’ (130)

Throughout the description of Syllabus E are terms such as, ‘Simple studies in relation to...’ (131); ‘Introduction to...’ (132); and ‘Common terms:’ (132); ‘...elementary treatment’ (133). These suggest a rather limited syllabus in relation to content, and a question that begs to be asked is: for whom was Syllabus E intended?

Reidy, in an essay critiquing the split Syllabus, suggested that Syllabus E, as an effort at a ‘coherent and integrated course,’ was a failure. He writes that, in 1990, 90% of students sat the exam for Syllabus A. (Reidy, 1985, 144) Reidy proffers three reasons for the limited uptake, including:
(1) ...as it is an integrated approach there is a fear that it could not give a proper foundation' for students continuing further science study;
(2) ...the experimental approach involved would be too difficult to implement when science facilities in schools were taken into account' (referring to the fact that schools needed to have, ‘a well-equipped laboratory but also a well-stocked garden, an animal house and a pond’, see Rules and Programmes' description of Syllabus E), and
(3) ...this course demands a teaching process which is alien to the majority of science teachers who have come through a classical physics, chemistry, and biology training....[this integrated approach would require]...the provision of in-service courses for teachers. Without this, there will be little or no change in the process of science education at junior level. (Reidy, 1985, 146)

As can be drawn from this quotation, the factors were 1) limited content; 2) additional, not in place, school laboratory resources; and 3) burden on the teacher. Two of these issues could have been presaged from the Rules and Programmes. The first could have been seen from the selected text taken from the description of Syllabus E given above. The third, from the section in the Rules and Programmes which states, ‘...the teacher must use his own initiative, insights and resourcefulness...[and he] must plan his programme...so that pupils will, at least, become acquainted with all sections of the course with a view to producing as coherent a framework as possible.’ (134. Italics added.) The second reason above, the issue of school laboratory resources, will be explored later, in relation to the most recent revision of the Junior Certificate Science curriculum. One might infer from Reid's points above that Syllabus E was a search for coherence at the expense of content.

The detailed emphasis in the Rules and Programmes of Syllabus E on 'cohesion and integration' and the limited uptake of the programme delineated by Reidy did lead to another effort, however. This effort, created by the Curriculum Development Unit (CDU) of the City of Dublin VEC, and labelled the Integrated Science Curriculum Innovation Project (ISCIP) will be examined next. It will be stressed here that ISCIP was an attempt at 'integration and cohesion' within Syllabus A—the full science curriculum, and not a separate curriculum or syllabus, but with a somewhat different form of assessment.
2.3.2 ISCIP

The Integrated Science Curriculum Innovation Project (ISCIP) was put forward by the CDVEC Curriculum Development Unit (CDU), and seemed to be a sincere attempt at converting the intent of Syllabus E of being 'coherent and integrated' to the wider and broader Syllabus A.

The CDU, ‘...was established in 1972 to develop new teaching and learning programmes. These programmes were intended for 12-15 year old students, and, as such, formed a natural link with the primary school curriculum. The early work of the Unit concentrated on the areas of science, humanities (English, History, Geography, and Civics), and outdoor activities.’ (CDU, 1981, 5). The work of the CDU highlighted progressive approaches to practitioner-based educational research, and sought a more inclusive and student-centred second-level syllabus effort. The Resource Manual for ISCIP asserts that (at the time) recent research in science education sought, ‘...reforms...:

...that the teaching of science should reflect the essential nature of science. This means that the emphasis is on enquiry and experimentation, on understanding and constructive thinking, rather than on the accumulation of facts to meet examination requirements. In order to meet this and other new much needed objectives, modern approaches to curriculum development have been adopted to produce a practical student-centred activity-based programme. (CDU, 1981, 6)

This is very much in line with the details provided above on Syllabus E. However, ISCIP was intended to provide materials for teachers working with students on Syllabus A, not Syllabus E, and provided details for doing so. Taking the burden away from teachers (as suggested in the description of Syllabus E above) was a means of both including more students into science at an applied level, and ensuring a ‘coherent and integrated’ science curriculum and syllabus.
ISCIP was a three-year science programme leading to Intermediate or Group Certificate Examination standard. It was designed:

1) ...to teach science with the emphasis on enquiry and experimentation, on understanding and constructive thinking. In using the materials the students will encounter new problems which often require new ideas and new techniques to reach new solutions,

2) ...to present Physics, Biology and Chemistry in a natural integrated fashion, showing the unity of approach, and thus continuing the philosophy and methodology of the primary school curriculum into the junior cycle of the post-primary school,

3) ...to create among students an awareness of the aspects of science which play an important part of their everyday life and world. (CDU, 1981, 6)

The documentation from the CDU for ISCIP, having been provided for both teachers and students, was based on the three strands of Syllabus A (Physics, Chemistry and Biology), and meant a complete working package in junior secondary science for all students in all schools. This was described as being, ‘...a laboratory and field based discovery approach to integrated Science in the junior-cycle...’, and of having an aim of placing emphasis on, ‘...enquiry and experimentation, on understanding and constructive thinking.’ (Rosney, quoted in Ó Maoldomhnaigh and Ó Bealáin, 1988, 124)

Basically, teachers would teach students according to Syllabus A as detailed in the Rule and Programmes, but ISCIP, ‘...was divided into ten areas of study. The basic concepts relate to the entire course and are not totally distinct, rather they interact with each other in the basic understanding of science.’ (CDU, 1981, 11). This was done in the form of ‘units’ which were grouped, ‘...interlinked with each other to form an integrated practical activity based programme.’(CDU, 1981, 11)

What was unusual about ISCIP in relation to Syllabus A was this effort at ‘cohesion and integration’—two elements missing from the latter. There was a possible danger in this effort, however.
Writing about the ISCIP Programme, Reidy notes that it was, ‘...really trying to impose an integrated framework on a programme which was never intended to be such and therefore can have only limited success in its efforts.’ (Reidy, 1985, 145) Reidy believed that such a programme, properly and completely implemented, would be, ‘...the most effective method of promoting the uptake of physics at senior level.’ (Reidy, 1985, 149)

For assessment, while ISClP was an alternative articulation of Syllabus A, assessment was not limited to a written terminal examination. Ó Maoldomhnaigh and Ó Bealáin note that, ‘...[ISCIP] is examined separately in recognition of its integrated nature and its [sic.] discovery approach. It’s [sic.] written examination consists of short answer and closed item questions and in addition to the formal written examining, 25 per cent of the total marks attainable by a candidate are offered via teacher assessment.’ (Ó Maoldomhnaigh and Ó Bealáin, 1988, 124) However, it should be added here that, in 1988, ‘this course [was] followed in only about 30 schools...as it is still classified by the Department of Education as a pilot program’. (Ó Maoldomhnaigh and Ó Bealáin, 1988, 124)

ISCIP can be seen as a laudable effort at promoting a different emphasis in junior secondary science education. A like effort in integration could be seen in later years in the form of the Junior Certificate Schools Programme (JCSP) which sought to motivate students otherwise labelled as being ‘at-risk’ of early school leaving.

As ISCIP worked within the context of the Intermediate Certificate Syllabus, it is now time to move ahead and examine the next iteration of the junior cycle: Junior Certificate, which was introduced in 1989, and first assessed in 1992.

2.3.3 Junior Certificate Science

As stated in the first section of this chapter, there was significant movement within Irish education beginning in the mid-1980s. The first shifts came from the
establishment of the Curriculum and Examinations Board (CED) and the publication of several documents looking at then current Irish educational curriculum and syllabi. The key documents, titled, *Issues and Structures in Education: A Consultative Document*, in relation to general education; and *Science, Technology and the Post-Primary Curriculum: A CEB Discussion Paper*. These were published in 1984 and 1987, respectively.

The former document included a section on, ‘Science & the New Technologies’, which stated that the Board, ‘...recognises the significance of the basic sciences and the new technologies in the lives of all our people today, and the central role they have to play in the economic and social development of the country. The Board would wish to have these views reflected in the school experience of young people at first and second levels. It intends to formulate a detailed policy on this matter.’ (CEB, 1984, 10-11) As it would turn out, the policy to be formulated was the Junior Certificate.

Furthermore, the Board explicitly stated the goals of any new policy on science education. In an extended extract, the discussion document stresses the:

- Understanding of basic scientific concepts; development of the scientific method; the application of science to technological developments; understanding and application of Technology; ecology and use of natural resources; basic knowledge and skills needed for home management (including design & use of materials); health education (including sex education). (CEB, 1984, 20)

As can be seen from this extract, issues relating science to technology, issues of ecology and issues of health and sex education are included in a way they were not in the earlier science curriculum and syllabus. This document began the move to an evolving dialogue within Irish educational circles that was followed in 1987 with a document looking directly at science education.

This latter document stressed that science education, ‘...depends on an understanding of the nature of science, its application, its power and its limitations, (CEB, 1987, 13) and that, ‘Application is an intrinsic part of science and the
combination of theory and practice lies at the heart of all scientific activity.’ (CEB, 1987, 13) Before looking directly at the Junior Certificate Science Curriculum and Syllabus, the notion of applying science, stated so explicitly above, is something to be taken into consideration.

One other important aspect of the 1987 document was the issue of language. While this will be explored later in this chapter, the CEB document did stress that, ‘Essential reliance on textbooks should be discouraged,’ and that, ‘The vocabulary of science should be introduced at an early stage.’ (CEB, 1987, 13) Again, the issue of language should be kept in the reader’s mind as the Junior Certificate evolves.

The Junior Certificate as a whole was introduced initially in 1989, with initial testing to commence in 1992. The Junior Certificate, in stated aims and objectives, claims that, ‘The general aim of education is to contribute towards the development of all aspects of the individual, including aesthetic, creative, critical, cultural, emotional, intellectual, moral, physical, political, social and spiritual development, for personal and family life, for working life, for living in the community and for leisure.’ (Department of Education and Science (DES), 2000, inside front cover) The Science elements of the Junior Certificate were drawn up, ‘...to cater for the entire range of student ability, aptitude, and achievement. It replaces the former courses presented as Science (Syllabus A), Science (Syllabus E) and Rural Science within the former Intermediate and Day Vocational Certificate programmes’. (DES, 2000, 1)

It is also stated that, ‘The course has been designed as a practical course, with an emphasis on student experience of science as a practical activity. There should be an emphasis on the thought process of science as well as the everyday applications of science in the student’s life and environment: these are the points of transference from

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3 It should be noted here that NCCA documents are frequently re-published in unchanged form. Hence a reference for 1989/1992 drawn from a publication from 2000.
school-based learning to general experience.’ (DES, 2000, 1) How that ‘practical course’ will work out in practice will be explored later.

Early in the Syllabus document is the link between science and technology (DES, 2000, 1) as is an interesting development that is referred to as the ‘core’ of the course, which is labelled as a ‘key feature’:

A key feature of this course is the concept of the core—the knowledge, skills, concepts, and attitudes in Science deemed essential for all school leavers. The core is an integrated section and is presented as such. For clarity of presentation, the relevant sections of the core are presented once again along with the corresponding extension material required for Ordinary and Higher Levels. (DES, 2000, 1)

It should be remembered from the discussion in the earlier section that Syllabus E of the Intermediate Certificate was also intended as an ‘integrated’ course.

The accompanying document, The Junior Certificate: Science Guidelines for Teachers, states that, ‘...while the essential features of the former syllabi have been retained there have been some changes in the nature of the syllabus’. (DES, 1995, 1) One shift from Intermediate to Junior Certificate Science was the introduction of ‘core’ and ‘extensions’ in the latter.

In the section above on the Intermediate Certificate, it says that Physics, Chemistry, and Biology would be covered. These specific areas are detailed in the Rules and Programmes document, with no reference to ‘core’ of knowledge that must be placed before learning specific content. The Junior Certificate introduces this concept, and defines it as being, ‘...the scientific knowledge, skills, concepts and attitudes essential for all school leavers in today’s world. This is an essential component of the course...All students...will be required to study the entire range of material presented as the core.’ (DES, 2000, 6) This core had five elements:

Introduction to Science,
The Human Body,
The Non-Living Environment,
This core, which is meant to underpin all other science learning in the Junior Certificate, allows for much greater scope and extension of the more detailed subject areas. It would appear little content difference between science in the Junior Certificate and science in the earlier Intermediate Certificate (other than specific progression within science and technology such as microelectronics and nuclear energy). But the Junior Certificate’s use of a ‘core’ provides a degree of integration that is missing in the earlier Syllabus A, and only hoped for in Syllabus E.

The extensions, of which there are five, are: Physics, Chemistry, Biology (identical to the earlier syllabus), Applied Science, and Local Studies. In the earlier syllabus, there was a Local Studies component (not documented above) which was part of the Day Vocational (Group) Certificate under the label of ‘Rural Science’. The descriptions of the extensions in the Junior Certificate include those areas of the ‘core’ (described above), suggesting a more integrated nature of the syllabus.

One change in the Junior Certificate was the introduction of levels of assessment. There would be two levels: Ordinary Level and Higher Level. These would be distinguished in the following manner:

At Ordinary Level, students will select any three of the extensions.
At Higher Level, students will take the Physics, Chemistry and Biology extensions and will select either the Applied Science or the Local Studies extension. (DES, 2000, 7)

It should be noted here that the earlier CEB document stated that, ‘Application is an intrinsic part of science and the combination of theory and practice lies at the heart of all scientific activity.’ (CEB, 1987, 13) How one can reconcile the intent of the CEB with the realization of the Junior Certificate Science syllabus is hard to imagine, other than the suggestion that students were being placed on two tiers.
Two areas of concern, stated at the time the Junior Certificate was introduced, were assessment and implementation.

In the Syllabus documentation, the assessment objectives are given as, ‘...to allow a student the opportunity to:...’ (DES, 2000, 8) and is then followed by a list of objectives each of which ‘demonstrate...knowledge of..., awareness of...[or] ability to...’ (DES, 2000, 8) do certain tasks. At the end of this list it is noted, however, that, ‘There will be a variety of modes of assessment, depending on the options taken. It may not be possible to assess all the above [stated] objectives within each mode of assessment’. (DES, 2000, 8)

Writing about assessment within the Junior Certificate syllabus, and concerned with practical aspects of science education, Reidy wrote in 1990 that, ‘...if practical process skills are not assessed then the science program in schools will continue to be didactic and non-experimental and it would be more honest to re-write the course objectives to reflect this.’ (Reidy, 1990, 11) His recommendation at the time was to, ‘Introduce practical assessment or re-write the assessment objectives.’ (Reidy, 1990, 11). In addition, Palmer, at the introduction of the Junior Certificate, writing in relation to science, wrote that one concern is, ‘...the 25% continuous assessment marks in ISCIP. How will these be used in junior science or are they to be lost?’ (Palmer, 1990, 162).

In addition, Godwin, writing in 1989, reports that within the new (at the time, forthcoming) science curriculum, ‘Teachers are given freedom and responsibility to choose the most suitable options, the emphasis is on the practical aspects of science teaching’ and, ‘the local area is used.’ (Godwin, 1989, 18. Bold in original.) She is referring not only to the practical aspects of science education, but to the responsibility on the teacher—is this the same critique that Reidy made in the previous description of Syllabus E of the Intermediate Certificate?
Finally, looking at just how much changed, and how much remained, in a teacher-orientated seminar on the introduction to the Junior Certificate in 1989, a section from the ‘Working Groups’ includes the statement that, ‘Certain features of existing Junior Cycle were seen as desirable and the retention in the new Junior Certificate framework was seen as important.’ Among these features were, ‘...the active, student-centered [sic.] methodologies and school based assessment modes associated with the...ISCIP programme.’ (Working Group, 1989, 30) Where ISCIP was focusing on the integration of the science curriculum, the Junior Certificate sought to extend not only towards integration but also to a more progressive pedagogy.

After over ten years of Junior Certificate Science having been taught in the classroom, and assessed as part of mid-term examinations, the NCCA established a review. This will be explored in the next section.

2.3.4 ‘Revised’ Junior Certificate Science

Responding to changes within wider society, in both Ireland and internationally, the NCCA began a review of Junior Certificate Science, which led to a Revised Syllabus. From NCCA documentation, ‘schools were given the option of taking up the revised syllabus when it was introduced in 2003. Approximately 90% of schools introduced the revised syllabus in the 2003/2004 school years.’ (NCCA, 2002a, n.p.) This revision, herein described, will allow comparison to be made between this latest restatement of science that young people should learn in school at second level and earlier versions of Junior Cycle Science.

Among the changes that emerged within Irish and international society since the introduction of the Junior Certificate in 1989, was a huge increase in the significance of scientific thinking demanded by a workforce. This can be seen in the contents of a document, *Science in Second Level Schools: Statement of the Irish Council for Science, Technology and Innovation (ICSTI)*, published in October 1999. This document stated
that, ‘As never before, science and technology are at the heart of issues in everyday life. The school system must reflect this changing environment by making changes to courses and processes at an appropriate level.’ (Irish Council for Science, Technology and Innovation, 1999, 3) One of the key recommendations contained in this report was, ‘School-based practical assessment should be implemented within three years.’ (Irish Council for Science, Technology and Innovation, 1999, 4) As it turned out, this is precisely what had been called for in previous educational documents (as detailed in this chapter); precisely what has been missing from the various incarnations of Irish junior cycle science documentation; and precisely what the revision of the Junior Certificate was to become.

In its consultation documentation, the NCCA commented on the then-existing Junior Certificate Science syllabus, noting that a number of concerns have been raised about it. Three concerns mentioned are:

- the length of the syllabus and the amount of material students are required to cover,
- the under-emphasis on the physical sciences, especially chemistry, in both the core and the extensions of the present syllabus,
- the absence of any assessment of practical work in science.’ (NCCA a., 2002, n.p.)

In continues that, ‘This revision was undertaken to address the concerns raised, to reflect best practice internationally and to support the provision of a science education for the 21st century.’ (NCCA a., 2002, n.p.)

In its own listing of similarities between the recommended new syllabus, and the previous syllabi, the NCCA lists: the revised syllabus giving equal weighting to the three major areas of science (i.e., biology, chemistry and physics); the syllabus being presented at Higher and Ordinary levels; and the fact that many topics familiar to teachers have been retained. (NCCA, 2002 a., n.p.) In listing differences, the document states the following:
• the revised syllabus is shorter than the existing science course,
• there is a new introductory section on the skills of the scientist,
• there is no applied science extension. Some aspects of the applied science extension are now contained within the three major topic areas,
• the learning outcomes associated with each topic are specific.
• many outcomes are of a practical or applied nature. (NCCA, 2002a, n.p.)

In an important move to alternative forms of assessment, it is stated that, ‘The most significant change is the new emphasis on scientific investigation and on the application of scientific skills in experiments and tests.’ (NCCA, 2002a, n.p. Bold in original). Two parts of this statement must be explicated.

First, it is important to define terms here. Investigation is defined as, ‘...an experience in which the student seeks information about a particular object, process, or event in a manner that is not pre-determined in either procedure or outcome’; while experiment is defined as when a, ‘...student follows a prescribed procedure to reproduce an expected outcome or to confirm an already known fact.’ (NCCA, 2002b, 6)

Second, in a move away from a terminal written exam (and harking back to ISCIP as detailed above), while there will still be two levels of assessment (Higher and Ordinary), ‘At each level, assessment will be by means of a terminal examination paper and coursework.’ (NCCA, 2002b, 42) The coursework element will include students’ keeping portfolios over the three junior cycle years, ‘...detailing six specific investigations...from the set of designated investigations.’ The investigations may vary from year to year, but this coursework will contribute to, ‘...15% of the total marks...’ students receive. (NCCA, 2002b, 42)

In a move towards ‘student-centredness’, each student, ‘...will have the option of undertaking an investigation of their own choice and submitting a portfolio of all aspects of that investigation.’ This element of assessment:

...will include an interview. 25% of the total marks will be allocated to this component. Students who opt for this assessment component
would not be required to answer the corresponding section on the examination paper. (NCCA, 2002 b., 42)

The above quotations are all taken from *Draft Syllabus for Consultation* flyer and printed document, both dated April 2002, published as part of the review by the NCCA.

There was some political wrangling over the implementation of this new Syllabus in the Spring and Summer of 2003. However, near the end of 2003, the teacher unions and government agreed that it would be phased into place in all schools, with resources being taken into consideration in all cases.

### 2.4 Synopsis of evolution of Junior Secondary Science Curriculum.

The above section looks in some detail at the various science curriculum and syllabi as they have evolved over the past 40 years. It looked at the various syllabi, the forms of assessment, and some idea of content, all drawn from official government publications. In addition, it offered some critique of the various efforts, drawn from both contemporaneous sources and later offerings.

Three ideas seem to run through this history of science in the Irish junior cycle. The first is the practical and integrated nature of science within schooling; the second, is the form of assessment; the third, and something that has been somewhat marginalised from public, political and academic discourse, is the language of science.

The antagonism between the practical and integrated natures of science and science education can be seen from the early CEB documentation. Earlier in this chapter, it is quoted that the CEB suggested that, 'Application is an intrinsic part of science and the combination of theory and practice lies at the heart of all scientific activity.' (CEB, 1987, 13) But the applied nature of science was not part of the Intermediate Certificate Syllabus A, which the majority of students sat, and the Junior
Certificate, as it was originally written, did not include significant applied aspects, while assessment was entirely re-written.

While the Intermediate Certificate was part of ISCIP, it should be remembered that only 30 schools in the country followed ISCIP to final assessment in 1988.

Likewise, for assessment, neither the Intermediate nor the Junior Certificate syllabi included forms of assessment beyond terminal written examinations. Again, while both ISCIP and the newly revised science syllabi have and do, it will only be seen in future if these develop in manner that suits the intent of the original CEB in a way that combines, 'theory and practice'.

In some ways, in light of both the applied use of science and assessment in science, perhaps Reidy was right in his conclusion in 1985 that, ‘...in some aspects there has been a degeneration in the quality of science education in our schools over the past 60 years.’ (Reidy, 1985, 154)

However, before completing this chapter, it is worth returning to the focal point of this thesis, language, and looking at how Irish educational practitioners, policymakers, and academics have looked at the language of school science.

2.5 Language in Irish Secondary Science Education?

Language in education, and specifically in the science curriculum, in Ireland was not of serious concern for much of its history. In general, it is perhaps salient to suggest that 'language' was seen within Ireland principally in relation to Gaeltge (the Irish language) and its establishment within the school system. However, as changes occurred in Irish education with the establishment, and later work, of the Curriculum and Examinations Board, this changed—though only slightly.

The first significant and documented mention of language within school science in Ireland is in the CEB discussion paper in 1987. The paper states quite clearly that, 'The vocabulary of science should be introduced at an early stage. A more specialty
vocabulary should be acquired gradually as the young person moves up through the stages of education. Care should always be taken to avoid alienating students through developing a false mystique.' (CEB, 1987, 13) Here the focus, quite clearly, is concerned with the specific vocabulary of science within education.

Further, the CEB wrote that, '...Essential reliance on textbooks should be discouraged.' (ibid.) An inference may be taken from these two quotations that the language of science textbooks at the time was responsible for the 'speciality text' and the alienation of students through the development of a 'false mystique' of science. However, there was little, if any, followup on these recommendations in the subsequent Junior Certificate Science documents.

While the documents spell out science in some detail, and hint at the communicative skills that students should achieve and be assessed on, there is virtually no explicit of features of the language of science mentioned in either the published Science Syllabus, or the accompanying, Science: Guidelines for Teachers. For instance, the inside front cover of the original Junior Certificate Syllabus states that, as part of the entire Junior Certificate cycle:

Particular attention must be given to reinforcing and developing the skills of numeracy, literacy and oracy...[and] should draw on the aesthetic and creative, the ethical, the linguistic, the mathematical, the physical, the scientific and technological, the social, environmental and political and the spiritual domains...[and that] Each Junior Certificate syllabus is presented for implementation within the general context outlined [here].' (DES, 2000, n.p.)

However, nowhere is the development of such skills as literacy illuminated, nor is language in relation to science (or other non-language subject content) in any way highlighted.

Among the specific aims of the Science Curriculum, one is listed as being, '...the practical, cognitive, affective and communication skills related to Science and
appropriate to their age.' (DES, 2000, 3) But, where else is communicating as one of the
set of, ‘...skills related to science’ explicitly stated? It is not.

In the Teaching Guidelines for science, it says that ‘...no matter what approach
is adopted the method of teaching must allow the student to learn through active
participation in both practical and experimental work...The ways of learning and of
being ‘scientific’ i.e., applying a scientific method are common to all science subjects or
disciplines, no matter what approach is adopted.’ (DES, 1995, 1) Note should be made
here that there is no direct reference to that which underpins every approach, both
practical and experimental: language.

In a continuation of this absence of language within school science, and relating
directly to science pedagogy within the Junior Certificate, is a section in the Teaching
Methods section of the Teacher Guidelines. While beginning the section with the
statement that, ‘There is no one or ideal way of teaching science,’ is the suggestion that
‘good teaching demands a combination of a wide variety of methods,’ including:

Traditional teacher ‘talk and chalk’ together with class discussion,
e.g., when introducing a topic, clarifying problems, summarising facts
etc. (DES, 1995, 5)

Perhaps, following the earlier CEB document, what might have been recommended
under teaching methods could have been a heightened and informed awareness of the
language of science in schooling to better help all students in learning science content.

Considering that the Junior Certificate was introduced in 1989, assessment
begun in 1992, and considering that the Junior Certificate was preceded by the
recommendations on language of the CEB, perhaps it would be apposite to remember
that the issue of language in content areas was only beginning to be seen as vital in the
educational process. Gordon Wells, writing in 1992, in the end piece for a book titled,
Thinking Voices: The Work of the National Oracy Project, suggested that the
publication of the book was cause for a celebration as, 'The centrality of talk in education is finally being recognised.' (Wells, 1992, 283)

If the importance of talk, or language, was only then being recognised, it did come up in a later piece of writing about science in Irish second level schooling. Palmer, in a paper published in 1999, wrote that, 'The precise language of any of the sciences makes considerable demands on students.' (Palmer, 1999, n.p.) She then suggests the three kinds of language demands are: Technical terminology; everyday language; and, the language in which it is examined. (Palmer, 1999, n.p.) The more specific issue of language in science education will be explored in detail in the third chapter, but Palmer's essays suggest awareness of the issue among the scientific community in Ireland.

In addition, in an essay published in 2002 and drawn from her M.St. thesis from the previous year, Duggan explored the notion of writing as a tool for learning science content. She concluded that, 'Clearly there is a need for more in-career education of science teachers that goes beyond the rather superficial level that they receive at present.' (Duggan and Matthews, 2002, 94) One thing that might be required prior to such 'in-career education' would be Irish research into the specific language of science education that underpins teaching subject content. This topic will be covered more specifically in the third chapter, detailing the academic literature in the field.

The issue of language also arises in an Irish context in the still in-progress study from the OECD: the Programme for International Student Assessment (PISA). The initial results of this project was published in 2001, and looked at the results of data in relation to second-level reading literacy, as well as mathematical and scientific literacy. While the complete results of this report are beyond the scope of this chapter, its results showed that Irish 15 year-olds, in the area of scientific literacy achieved a mean score which, '...ranked 9th overall, ...significantly higher than the OECD country average.'
It will be important to watch the further results of the PISA research in future. However, PISA looks at 'literacy' and is somewhat limited in scope to other forms of language (including the language of teaching and learning in the classroom).

This section has tried to show that language has been an issue in junior secondary science education in Ireland for some time, but not a significant issue. Perhaps language is becoming in Wells' words above, 'central' to content teaching and the remainder of this thesis will explore this in different ways.

2.6 Conclusion

This chapter looked at science in the Junior Certificate or early secondary schooling, detailing the progression that takes into account what students are studying today. This outlined the evolution of science in the curriculum since the creation of the Irish State; what the Intermediate Certificate was comprised of and how this Certificate was seen after a number of years; how an alternative science syllabus, the Integrated Science Curriculum Innovation Project (ISCIP) was introduced and what it contained; the evolution into the Junior Certificate in the late-1980s; and introduction of the new curriculum/syllabus in 1990; and, finally, the recently revised Junior Certificate Science syllabus, which sought to introduce a more practically-based work load for students.

The chapter also suggested that there has never been a sustained look at the language of science within the Irish post-primary curriculum. While there have been efforts to broach the subject of the language of science, these did not include the actual language that students would face in the classroom. This will now be addressed.

The next chapter will extend this look at school science through a journey through the literatures of: classroom discourse; the language of school science; and the language in use in secondary school science classrooms. This review will include perspectives of educationalists as well as the perspectives of linguistics. This is being
done to see how different 'disciplines' see the same phenomena. But it also allows for a look at theory which would have informed and influenced those within the academic area of education (i.e., teachers of teachers), curriculum developers, and teachers. The next chapter will look at those perspectives drawn from the practical work of 'what happens in the classroom' in teaching and learning science, and draw on various perspectives from the English-speaking world.

The next chapter will also allow for directly seeking to answer the first of the four research questions at a theoretical level—as would be expected when drawing from a swathe of the literatures available. Further movement to answering the thesis questions will accrue over the analytical chapters.
A potent reason why we all tend to overextend literature reviews is that doing so postpones [the] psychologically taxing moment when we have to think through ideas for ourselves. (Dunleavy, 2003, 32)

3 The Language of School Science: A Review of Three Literatures

3.1 Introduction

In the Introduction to this thesis, a set of research questions were posed. These questions revolve around issues relating to the specific features of language used in the teaching and learning of secondary school science. The second chapter presented a brief journey through the changing role of science within Irish post-primary, or secondary, schooling. The function of the second chapter was to help situate the focus of this research into what happens, through language, within one such classroom. Through an exploration of the evolution of science in the first years of Irish secondary schools, it was hoped to isolate, and highlight, the subject of this thesis. This current chapter moves from a broad overview of science as a discrete subject matter within Irish schools, as offered in the preceding chapter, to begin looking within the classroom where that subject matter is being taught, with a specific focus on the language used in teaching and learning: first, in general; and then, in school science. This, of course, takes us to the focus of this thesis.

The purpose of this review of the literatures is to explore different views of classroom language from the past 40 or more years in the English-speaking world. In addition to the academic literature within the areas of classroom discourse and the
language of school science, the literature about literature reviews will first be briefly
delineated.

3.1.1 Exploring the Purpose and Function of This Literature Review

In a chapter detailing the purpose of literature reviews, Kamler and Thomsen suggest they are akin to, 'persuading an octopus into a glass.' (2006, 28) They state that the specific purposes of, and the key tasks achieved within, literature reviews should be to:

1: ...sketch out the nature of the field or fields relevant to the inquiry, possibly indicating something of their historical development and;
2: identify major debates and define contentious terms, in order to;
3: establish which studies, ideas and/or methods are most pertinent to the study and;
4: locate gaps in the field, in order to;
5: create the warrant for the study in question, and;
6: identify the contribution the study will make. (Kamler and Thomson, 28)

The same authors comment that notions of such reviews must be re-thought. They recommend that, '...we continue to use the term literature, but always in the plural and with a lower case l – literatures. This is to signal that there is neither ore monolithic research canon, nor necessarily one place only in the thesis where it belongs.' (35. Italics in original.) Hence the working title of this specific chapter.

In addition, Potter suggests that, 'there is no point in simply wading into the literature and other contacts thinking you can 'immerse' yourself in your subject. Particularly today, when electronic information systems are so powerful, there is an immense danger of simply being overwhelmed by the vast amount of information that is out there.' (Potter, 2006, 153. Quotation marks surrounding 'immerse' in original.)
As well, Dunleavy notes that, 'students often write literature review chapters in a perfectionist tone, fastening terrier-like on smallish deficiencies of previous work.' (2003, 57) Dunleavy suggests one problem with such a tendency is that it opens the researcher up to neglecting, '...the extent to which similar difficulties are likely to recur in their own research.' (ibid. 57)

Taking each of these views into account, the following points will be made in relation to this chapter.

The chapter looks at a set of issues through the lens of academic literatures covering diverse areas of research over the past 40 years within the English-speaking world in relation to the language of teaching and learning, ultimately in relation to school science. Following Kamler and Thomson, this chapter seeks to sketch out the nature of the research to date in the area of classroom discourse and the language of school science, covering both educational as well as linguistic literatures. This will be done by providing a synthesis of the key points of these disparate literatures, and suggest linkages and fissures amongst the various approaches. The chapter also seeks to establish which studies are most relevant to this thesis. It locates perceived gaps in both the literatures discussed, as well as the current thesis research. This chapter will establish a warrant for this specific research, and for the use of the specific theoretical framework applied. Finally, it identifies contributions this research hopes to make to specific academic and educational fields.

Following Potter, this review of the literatures recognises that while attempting to be broad and inclusive, it is beyond the scope of an individual piece of work to cover all of the research internationally. One reason for this is that the literature reviewed is limited to the English language. A second reason is that it looks at the literature relevant to secondary schooling (rather than primary and tertiary education—these are introduced, but not detailed throughout).
Finally, following Dunleavy, this review seeks a critical perspective and points out perceived gaps in the extant, covered literatures, without assuming that the researcher has all the answers. This critique is meant as a critical engagement with the literatures, and not a negation of any researcher or theoretical approach.

### 3.1.2 Outline Structure of This Literature Review

The specific approach in detailing the particular, disparate, literatures, as stated above, will be to synthesise material relevant to each subject area. So rather than considering each theorist or piece of research in detail, a set of issues in relation to the three specific areas will be reviewed and discussed. These three areas of the literature covered are:

- **Classroom discourse, generic**: the academic literature over the past 40 or so years, in English, on features of classroom language, without looking at course content specificity (mentioning work by Barnes, 1971/1969; but beginning with Sinclair and Coulthard, 1975). The key issue here is a look at the nature of pedagogic exchange. Exchange is one aspect of classroom talk, and one that features the teacher directing intended learning at, and with, students. One point to consider here is the individual research orientation: is the research based on educational and pedagogical principles, or is it based on a linguistic analysis? This distinction will be made throughout the chapter.

- **Language of school science**: the literature exploring features of language used in school science, much of which conflates written and spoken language. Specific sources of language in school science include, of course, the teacher and students, but also textbooks, curricular and syllabus documents and any other source of semiotics in the classroom. Linguistic work does suggest differences between written and spoken English (for example, see Biber, et al, 2002; Halliday, 1994; and Halliday and Matthiessen, 2004), so the initial section here will look solely at educational perspectives, to be followed by one specific and detailed linguistic look at the subject matter. The key focal issue in this section is the specific nature of the language of school science from the two perspectives.

- **Language of the school science classroom**: moving beyond the conflation of the language of school science (not distinguishing between written and spoken language) this section will draw from research that looks at how teachers and students 'speak science' (Lemke, 1990, x.) in the classroom. Features drawn from various efforts to analyse this language will be explicated and compared. The key issue in this section is how different approaches analyse the linguistic exchanges towards the teaching and learning of science content within the classroom.
The main goal of these sections is to highlight research that focuses on quite specific and discrete aspects of the classroom and the teaching and learning of science. As the perspectives also have different orientations, this will allow for a link to the framework (Systemic Functional Linguistics) used in this thesis.

The use of such a synthesis for a literature review is suggested by Lunenberg and Irby (2008) when they write that, ‘A good review of the literature is a critical synthesis...describ[ing] and analys[ing] the literature to show how previous studies are related to each other and the [the] study.’ (2008, 154)

This literature review will further seek to provide opening answers to two of the research questions this thesis is pursuing. The first question inquires into what is known about the language used in teaching and learning science in secondary schools; and the second asks if there are specific patterns of language used in secondary school science that could add to students’ learning of science. In addition, the third research question is addressed in this review of the literature by looking at the use of a detailed linguistic framework in a search for answers to the first two questions.

It must be noted here that in looking at the various literatures of the language of school science, other semiotic modes are not being considered. It is accepted that classroom images and activities (for instance scientific tools and equipment, or props, and computers and projectors) contribute meaning within science (see: for computers: Barba, 2004; diSessa, 1997; Gates, 2004; Murphy, 2004; for multimodal work in general: Jewitt, et al, 2001; Kress, et al, 2001; Guo, 2004: for science props: Shapiro, 1998). In addition, non-linguistic features such as gestures and physical actions also contribute to such meaning (for example, Martinec, 2004; Roth, 2000, 2004). These are fertile areas of research within contemporary academia. This should not deny the view that language is central to teaching and learning that is pervasive in the academic world.
Two apt quotations over nearly 20 years support such a view on the centrality of language in education. Lemke writes that, ‘Learning science means learning to talk science.’ (1990, 1. Italics in original.) Nearly 20 years later, Hanauer concludes that, ‘The teaching of science cannot be addressed without an understanding of the discourse of science.’ (2008, 19) This thesis will situate itself within the literature looking at that discourse.

Each section will include a synopsis of how Systemic Functional Linguistics, and its associated grammar, help illuminate specific features of language, and how they contribute to making meaning (in this instance, in school science), thereby seeking a justification for the use of SFL as a theoretical framework for this thesis.

The conclusion of this chapter provides a further synthesis of the three sections, by highlighting specific features that have been presented. This review of the academic literatures into the language of the science classroom provides a way of thinking through the remainder of this thesis, and allows for possible further development in the understanding of what happens, through language, in teaching and learning school science effectively.

3.2 Language of the Classroom: Generic

3.2.1 Identifying Issues of Concern

Looking at language in the classroom could be seen as a fairly simple, and commonsense, task. Consider the following classroom extract drawn from the transcripts used in this thesis:

Teacher: Where did I say it was in your body?
Student: In your stomach.
Teacher: What is the name of that acid?
Student: Hydrochloric acid.../
Teacher: Good girl—hydrochloric acid.

This extract could be considered typical secondary school talk between teacher and student(s). Here, the teacher asks a baseline, or starting, question; this is followed by a single student answering; next comes feedback from the teacher (in different forms here: in the first teacher response, there is another question; in the second teacher response, there is a positive acknowledgment, or evaluation, of the student answer). This iterative sequencing is characteristic of schooling, where the teacher asks the bulk of questions, and tends to control the language used. Note here, as well, that the teacher invariably knows the answers to questions being asked.

This first section of this chapter will explore the literature analysing such classroom language, or discourse. For the sake of this thesis, discourse is used as a generic term to refer to language in use—nothing more or less. Noting this should prevent any possible hesitation on the use of a contested theoretical term. More specifically, discourse in this chapter will refer to the spoken language used within the classroom.

The literature looking at classroom discourse is quite large. Much of it is highly specific (looking at either primary or secondary schooling; looking at specific subject content; or looking at some other phenomenon in the classroom—gender, power, disadvantage, etc.). As well, perhaps no area of research in the classroom has been as extended by technology as research into classroom (and other arenas of) discourse for the simple fact that recording, transcribing and analysing that discourse has made much more data available in forms relatively easy to collect and use. As this takes into account the shift in electronic technology over the past decades, in particular, it has to be stated that recording classrooms, and moving that recording from camera to computer for work, has become an almost trivial technical task. Transcribing is still
problematic (which will be explored in the next chapter on methodology) but getting the
discourse to analyse is no longer a substantial hurdle to such research.

For the purposes of situating this thesis within the existing literature, this section
will explore the general, or generic, nature of language in the classroom. Christie notes
one theme, which she calls fundamental, ‘...that runs through virtually all the work in
classroom discourse analysis is the recognition it gives to behaviour, including language
behaviour, as structured experience.’ (Christie, 2002, 3. Italics in original.)

Looking at the opening extract above as part of such a ‘structured experience’,
and the sequencing of language involved in that experience, means taking into account a
very pervasive aspect of classroom discourse. Lemke has labelled this sequence the
‘triadic dialogue’ (Lemke, 1990, 8; Wells, 1999a, 167), as it comprises, ‘...at least a
three-part Question-Answer-Evaluation’ (Lemke, 1990, 8). But there is more to the
exchange in classrooms, and Lemke also notes that, ‘A lesson is not just give-and-take
between teacher and students. In the course of moves in the dialogue game, some
science is getting talked about.’ (Ibid., 11) This articulation leads to the issues taken into
account in this opening section of the literature review.

Consolidating the points from the previous paragraph, the key focal issue to be
considered in this section:

- Exchange: what specific features have been identified over time in
  relation to the nature and function of exchanges within the
classroom? This includes looking at the exchange, the functions of
language within the exchange, and patterns of types of exchanges
that happen in classrooms.

- Irish research in the area: what specific research has been undertaken
  in Ireland, over the past forty years, in the area of classroom
discourse? This section will be brief, as little research has been
completed in the field, and that has tended to be quite specific in
range.
The opening section will detail academic research into the specific area; how that research has changed (developed, evolved or been enhanced) over time; and highlight the theoretical focus of each. This means that each section will have a certain historical progression within it. The second section will offer a brief look at Irish research into classroom discourse. This will be contained in a short, highly specific, separate section, and should help situate this thesis in a local context. As well, links will be made connecting each issue to the proposed theoretical framework of this thesis (Systemic Functional Linguistics) to justify the use of that framework.

In looking at the issues in this section, two points must be made. The first is that no account will be taken in this section of the quantification of the specific issues. So while Wells reports that the, ‘...actual frequencies of occurrence [of the triadic dialogue] vary considerably, of course, in many secondary classrooms it is estimated that this format accounts for some 70 percent of all the discourse that takes place between teacher and students...’ (Wells, 1999, 167). Rather the patterns that have been identified and articulated will be discussed in relation to each other at an abstract, distanced level.

The second point to be made is that the issues identified here are documented in much of the educational research, and there has been an effort towards cohesion in presenting this research, this section tends to jump from theorist to theorist in its development. While the focal issue is exchange within the classroom, this notion tends to be an overview of what happens in classroom discourse, and other points of concern (for example: questions, follow-ups, identification and knowledge) are contained within the exchanges. In many ways, exchange is all that happens within classroom discourse.
3.2.2 Exchange Structure in the Classroom

Research based in the classroom has taken place over a number of decades. Sinclair, et al (1972) write that, ‘...since the late 1940’s there has been a growing interest in studies of language interaction in the classroom, particularly in the U.S.A.’ (11) They suggest this research began with Flanders, and they detail that he was, ‘...the principal investigator of the first of these, [he] has not only personally supervised seven major projects, his methods for handling data have also been used in literally hundreds of independent studies.’ (11) Drawing from Flanders’ research, these authors highlight this identification of Initiation and Response (seen in the extract above). This work was extended, as will be seen later in this section.

The structure of this initial section will be to first identify specific issues that have been highlighted over this period of research, then to highlight how theorists have looked at, analysed, or sought to better understand what it is that happens within classrooms via language. This field of the teaching and learning process is, by no means the only mode of communication with the classroom. Nevertheless, several theorists have highlighted the importance of language in the classroom. Christie highlights this point when she writes that, ‘...unless we are willing to engage seriously with the discourse patterns particular to the institution of schooling, then we fail to genuinely understand it. It is language, after all, that the business of schooling is still primarily accomplished...’ (2002, 2)

Selecting a starting place in such a literature is necessarily problematic. The researcher either seeks to cover the entire literature (in the case of multiple literatures, virtually impossible) or selects an arbitrary beginning and seeks to justify that location. For the purpose of this research, what will be explored is the structure of classroom talk. Christie notes that Flanders was, ‘among those who early began to conceive classroom talk in terms of structure’; but continues that the labels used, ‘were general terms and
often difficult to apply with certainty to different utterances.' (2002, 5) Following Flanders’ work was that of Barnes, in the late 1960s. Christie writes that Barnes’ commentaries were:

...often very perceptive, revealing for example, ways in which teachers’ talk appeared to impact on students’ learning, sometimes facilitating it, sometimes stifling it, while other work, most notably on students learning in small groups, also revealed a great deal of ways students could usually learn together as they collectively build some understanding in talk. (Christie, 2002, 6)

One interesting point in Barnes’ research was the role of teachers in its development. This work is important today, as can be seen from the Introduction to a recent work which notes that Barnes’ work, ‘...has become a core text for the more enlightened initial teacher education courses, and the clear but profound message that it conveyed has reverberated across time.’ (Hodgkinson and Mercer, 2008, xi) Note, however, that Barnes does not provide a framework as such for analysing language from the classroom, he does offer a set of questions relating to issues that later frameworks seek to make more explicit. As such, Barnes’ research will be glossed over in the opening section.

Perhaps the most significant work looking at classroom discourse structure was Sinclair and Coulthard’s research, which culminated in the 1975 publication of their seminal work, *Towards an analysis of discourse: The English used by teachers and pupils*. This volume firmly established the Initiation-Response-Feedback (IRF) sequence in classrooms within wider academic discourse. What Sinclair and Coulthard call the IRF is also in the literature referred to as Initiation-Response-Evaluation (or IRE). This will be looked at shortly, but for the purpose of this review both will be captured using the umbrella term ‘triadic dialogue’, a structure that has become accepted as given within educational and linguistic research into classroom discourse.
Writing in 1981, Burton describes Sinclair and Coulthard’s work as, ‘...the most significant contribution to the rigorous socio-linguistic analysis of naturally spoken discourse at present available to linguists.’ (Burton, 1981, 61)

Gauging the significance of this work can be seen through a cursory glance through the more specific educational literature. Edwards and Mercer state that, ‘The basic ‘I-R-F’ exchange structure [Sinclair and Coulthard] identified...is, once again, impossible to ignore in any observed classroom talk’ (Edwards and Mercer, 1987, 9). Shuy describes this triadic dialogue as being the ‘...major interactional sequence in classroom talk,’ (Shuy, 1988, 118). Devitt suggests that, ‘The work of Sinclair and Coulthard and their colleagues has provided some of the most interesting insights into this interaction...’ (Devitt, 1989, 21) Wells notes that while, ‘...actual frequencies of occurrence vary considerably, of course, [that] in many secondary classrooms it is estimated that this format accounts for some 70 percent of all the discourse that takes place between teacher and students...’ (Wells, 1999, 167). Edwards and Westgate suggest of the triadic dialogue sequence that, ‘The frequency of those exchanges, and the overwhelming tendency of teachers to make the first and third moves, is ‘essentially’ what makes classrooms so distinctive.’(Edwards and Westgate, 1994, 125)

Scott and Mortimer write that, ‘...the I-R-E pattern of interaction is very distinctive in all classrooms, and most authoritative interactions are played out through an I-R-E pattern.’ (Mortimer and Scott, 1998, 41)

At times, it feels difficult (through not impossible) to find classroom discourse research that does not use Sinclair and Coulthard’s now over 30-year-old framework as a beginning point (though for one example in an Irish educational context which ignores this work, see Lyons, et al, 2003).

Not all of the literature is positive of the IRF(E) framework. Edwards and Westgate declare that if the Sinclair and Coulthard’s, ‘...study now appears somewhat
limited in its view of both discourse and classrooms, its success in highlighting some of
the important features of 'normal' classrooms serves to underline how limited and
limiting such classrooms can be in the options they normally make available to pupils.'
(1994, 149)

This section will begin by looking at Sinclair and Coulthard's work on
identifying classroom exchange, before looking at research following, and principally
derived from, that work. Principals here will include Mehan, Berry, Edwards and
Mercer, Wells and Christie (which in some ways follows theory through the decades:
1975 to the mid- and late-1990s), among others in the area of classroom discourse.
Much of this (and other) work either critiques or attempts to extend Sinclair and
Coulthard's work—but virtually all of this work recognises the importance of their
research.

3.2.2.1 Inquiry-Response-Feedback

Sinclair and Coulthard's work (1975) begins with establishing two initial ranks:
utterance and exchange: '...utterance was defined as everything said by one speaker
before another began to speak, exchange as two or more utterances.' (21) They decided
to abandon utterances, however, as they observed that, '...there is a smaller unit than
utterance...:'

we called this a move, and wondered for a while whether moves
combined to form utterances which in turn combined to form
exchanges. However...the vast majority of exchanges have their
boundaries within utterances. Thus although utterance had many
points to recommend it as a unit of discourse, not least ease of
definition, we reluctantly abandoned it. We now express the structure
of exchanges in terms of moves. (21)

Their descriptive framework moved on from there, as exchanges within the
classroom contained three moves: initiation, response, feedback. They write that,
'While we were looking at exchanges we noticed that a small set of words—'right',

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‘well’, good’, ‘O.K.’, ‘now’, recurred frequently in the speech of all teachers. We realised that these words functioned to indicate boundaries in the lesson, the end of one stage and the beginning of the next.’ (21-22) As such, Sinclair and Coulthard, ‘…labelled them frame. Teachers vary in the particular word they favour but a frame occurs invariably at the beginning of a lesson, marking off the setting-down time.’ (22)

After describing in great detail (beyond the scope of this chapter) the stages of analysis, Sinclair and Coulthard delineate the elements at the level of Exchange. Included here is a list of possible exchanges: Preliminary, Boundary, Medial, Teaching and Terminal, (26) which make up activity within the classroom. What makes this focus relevant to education is that it is here the principle components of IRF come into play. The authors state that within the Teaching Exchange are the elements Initiation, Response and Feedback, which provides the IRF(E) framework of pedagogical exchange.

This sequence was not limited to the three steps described so far, however, as Sinclair and Coulthard delved deeper into the structure of classroom language. They write that, ‘When the teacher gets no response to an [inquiry] he can start again using the same or a rephrased question or he can use one or more acts—prompt, nomination, clue—to re-initiate.’ (53) In this context, ‘prompt’ would be seeking to extend the student’s answer; ‘nomination’ used to call on another student to answer; and ‘clue’ to offer possible approaches to the student in revising their answer. This use of iteration allows for the sort of scope teachers need for students to rearticulate answers from uncertainty. All of these acts are under the heading ‘feedback’. However, Sinclair and Coulthard state that, ‘…feedback is not essential, [in the event of questions to which] the teacher does not know the answer.’ (53)

In a slightly later essay, Coulthard and Brazil focus more specifically on the nature of exchange in seeking to elaborate on the earlier work. One point the authors make in
this work is to question the label of Feedback within the IRF model. Coulthard and Brazil write that, ‘the label ‘feedback’ turns out to have been an unfortunate choice.’ (Coulthard and Brazil, 1979, 39) What they offer instead is the label Followup, which they state is a structural label. Here, they seek to establish two criteria which can be used in defining a Followup:

(1) ...does the given element generate constraints which amount to a predication that a particular element will follow; and
(2) ...has a preceding element predicted its occurrence?
(39)

What the authors are pursuing here is the notion of predicting whether a Followup is required, or obligatory, within any given exchange. This seeks to extend the initial labelling of ‘feedback’ in their research.

Pursuing research in this area, Mehan (1979) suggests that classroom activity is, ‘...accomplished by and revealed in the verbal and nonverbal behaviour of lesson participants.’ (36) He notes that, ‘more specifically, teacher and student behaviour is organised into ‘interactional sequences,’ which perform distinctive functions in specific places in the organisation of lessons. Directive and informative sequences contribute to the assembly of opening and closing phases, while the instructional phase is composed primarily of elicitation sequences.’ (36) The stages of ‘directive’ classroom activity (setting up a lesson, opening a lesson, conducting a lesson, and closing a lesson) are described in detail, using a variation of the above described IRF(E) sequence for all but the initial phase.

In Mehan’s description, ‘the totality of activity that classroom participants and researchers call a ‘lesson’ is set apart from other classroom activity in a number of ways. Prior to the actual lesson itself, the teacher assembled students in one or two places in the room’, (36) which involves settling students within the classroom. This is
the initial phase of classroom lesson activity. Here, Mehan was detailing his work within a primary classroom. In secondary school contexts, such arrangements would very likely be different and see students shuffling into the room, seating at assigned or known seats, followed up by the calling of a register (taking attendance) and making any announcements. Mehan notes these generally, ‘...occur only at the beginning of the activity called a lesson, and at no other time. This unique configuration of proxemic shifts both serves to mark lessons off from other classroom activities and informs the students that that particular classroom activity, and not some other, is to begin.’ (37) Of course, in a secondary school, it also signals the shift from one subject area to another.

The second phase, opening a lesson, means situating the students (again, in Mehan’s case, primary level students) into specific learning groups and lessons. He notes that in this phase the IRF(E) sequence is used, but that, ‘...the students’ responses to these introductory remarks can be characterised as ‘acknowledgement’ [following Sinclair and Coulthard], this does not mean that the students are simply passive... [as] successful accomplishment of these interactional sequences requires active listening on the part of the students.’ (40)

The third phase enters into the picture once the lesson has been established. At this point, Mehan stresses the, ‘...prime activity was the exchange of academic information. The teacher and students exchanged factual information, opinions, interpretations of academic materials, and the grounds of their reasoning.’ (40) Part of this exchange of academic information, for Mehan, involves the use of questioning, and suggests that, ‘...from the point of view of the functions of language in the classroom, the teacher elicits information from students; she does not ask them questions. These observations reinforce the view that the study of language in naturally occurring situations requires the use of functional rather than grammatical concepts. For these
reasons, terms like “initiations and replies,” “elicitations and responses,” are used here instead of the grammatically based expressions like ‘questions and answers.’ (p. 43)

In some ways moving beyond Sinclair and Coulthard’s articulation of ‘elicitation’ as being one of several Acts in the classroom, Mehan writes that an elicitation:

...does not seek just any information, it seeks particular information. In fact, four different kinds of elicitations were located in the instructional phase of [his recorded] lessons: (1) choice elicitations, (2) product elicitations, (3) process elicitations, and (4) metaprocess elicitations. Each of these initiation acts was followed by a specific kind of reply. (p. 43. Italics added.)

Mehan then describes each elicitation in turn. First, ‘the choice elicitation calls upon the respondent to agree or disagree with a statement provided by the questioner.’ (p. 44) Second, ‘the process elicitation asks respondents to provide a factual response such as a name, a place, a date, a colour.’ (44) Next, ‘the process elicitation asks for respondents’ opinions or interpretations.’ (44)

Mehan states that each of these three elicitations, ‘ask[s] for factual information, opinions, and interpretations.’ (45) The fourth kind of elicitation, ‘asks students to be reflective about the process of making connections between elicitations and responses.’ (46) Mehan labels such elicitations:

metaprocess elicitations because they ask students to formulate the grounds of their reasoning. They ask students to provide the rule or procedure by which they have arrived at or remembered answers. Metaprocess elicitations appear very infrequently in [Mehan’s transcripts]. Although students are not always successful in formulating the grounds of their reasoning, there may be pedagogical potential in having students become aware of the grounds of their reasoning... (46)

Here one can see both the direct influence of earlier work (specifically Sinclair and Coulthard) as well as the evolution of that work. By distinguishing each elicitation and
response type, Mehan is looking in somewhat greater depth at what happens functionally within the classroom.

Mehan progresses the earlier work by specifying more detail in relation to the teaching and learning sequencing than do Sinclair and/or Coulthard. But more development came from Margaret Berry’s subsequent research.

At the beginning of one essay published in 1981 (and relating to other work by her), Berry quotes that Sinclair and Coulthard, while they do use Halliday’s linguistic framework for some of their theoretical framework, note early in their 1975 work that

\[\text{Halliday}\] finds in the structure of the clause three functions: (1) the ‘ideational’—expressing content; (2) the ‘interpersonal’—maintaining social relations; and (3) the ‘textual’—enabling links to be made with the situation and cohesive texts to be constructed. This approach to function did not provide us with a useful starting point. (Sinclair and Coulthard, 1975: 12, cited in Berry, 1981a: 120-121)\]

Berry (commenting that she was, ‘surprised when [she] first read’ that quotation from Sinclair and Coulthard) then suggests that the three functions introduced above will show that, ‘the discourse framework set up by an initiating move in an exchange has three aspects…’ (121) She then proceeds to illustrate each.

There are three aspects of language in use in Berry’s exchange framework. These she details (following Halliday as above defined) in her essay in this way:

- Interpersonal layer: ‘...intended to reflect the view of discourse as knowers transmitting and receiving information...’, (131, italics added)
- Textual layer: ‘...intended to reflect the view of discourse as speakers taking turns...’, (131, italics added)
- Ideational layer: this is glossed over by Berry as being, ‘the other essential ingredient for the transmission of information...the information itself.’ (139)

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4 It may be worth noting that at the time of Sinclair and Coulthard’s work, Halliday was still using the notion of Scale and Category to describe his linguistic work. This evolved into Systemic Functional Linguistic theory at a later date, and Berry refers to this designation in her own work.
For each of these, she then provides three descriptive features: details of the function in question; layers of structure of the specific function; and the options available within the specific functional structure. This is a far more detailed view of the language of the classroom than presented earlier. However, this also means a more abstract articulation is required in describing this framework. Rather than looking at each of these three layers here, the Textual layer will be examined, in comparison with Sinclair and Coulthard and Mehan.

Within the Textual layer, Berry suggests that there are three specific features of classroom discourse. These are called Support; Query; and Challenge. (135-136) In using these labels, Berry notes that she is concerned with how, '...they affect the structure of exchanges.' (135) Again, the use of multiple layers of analysis (referred to above) allows for a more finessed look at what is happening within the exchange. Berry notes that, 'when all three are present they seem to represent three stages in a progression through the exchange.' (141)

In addition, she claims, '...that each of these functions can occur only once in an exchange. Each, when it does occur, must be mapped onto a function from the textual layer and onto a function from the interpersonal layer.' (142) For each segment of an exchange, Berry labels for each of the layers, and focuses on the progression through the exchange at each layer.

One further contribution Berry makes to the IRF/E structure is the point that two features of such a structure are ellipsis and polarity. In considering the proposition stages noted above, Berry writes that there seems to be, '...another kind of progression through the exchange. The second kind of progression through the exchange takes the form of an increase in ellipticity.' (142) In the context of classroom discourse, for instance, this might be seen in the following modified exchange from the example at the beginning of this chapter:
Teacher: Where did I say it was in your body?
Student: In your stomach.
Teacher: Yes.

The student reply, 'in your stomach' provides sufficient detail to answer the question, but elides 'you said it was in your stomach'. While there is ellipsis in the first frame, 'it', there is 'increased ellipsis' in the response. In a later essay, Berry defines ellipsis as, '...any total absence of a reference to a component or any representation of a component solely by means of grammatical items such as pronouns or substitute verbs.' (Berry, 1981b, 42. Underline in original.)

Similarly, looking at the final utterance above, Berry notes that in completing the proposition above, '...is usually conflated with a function from layer 1 to the extent that two together can be realised by a single item.' (Berry, 1981a, 141) This is a common occurrence within classroom discourse (and, more generally, within spoken language).

Both of these points, of ellipsis and polarity, are spelled out in some detail in 1981b, in reference to work by Coulthard and Brazil (1979).

Berry is cognisant of the value of Sinclair and Coulthard's work both in her 1981 essay (from the opening paragraph) but also later in 1987. There, she writes that, 'the strength of the work of the Birmingham discourse analysis (e.g. Sinclair and Coulthard, 1975), or at any rate one of the strengths, would seem to lie in the bringing to light of a number of interesting, but hitherto unnoticed, facts about different types of discourse and their relation to their social context.' (Berry, 1987: 41) She continues that quotation, however, by noting that

The weaknesses of this work is that there is no overall theory of the relations between language and social context which could account for the facts that have been discovered. (41)
Her goal, in many ways within the articulation of her framework, is to look at the relations between language and social context.

While her framework is more abstract (though perhaps theoretical is a better term) than those introduced above, it is presented here for two reasons. First, with Sinclair and Coulthard having been published in 1975 and Mehan in 1979, it is indicative of a widening out of the lens of research in classroom discourse—Berry seeks here to extend the earlier work directly. The second reason to introduce Berry’s work, and the theories of Halliday which underpin it, is to situate this linguistic framework as the foundation for this thesis. This is more than a brief entry into the framework, but an indication that the work has been applied in educational contexts at various levels.

Further work, not directly relating to educational discourse, has sought to extend Berry’s theoretical framework. This will be commented on briefly as it is also seen from within the Systemic Functional lens.

While Eija Ventola does not directly explore discourse within the classroom, she does look at work based on classroom language (specifically both Sinclair and Coulthard, as well as Berry’s above detailed work). For Ventola, the focus is the ‘service encounter’. For brevity’s sake, this section will not detail all of Ventola’s work in this regard, but deal with those aspects of it seeking to extend Berry’s framework. It is hoped by including Ventola in this review, that a strong linguistic focus on future classroom research might be encouraged.

To start, Ventola’s work looks at service encounters generally, rather than specifically, classroom discourse. However, her detailed discussion on the literature includes key references to Sinclair and Coulthard’s work above as well as Berry’s extension to that work. What Ventola contributes to Berry is a sense of the dynamic nature of exchanges. These will be introduced here.
For Ventola, ‘Social interaction inherently involves the notion of exchange or an adjacency pair. Built into the notion of her exchange/adjacency pair are the notions of initiation and response.’ (1987, 90) This follows from the work already reviewed in this chapter. Where Ventola extends this exchange or adjacency pair is by introducing a dynamic structure to exchanges.

First, Ventola distinguishes between synoptic structure, which she suggests is, ‘...rigid...’ (1987, 105) and offers a dynamic structure in its place. She covers labels drawn from the literature including, ‘...‘side sequences’, ‘insertions’, ‘challenges’, ‘queries’, ‘repairs’, and so on...’ (104-105), and notes that, ‘...challenges are not the only kind of dynamic phenomena in discourse. There are other kinds of systems which also generate dynamic moves to repair exchanges and guide their completion...’ (105) She labels these dynamic moves as: Suspending, Aborting and Elucidating. Each will be detailed here.

She describes Suspending moves as those which, ‘...concentrate on checking and giving assurance about the transmission of knowledge/action.’ (106) She then gives, ‘...four types of suspending phenomena...: giving confirmation, back-challenging, requesting confirmation and checking.’ (106)

Aborting sequences ‘generate moves which function, as a kind of a challenge—they focus on the interpersonal contact of a preceding move and attack its validity.’ (Ventola, 1987, 107, following Martin, 1992)

Finally, Ventola looked at Elucidating moves, and defines them as those exchanges in which speaker 1, ‘...first confirms the reception of the message... but then realizes he cannot provide a Compliance to [the other speaker’s] need without obtaining some further information from [that other speaker].’ (108)
Introducing these labels, Ventola writes that, ‘a consideration of suspending, aborting and elucidating moves is necessary if an account that shows what actually happens in the exchanges in the service encounter texts is aimed at.’ (109)

As can be seen, Ventola is drawing from linguistic theory and the theory of speech acts when she establishes her framework of exchange. While she does not relate directly to classroom language (rather, pursuing service encounters more generally), her work does seek to extend what Sinclair and Coulthard, Mehan or Berry offer as a full set of working labels.

Continuing in this linguistic tradition, Jim Martin also seeks to extend Berry’s work and situates it in the context of a much larger project he refers to as Discourse Semantics. His rationale for this label is his intent of looking at whole texts (spoken as well as written) and he notes that, ‘...a semantics of this kind focuses on text-size rather than clause-size meanings...’ (Martin, 1992, 2) Also based on Halliday’s linguistic theory and grammatical framework, Martin is looking at structures of language. One of those structures, the one relevant to classroom discourse, is labelled Negotiation.

More specifically Martin, within his chapter on Negotiation, includes a look at exchange structure, in which he reviews the literature on exchange, including that of classroom discourse reviewed above. Martin writes that as, ‘Berry has considerably elaborated on [Sinclair and Coulthard’s] framework within a systemic functional paradigm; it is this work that will be taken as a point of departure here.’ (Martin, 1992, 47)

Perhaps the most significant contribution Martin makes here is in the area of ‘adjacency pairs’. In other words, looking at structures as the IRF/E structure introduced by Sinclair and Coulthard and discussed earlier. Following Berry, Martin writes that, ‘...there is a strong tendency for exchanges to begin with non-elliptical major clauses,
continue with elliptical major ones, and close with minor clauses...’ (47) This was introduced earlier in the section reviewing Berry’s work.

Within such exchanges as adjacency pairs, however, Martin suggests two problems: ‘...interacts do not always come in pairs...[and they] are not always adjacent...’ (66) Exploring interruptions within spoken exchanges, Martin looks at two ways into analysing them: tracking and challenging. Each will be described now.

For tracking, Martin suggests that, ‘...in order to negotiate interpersonal meaning, interlocutors have to agree on what they are negotiating about.’ (67) To do this, he writes that to account for, ‘...the resources used to ensure that the experiential meaning under consideration is shared.’ (67) Here, Martin (building on Ventola’s work referred to above) offers the following labels (with descriptors):

- Backchannel: ‘used to monitor the dialogue, reassuring interlocutors that negotiation is proceeding smoothly’ (67);
- Clarifying: ‘that the experiential meaning of a previous turn and elaborate it in specific ways’ (68);
- Replay: ‘where interlocutors request a complete replay (68);
- Probe (WH-) questions: ‘used to probe the preceding move’ (68);
- Confirmation: ‘replay experiential meaning...by way of confirmation.’ (69)

Martin writes that,

Tracking moves are found at any point in exchange structure, although the more experiential meaning a given move makes explicit, the more likely it is to be misunderstood and so tracking is more common at the beginning of an exchange than at the end. (69)

Finally, Martin states that, ‘tracking moves will...be treated as dependent on the moves they track, rather than as constituents of the exchange.’ (70)

The progression here has taken the literature review from Berry’s engagement with Sinclair and Coulthard’s early work, to Ventola’s and Martin’s extensions of Berry’s work. As should be seen, a shift has been from linguistic work in the context of
education and schooling, to a linguistic look at exchange structure more broadly—but taking into account education and schooling.

The work so far has had a strong linguistic flavour, but seeks to inform pedagogical practice. There has, however, from within education more specifically, be work critical of Sinclair and Coulthard’s exchange structure. The works of Edwards and Mercer in the late 1980s and beyond explores a range of disciplines involved in researching the language of the classroom, situating their own work in an educational framework.

Specifically, these authors note that the research they review includes, ‘not only teachers’, but, ‘...also anthropologists, psychologists, linguists, and researchers from a number of different schools of sociological thought.’ (Edwards and Mercer, 1987, 8) They then review each of these disciplines, ‘...to the extent that they inform our basic concern with the establishment of common knowledge.’ (8) They wish to consider their own work as being ‘interdisciplinary.’

An interesting point these authors make in this regard is when they write that, ‘we knowingly take the risk of ‘pigeon-holing’ researchers to neatly as ‘linguistics’, ‘psychologists’, and so on.’ (8) They stress, however, that such

...disciplinary traditions — which are still an important influences on researchers—do embody certain perspectives, with the attribution of greater importance to some questions than to others, which makes them useful for our own for our own interdisciplinary purposes. (8-9)

The starting point for their review is, of course, Sinclair and Coulthard. While they do comment on the value of the earlier work, at one point suggesting that, ‘...to many people in the field of educational language research—in Britain, at least—the words ‘discourse analysis’ are firmly attached to the names of Sinclair and Coulthard.’ (9) However, these authors then note that there are limitations to Sinclair and Coulthard’s research. Specifically, that their, ‘...primary interest was not educational.’ (9) Further,
they note that discourse analysis, ‘...has some limitations... [as] it was devised to reveal linguistic structures, not educational or cognitive processes.’ (10)

In a stimulating critique of the early work in establishing the IRF/E sequence in the classroom, writing in 1999, Wells notes that, ‘if there is one finding on which students of classroom discourse area agreed, it must be the ubiquity of the three-part exchange structure...’ (167) Writing about Sinclair and Coulthard, Wells comments that these two authors, ‘...seem to assume that triadic dialogue simply is the unmarked mode of classroom interaction: Unless there is a good reason to behave otherwise, teachers adopt this mode by default. Not surprisingly, therefore, they offer no evaluation of its educational effectiveness.’ (167. Italics in original.) Looking at the effectiveness in the classroom of the triadic exchange is something hinted at in the work of Edwards and Mercer above.

Wells suggests that, ‘...triadic dialogue is neither good nor bad; rather, its merits—or demerits—depend upon the purposes it is used to serve on particular occasions, and upon the larger goals by which those purposes are informed.’ (169) Some of the most interesting aspects of Wells’ work are his comments on this triadic dialogue in the classroom.

He suggests that there are three varying styles, or realisations, of the IRF(E) dialogue. These he lists as:

1. ...the teacher checks on and consolidates the students’ knowledge...

2. ...the teacher employs the triadic dialogue genre to help [students] envisage the problems to be solved...and the conditions that will have to met I order to make...a fair test..., and

3. ... [when] the same discourse genre is used to help students reenvision the activities in which they have engaged as particular instances of the application of [the principles under investigation]...to construct it as part of the [entire class] group’s common knowledge. (206)
Wells concludes his extended chapter critiquing the triadic IRF(E) structure by noting that, ‘...when the third part of this structure is characterized as followup, rather than more narrowly as evaluation, there are compelling reasons for seeing the...sequence as the prototypical action for the achievement of over-arching goals of education...’ (206) This essay, subtitled, ‘A re-evaluation of the IRF sequence’ is an extended look at what has become established as a key aspect of classroom language.

Elsewhere, Wells and colleagues have provided additional research looking at the triadic sequence within schools and suggested that key element in teacher talk is the function of the Feedback. In Nassaji and Well (2000), the comment is that, ‘...there is a much wider range of options available to teachers in the third move.’ (380) They review Sinclair and Coulthard’s work (see discussion above) and highlight their shift from Followup to additional options, and then combine it with Berry’s work (also see above) on Primary and Secondary Knowers. These authors comment that, ‘...to cast the responder in the role of primary knower and thereby to create a more equal mode of participation...the teacher can encourage a more dialogic and exploratory stance to the topic under consideration.’ (381) They show in this essay how that works itself out in late-primary school classrooms.

In Wells and Mejia Arauz (2006), the suggestion is made that, ‘...when the prevailing discourse structure has the form of the triadic dialogue, classrooms can indeed be places in which knowledge is dialogically constructed.’ (380) In this essay, the authors conclude that, ‘...it is clear that an inquiry orientation to curriculum does make dialogue more likely to occur...[and] the single most important action a teacher can take to shift the interaction from monologic to dialogic is to ask questions to which there are multiple possible answers and then encourage the students who wish to answer to respond to, and build upon each other’s contributions.’ (414) This pedagogical focus
of looking at how the IRE(F) sequence can be transformed into a more inquiry-based form of teaching and learning is key in Wells’ work.

Further looking at work on exchange in the classroom, and in reference to the IRE(F) triad, Christie states that, ‘Ironically, a deal great of classroom discourse has had a lot to say about the structuring of talk in terms of IRE and related moves…’ and comments, however, that:

…it has often neglected to look at the nature of the meanings in construction, the relative roles and responsibilities of teachers and students at the time of constructing those meanings, and the placement of such patterns in the overall larger cycle of classroom work. As I have already suggested, I shall propose in this book that we think of larger units of curriculum activity as either curriculum genres or curriculum macrogenres. (2002, 5)

This is a similar point to the one Mercer and Edwards make above. In the same book, Christie writes that she ‘…will suggest…both that any analysis of classroom activity must always involve some selection of the potential data available for consideration, and that, while I acknowledge the significance of other meaning-making systems, in my view language remains the most fundamental mental resource with which participants negotiate and construct their meanings in classrooms.’ (2002, 10) She then notes that, ‘while I find much to enjoy and agree with in Wells’s account of his models of dialogic inquiry, the methodology he adopts does not permit the very fine linguistic analysis that [a] functional grammar makes possible.’ (10)

Christie suggests that research into classroom discourse over the past 30-40 years had two distinct themes:

- …the first of the themes involved in the initial interest of the late 1960s and 1970s in studying language behaviour in the classroom... all of them committed to a general view of classroom activity as structured activity.
- …the second broad theme, more recent in its expression, concerns the greatly extended scholarly interest in language as social phenomenon, involved in the negotiation and construction of meaning. (10. Italics in original)
What Christie is looking to achieve is a way of looking at the language of the classroom in a full-curricular context. Her research has included looking at English and literacy in the classroom (1989; 1999b), science in the classroom (1998), and a set of other subject areas (2002; 1997b) over the past 20 years.

Finally, writing in 1990, Lemke writes that, ‘Triadic dialogue is an activity structure whose greatest virtue is that it gives the teacher almost total control of classroom and social interaction.’ (1990, 168) One consequence of the sequence, however, for Lemke, is that ‘It tends to lead to brief answers from students...[and]...is a form that is overused in classrooms because of the mistaken belief that it encourages maximum student participation.’ (168) The participation, Lemke suggests, ‘...is illusory: high on quantity, low on quality.’ (168) Lemke will be further considered in the third section later in this chapter.

This review suggests that having established the standard method of communicating within pedagogy, the triadic structure of IRF/E, Sinclair and Coulthard are not with criticism. Efforts have been made since 1975 to both extend the framework these key researchers identified, but also to critique the function of that sequence in the context of classroom discourse.

The next section will explore Irish research into classroom discourse via English over the past few decades.

3.2.3 Irish Research on Classroom Discourse

The above research has all been conducted into the English used in classrooms over the past four decades in countries with English as a first or native language. What is missing so far, of course, is research from Ireland in the same area.
Unfortunately a search for material looking at classroom discourse of English in Irish academia (educational or otherwise) is frustrating as there is so very little. There may be historical or ideological reasons for this situation.

In 1989, Devitt published a look at classroom discourse that was based principally on Sinclair and Coulthard’s work above. He writes that he uses their work, ‘…not because it is necessarily the best, but rather in order to have a consistent frame of reference.’ (1989, 21) Devitt uses the Sinclair and Coulthard framework to look at classroom transcripts in various subject areas (specific content as well as within modern languages), that were taken, ‘…as part of a project for students in initial teacher training in Trinity College, Dublin…’ (23)

While focussing on the subject content, Devitt writes that such classrooms, ‘…would seem to have both elements of the scaffolding required for language leaning: knowledge of the world and a clear discourse structure.’ (26) Contrasting ‘content’ with ‘language’ classrooms, Devitt remarks that in ‘language’ classes, ‘…there is a notable difference in the nature of the display questions: a very high proportion of them relate to form rather than content; the teacher is asking the pupil to display knowledge, not of content, but of the correct form.’ (27. Italics in original.) He continues by writing:

If language lessons focussed on content rather than on form, the learning context for the pupil would alter radically. For one thing, it would become much more like the natural context of language learning, precisely because of the concern with meaning. For another, focus on content would allow the learner to activate his or her knowledge of the world, something which (as I have insisted) simply does not happen in traditional language lessons. Furthermore, the pupil’s own participation would be limited to short utterances within the strictly limited range of speech acts. Finally, as in the case of the discourse between mother and child, the horizontal structure of the language would be modelled naturally by the teacher at the very point where it would be most relevant to the learner. (32)

In this brief monograph, Devitt has a focus on meaning (illustrated in the above quote) and the relationship between form and content. This will be explored in detail in relation
to science later in this chapter with Lemke’s work, which looks at the content of science through form.

The second piece of Irish research into classroom discourse was published in 2003, and offers a look at the teaching and learning of maths and English. More specifically, this book looks at the language of the classroom. In the Introduction, the authors write, ‘this book represents a unique venture in Irish educational research. With the co-operation of teachers and students, it takes a video camera into classrooms to analyse the ways in which mathematics (and some English) classes are taught in second-level schools.’ (Lyons, et.al., 2003, xiii) It also states, ‘it is the first intensive video study of its kind to be undertaken in schools in Ireland...’ (xiv. Bold added for emphasis.)

This particular research, ‘...focused on the style of teaching, language content, teacher-student interaction patterns, and gender differences in interaction flows.’ (72) Looking at the language and teacher-student interaction, the authors look somewhat differently at one point of the IRE(F) structure, and examine classroom discourse from a non-linguistic or non language-orientated way, using Good and Brophy’s Looking into classrooms, which focuses not on discourse as such but properties of that discourse.

For instance, in looking at the ‘I’ of the IRE(F) sequence, Good and Brophy write that, ‘Addressing questions to the class involves first asking the question, then allowing students time to think, and only then calling on someone to respond. This makes everyone in the class responsible for the answer. If the teacher names a student to respond before asking the questions or calls on a student immediately after doing so, only the student who is named is responsible for answering. Other students are less likely to try to answer it.’ (Good and Brophy, 2000, 392-393) This is a valid observation into the use of language in the classroom, but offers little insight for replication.
Lyons, et al offer detailed analysis of their transcripts in their book into the mathematics and English classes, but the focus seems to be sociological than language oriented. For example, in their analysis of English classes looks at three areas of interaction:

- Overall patterns of public interactions;
- Teacher-initiated interactions; and
- Interpreting the text. (235-237)

Each is used as a heading to look at transcripts, but there is little relating directly to the transcripts other than the labels for questions taken from Good and Brophy. (2000) Such a sociological view of language offers little insight into the direct pedagogical exchange as other work detailed above; but it does offer valuable insight into power relations in the context of specific subject areas and relating to gender differentiation in the classroom. There is a shift here from looking at specific language features, to exploring or suggesting how that language in use illuminates power.

As these provide the only two published works of research into the post-primary/secondary school classroom discourse in Ireland (via English), it is hoped that in future additional work will be added to this small corpus.

### 3.2.4 Contextualising Systemic Functional Theory (A)

The research into classroom discourse has been evolving over the decades as indicated above. Much of the above research looks at exchange from the perspective of how pedagogy might be improved by exploring how teachers and students talk in schools (specifically, the work of Mehan; Edwards and Mercer; and Wells). Other research seeks to understand the theoretical underpinning of classroom discourse (Sinclair and Coulthard; Berry; Ventola; Martin). Meanwhile, Christie has made an
effort to merge the perspectives together by combining a strong linguistic orientation with explicit pedagogical concerns.

It should be noted, however, that the bulk of the researchers noted here (excluding the limited Irish research) specifically refer to Systemic Functional Linguistic theory and its application in analysing classroom research.

In the cases of Berry, Ventola, Martin and Christie, all seek to rely on Halliday's theories for outlining structures of talk in the classroom in ever more progressive ways.

This thesis will continue in the vein of using SF theory, and seek to look at the activity within one classroom at junior secondary level over two class sessions. The purpose is to look at, and beyond, exchange, to explore the complete lexicogrammatical resources used by the teacher and students. This will seek to provide specific features of language used by teacher (in particular) in her pedagogical pursuit of teaching science content, and how those features of language compare with the talk of students.

This thesis will explore exchange as one of several levels of language in use in the classroom. The hope is that by drawing from theory that has contributed significantly to the development of a more nuanced understanding of what happens through language in the classroom, specifically the science classroom, how teachers communicate science content might be improved.

3.3 Language of School Science: Generic

3.3.1 Identifying Issues of Concern

The initial section of this chapter focused on the language of the classroom, with no specific look at school content, or subject matter (though Wells and Christie has each explored subject content through discourse—in particular school science, which will be explored briefly in the final section of this chapter). In continuing this review of the
literature, and beginning to look at the language of school science, there are two particular questions, or issues, to consider from the outset.

First, is there a set of features that can be identified in looking at the language of school science that might distinguish it from other school subjects? In seeking to answer this question, effort should be made to look at range of sources of that language. In other words, it is important to look at features of that language drawn from the science classroom, but also from other sources. Such additional sources may include science textbooks, curricular and syllabus materials, as well as how people talk about school science. Doing this means effectively ignoring differences between spoken and written language and focussing instead on its science content. As there are documented differences between spoken and written language (see Halliday, 1985/1989a, and Chafe 1985, 1986, 1981 for views of these differences), it is useful to note that the initial section here will focus on educational rather than linguistic perspectives on the topic of the language of school science. This point, of conflating speech with writing, should be kept in mind in reading this section.

A second issue is that of describing the language of school science from multiple disciplines. Here, the concern is that while educationalists looking at the language of school science may do so in a way that is quite amenable to educationalists, including teachers and school administrators and planners (including curriculum developers), linguists may present their case using the language of their own discipline. This language, as with any discipline-bound discourse, must be taken into account, when addressing concerns within education and schooling.

In order to deal with both points, the first section here will look at educational views of the language of school science, while the second section will focus on more explicit and detailed views of linguistic theory.
In looking at content learning within schooling, Mohan writes that ‘...language is a system that relates what is being talked about (content) and the means used to talk about it (expression)…but in research and in classroom practice, this relationship is frequently ignored. In subject matter learning we overlook the role of language as a medium of learning. In language learning we overlook the fact that content is being communicated.’ (Mohan, 1986, 1) While Mohan was writing in the context of learning non-native languages, in many respects his statement above is in line with much of the literature of school science.

There has been much research internationally over the past few decades that has focussed on the language of school science. Bennett writes that this research has come in stages. The first stage was, ‘undertaken in the 1970s and early 1980s, [and] concerned pupils’ understanding of scientific terminology and other vocabulary associated with the teaching of science.’ (Bennett, 2003, 149) This work was heavily influenced by the work on English language development by Douglas Barnes and James Britton. The next stage, in the early 1990s, is described by Bennett as tending to be, ‘...documents drawing on research to make recommendations for practice in science lessons...or ‘position papers’ putting forward commentary and ideas on the current status of the role of language in science education.’ (p. 149). Later research has been in three key areas:

1. ‘...an increased interest in relating theories of language development to the teaching of science,’
2. ‘...a focus on the analysis of talking (often called discourse analysis) in science lessons,’
3. ‘...an exploration of the nature and purpose of writing styles (genres) in science.’ (Bennett, 2003, 149-150. Italics in original.)

The literature on the language of school science, particularly in the English-speaking world, has been growing and coming from two theoretical domains: educational theory and linguistic theory. Bennett writes that much research into the
The language of science has largely taken place '...without reference to theories on language development and the literature on language as a means of developing understanding'. (Bennett, 2003, 151)

The first section, on educational perspectives, will focus on two specific areas: first, is the notion of the technical nature of the language of school science; and second, is the measuring of readability in school science. The latter, of course, relates solely to written texts.

The second section will present the details of the description of one linguistic perspective. This perspective has explored the language of school science to some depth, and sought to allow for explication of problematic areas of learners (at various levels) in the learning of science. The sections will be briefly described, and then compared and contrasted.

### 3.3.2 Educational Perspectives of the Language of School Science

As noted above, Bennett (Bennett, 2003, 151) suggests that much of the work into the language of school science has '...largely taken place without reference to theories on language development...', or the field of linguistics. It may be worth looking at a salient quotation, which almost serves as a 'starting point' into this research. In 1990, Wells stated that, 'the centrality of talk in education is finally being recognised.' (Wells, 1992, 283) Wells in that essay was looking more broadly at the work of the National Oracy Project in the UK in the early 1990s, but is taking into consideration research over previous decades (see, for example Halliday, McIntosh and Strevens, 1965; Sinclair and Coulthard, 1975; Cazden, 1988 (2001); Cope and Kalantzis, 1993; Christie, 2002 in a progression through the decades) in the area of school language.
However, an interest in the language of school science can be seen much earlier. Writing in 1903, Armstrong noted, ‘...at school the habit is acquired of learning lessons—of learning things from books...’ (Armstrong, 1903, 9) In other words, this entails learning from books and through language. Rather than looking at the history of the language of science (Bazerman, 1989; Halliday in Halliday and Martin, 1993), this section looks at how educationalists, over the past 25 years, have seen the language of school science.

It is accepted from the outset that much of the educationalists’ work documented here can be considered valid from the perspective of the educator, or perhaps even the classroom practitioner—but one question to consider is: does it really look at language? The subsequent section will differ in focus by shifting away from how educationalists see the language of school science to how linguistics see the same phenomenon.

This overview of school language through educationalists’ eyes will focus on two specific categories. First, will be views of technical vs. non-technical language, and second will be a look at readability in relation to reading and writing in the science classroom. The focus here is invariably in relation to written language, and neglects specific characteristics of spoken language. This is in contrast to the previous section of this chapter looking at classroom discourse, which neglected written language in order to focus on the interactive talk of the classroom.

3.3.2.1 Technical Language in School Science

In looking at the language of school and classroom science, perhaps it is first important to identify what it is that distinguishes scientific language from other language. Here, from an educationalist perspective is the notion of technicality. Or, rather, technical as opposed to non-technical language. Bazerman suggests that when considering the language of science, ‘...we see a very specialised development of
language, distinct from our everyday conversation and newspaper reading.’ (Bazerman, 1988, 293) This is where the key distinction will sit: everyday as opposed to specialised language.

Proposing a list of differences between everyday and specialised, scientific language, Bazerman offers the following:

Unfamiliar words signify objects and phenomena from the microscopic and macroscopic limits of the universe, objects distinguished from each other and classified with a precision and taxonomic care have little to do with our everyday fuzzy naming of the objects of domestic life...this specialised language of science seems constantly filled with evidence, numbers, observations, pictures, to ensure that the formulations correspond to real things. (Bazerman, 1998, 293)

Bazerman is suggesting that what science requires (or, rather, how scientists use language) is to seek to make sense of the world through a specialised discourse.

Wellington and Osborne, who have written extensively in the area of science education, state that, ‘...language in science matters. We believe that there is a body of disparate research of the past 30 years that shows that one of the major difficulties in learning science is learning the language of science.’ (Wellington and Osborne, 2001, 1) In fact, Osborne, writing on his own, says that, ‘...the student can be confronted with more new terms in a science lesson than a language lesson.’ (Osborne, 2002, 210)

From the outset, it is important to note that science, and the language of science, must be contextualised. In the wider world, in the school, in the classroom, the language used by teachers, textbooks and students is meant to construe the world in ways that are highly specific. This specificity of language is used to objectify the world. Leach and Scott comment that, ‘In some areas, there are striking differences between ‘everyday’ social language and the ‘school science’ social language introduced through teaching. For instance, in being introduced to the scientific concept of gravity, the learner is
required to take on board the concept of ‘action at a distance’.’ (Leach and Scott, 2004, 92). This objectivisation requires a technical language.

But the technicality of the language of science that is not the only difficulty. Wellington suggests that, ‘...many of the naming words of our lives have been commandeered by science. Consider: element, conductor, cell, field, circuit, compound. This is made worse because many of the terms of science are metaphors. For example, a field in science is not really a field.’ (Wellington, 2000, 3) What Wellington means, of course, is that a scientific ‘field’ is not the same as an everyday, vernacular ‘field’. This use of non-technical language, applied semantically in a different context, contributes to problems in learning science in schools.

O’Rafferty, writing in an Irish research context, notes that, ‘Virtually all of the pupils tested [in her M.Ed. research] were found to have deficiencies in their understanding of non-technical vocabulary—a vocabulary important to their learning of science and used in science textbooks and teaching.’ (O’Rafferty, 1987, 199) She further stresses that, ‘...while science teachers may expect to teach their pupils a very large number of technical words, they may be unaware of the difficulties which non-technical vocabulary causes their pupils.’ (O’Rafferty, 1987, 1999)

Also referring to non-technical language, Carré, writing in 1981, notes that, ‘Apart from the problem of understanding specialist vocabulary, pupils also find great difficulty in handling non-technical words when used in a science context.’ (Carré, 1981, 10) He further comments that:

Vocabulary poses particular problems, but the books which pupils meet present them with many other problems. The formal grammatical structure of scientific prose, where heavy use is made of the passive voice, is a style of communication quite foreign to many pupils. Also the average sentence-length in science texts is generally far too long for slow readers to cope with, and even if their visual memory-span were greater the sentences carry a heavier ‘load’ than other school texts...[P]upils must come to grips with the science register if they are to succeed in the subject. (Carré, 1981, 11)
This paragraph takes into account notions of technical (as well as vernacular) language, but also begins to highlight difficulties in relation to reading school science.

Looking specifically at the technical nature of the language of school science, however, and using Wellington and Osborne’s reference to ‘research of the past 30 years,’ (Wellington and Osborne, 2001, 1) there have been numerous attempts, based on educational research, that classifies the language of school science. While linguistics does inform some of these analyses, much of the research within educational research is principally lexical. This will hardly cover all the research over the past few decades, but will begin to dissect specific aspects of the technical nature of the language of school science.

Writing in 1973, in quite early research in the area, Evans states that, ‘In the sciences, terminology causes special problems...Secondary school pupils, for instance, may be expected to learn as many new terms in a science subject as they encounter in studying a foreign language—with the additional difficulty of detailed conceptual content.’ (Evans, 1973, 585) Evans then attempts to identify those technical aspects of science language.

‘Technical term’ is defined by Evans as, ‘...a word or phrase which, when used in the context of a particular academic discipline, carries a single specific meaning...the majority of [which] are single words...’ (Evans, 1973, 585) He suggests two specific types of words potentially posing problems for students:

- ...the first concerns homonyms---words which have the same spelling but different meanings, and
- ...the second difficulty...is caused by derivatives. The problem in this case is whether joining a prefix or a suffix to a root represents an addition to the technical vocabulary, or whether the meaning of the new expression can be readily deduced from those of its components. (Evans, 1973, 585-586)
Here, as will be seen in other, later, sections, the focus is frequently seen to be the specific word or words, or lexical items. Evans then breaks the set of words students may find difficult in learning, with the intent of compiling 'vocabulary lists' for them. There are five approaches for categorising words into such lists, including:

- ...according to parts of speech...most scientific terms are nouns; the rest are usually verbs or adjectives,
- ...according to their derivation...the majority have been taken from Greek...or Latin...and some from other languages,
- ...by subject. All disciplines include a number of specialised approaches which have their own names,
- ...according to entry into the technical vocabulary. Fundamentally, there are two vocabularies: the technical and that of ordinary language, and
- ...according to function. The primary dichotomy in such a scheme should reflect the two fundamental aspects of any academic discipline, namely its subject matter and its methods of study. (Evans, 1973, 590-591)

The thinking behind this, for Evans, is that, 'Any research into the roles of technical terminology will have to decide how terms may be recognised and sampled, and the work is likely to be of greater value if the vocabulary collected is classified.' (Evans, 1973, 590)

This is an early example of how technicality might be seen within educational perspectives of the language of school science.

Slater, writing in 1978, notes that, 'Scientific English has been considered a sufficiently discrete and coherent entity to admit of a description using tools of theoretical linguistics.' (Slater, 1978, 7) He further suggests that, 'Analyses of scientific English tend to be of two kinds—those which attempt a comprehensive description of its general linguistic properties, and those which deal in more detail with just one or two of its features—usually from a more general theoretical perspective. Of those features mentioned by the former type of study, the most comment is the high proportion of passive constructions.' (Slater, 1978, 10)
Distinguishing between ‘technical’ and ‘non-technical’ language, Slater writes that, ‘... the two behave in different ways, since the writer has more freedom in his choice of non-technical words than of scientific terms. Taken together, however, the two types of vocabulary have, until recently, been singled out for more attention as a major cause of difficulty for the learner of science than any other aspect of scientific English.’ (Slater, 1978, p. 14)

Slater then draws from the linguistic work of Peter Strevens, who offered a set of characteristic features of ‘scientific English’ in 1976, which include:

...long and complicated noun-phrases...a higher proportion of passive constructions--the frequent use of logico-grammatical items...a high proportion of items of specialized vocabulary. (Strevens, 1976, 64-65. Cited in Slater, 1978, p. 15)

Slater then adds, from Strevens, the following quote: ‘...such surface features of scientific discourse tell only part of the story. Equally important is the fact that the argument, the rhetoric, the communicative function of Scientific English is chosen so as to serve the particular purposes of the writer or speaker...’ (Cited in Slater, 1978, 15)

Strevens here is seeking to highlight the rhetorical and discourse features present in scientific language. These, then, are ignored by Slater, who, continuing to describe technical language in science, writes that:

To Strevens’ list of surface features, we can add the following items: the frequent use of auxiliary verbs (such as ‘may’, ‘can’, and ‘will’) in an uncommon setting, an unusually high proportion of non-finite verbs, frequent recourse to rules of morphology in the construction of vocabulary items, a relatively simple clause structure within sentences and frequent use of sentence adjuncts, the expectation that the reader can derive and use implicitly presented information in the course of comprehension of connected discourse, and the frequent drawing of explicit or implicit comparisons. (Slater, 1978, 16)

The issue of ‘surface features’ will be explored later, and is a feature of nearly all of the education literature of school science. While Slater does draw from linguistic theory, it
is difficult to see what is being explored here, in linguistic terms, but the identification or classification of lexical items, as if words (by themselves) stand on their own.

In looking at the notion of 'technical' language, O'Rafferty comments that, 'The English used in scientific and technical writing has been considered an adequately well-defined entity to allow its description using the tools of theoretical linguistics.' (O'Rafferty, 1987, p. 48)

She continues by writing that:

While the English used in scientific writing uses no unique phonology, orthography or grammar, it uses an elaborate range of written symbols, and some types of scientific writing make frequent use of mathematical formulae or graphs, and, in others, use of illustrations is common. The complexity of science textbooks has been considered a product of three distinct yet related variables: linguistic, rhetorical and conceptual. (O'Rafferty, 1987, p. 48)

Here, O'Rafferty notes linguistic, rhetorical and conceptual factors in complexity, which she sought to elaborate on when she identified features of scientific prose including:

- ...long and complex noun-phrases, a high proportion of passive constructions,
- frequent use of logico-grammatical items such as 'unless', 'whenever',
- a high proportion of items of specialised vocabulary,
- frequent use of auxiliary verbs in an uncommon setting,
- a high proportion of non-finite verbs, a relatively simple clause structure within sentences,
- frequent use of Greek and Latin affixes, and pronouns which serve purposes differing from those they fulfil in everyday discourse. (O'Rafferty, 1987, 40-50)

Note that there is much overlap between the O'Rafferty, Evans and Slater classifications above. Taking her analysis further, O'Rafferty writes, in relation to helping 'weaker' students in science class, that, '...the context in which these words—
be it spoken or written—should be such as to enable pupils to acquire at least possible meanings for these words.' (O’Rafferty, 1987, 199-200)

These analyses are valuable as they highlight different characteristics of the language used in the teaching and learning of science.

More recently, Wellington and Osborne offer their taxonomy of the words of science. They preface this by writing, ‘...it can be useful to divide the words of science into various types or categories. Through doing this, science teachers can become more aware of the language used in their classrooms. A classification or ‘taxonomy’ of the words of science [shows how]...each category of words acquires meaning in a different way, and it is this complexity that teachers of science need to be aware of.’ (Wellington and Osborne, 2001, 20).

Their broad taxonomy includes four base types of words: Naming Words; Process Words; Concept Words; and Mathematical ‘Words’ and Symbols, and are thusly described:

- The first category can be called naming words. These are word that denote identifiable, observable, real objects or entities...many of these are simply synonyms for everyday words already familiar to pupils...[and] part of learning in science involves giving familiar objects new names...[though] some learning in science involves giving new names to unfamiliar objects, objects which pupils may never have seen before... (Wellington and Osborne, 2001, 20)
- The second category of scientific words, at a new level of abstraction, can be called process words. These are words that denote process that happen in science...some of these process words acquire meaning for a pupil more easily than others...certain process are in a sense visible, or at least ‘showable’. Their meaning can be learnt by ostensive definition. (20-21)
- The third, and largest, category of words in science are concept words. These are words that denote concepts of various types... [and pose] most learning difficulties...for concept words denote ideas at gradually ascending levels of abstraction. The difficulty is magnified because these words cannot be understood in isolation. (21)
- The language of mathematics, its ‘words’ and symbols, can be placed at the fourth and highest level of abstraction in a hierarchy of scientific words. The mathematical language used in advanced physics is neither derived from, nor directly applicable to, experience. Its meaning is so detached as to become
almost independent of the physical world.(21-22. Italics in above quotations as in original.)

As can be seen, this provides much more detail than either Evans or O’Rafferty, but again there is much overlap (compare this approach for classifying words within science with Evans above).

Noting that linguistic theory is not absent from Wellington and Osborne’s fine work, they do refer to Halliday and Martin’s work when they introduce the notion of ‘grammatical metaphor.’ The description of grammatical metaphor is given as:

...the use of grammatical metaphor, where one grammatical structure is substituted for another. The most common is nominalization, where a noun is substituted for a verb or where nouns are used as adjectives. So instead of talking about ‘how fast a car speeds up’, we talk of the ‘car’s acceleration’, or instead of talking about ‘how quickly cracks in the glass grow’, we talk about ‘glass crack growth rate’. Scientific language is riddled with such examples and this process of nominalization is inherent to the discourse as it attempts to construct nouns between which it can define causal relationships. As a discourse, it serves its function of communicating complex ideas in an economic and efficient manner. (Wellington and Osborne, 2001, 66)

This is perhaps the most explicit and detailed reference to linguistic theory in the educational literature. However, in a footnote, Wellington and Osborne write that, ‘space here does not allow the kind of detailed insights provided by the work of the linguist Martin Halliday [sic.], to which the interested reader is referred.’ (Wellington and Osborne, 2001, 81) Later in this chapter, Halliday’s linguistic analyses of science language will be explicated and reference will be made back to Wellington and Osborne’s work.

Writing just a year later, Osborne offers a slightly more detailed analysis. In this essay, Osborne (2002) states that the complexities of science language include: ‘...the polysemic nature of language, the role of logical connectives, the multi-semiotic nature of its discourse and science’s unfamiliar genres,’ and describes the first three of these in turn:
Polysemy: ...a consequence of language’s inherent polysemy is that scientists are troubled by language. Scientists...want their words to be purely technical signs with no index of meanings. But the danger of words lies in their natural ambiguity;

Logical connectives and their significance: Logical connectives are essential to the process of constructing an argument, generating the relationships between claims, warrants and data and contrasting and comparing similar and distinguishable phenomena...most teachers of science do recognise that much of the vocabulary they introduce may be unfamiliar and require careful exposition, but how many are cognisant of the converse, that many of the words they use are familiar but used with unfamiliar meaning in strange new contexts? Or that, whilst using the language of science, it is necessary to teach students about that language if they are to comprehend its meaning.;

Science as multi-semiotic language: ...the student can be confronted with more new terms in a science lesson than a language lesson; that standard school science texts can contain as many as 2000 different technical terms, and by the fact that the students is confronted by a multi-semiotic mode of communication... The problem for science is that natural language is very limited in its ability to describe continuous variation, shape and the interrelationships of structure, form and function. (Osborne, 2002, 210-211. Italics as in original.)

In taking this further, and insisting that, ‘The task confronting the student is not one of learning the language of science but one of learning the languages of science’ (Osborne, 2002, 211, emphasis in original), and, beginning an interdisciplinary leap, Osborne continues that, ‘...the language of science is exceptional in that its discourse is cumulative. This does not mean that it contains some inner hierarchy but merely that each conversation in any given scientific domain builds on ones that have gone before; science thus progresses in a fundamental way that most other disciplines do not.’ (Osborne, 2002, 211)

Highlighting features of such writing, and in a glossing of ‘genre,’ Osborne writes that, in science writing, ‘...the personal is excised and pupils are encouraged to write in the passive voice. So rather than writing ‘we took the Bunsen burner and heated the copper sulphate’, the standard genre of science would use the wording ‘the copper sulphate was heated’ resulting in the excision of any sense of an actor or the personal.’
It is at this point in his essay that Osborne gets close to introducing a linguistic orientation into his thinking. In this move, Osborne, moves beyond the lexical item explicitly and states that...

...science is more than its vocabulary; words have value only when used as referents or to represent meanings. Knowing the vocabulary of science without understanding how it is used, or why, is akin to knowing the words of a foreign language with no understanding of its grammar or standard modalities of expression. Likewise, emphasising the role and value of empirical activity at the expense of exploring the language of science is similar to proffering a hammer without a nail. (Osborne, 2002, 211)

He states further that, ‘...without this case for the importance of language in science education being acknowledged, all else is in vain.’ (Osborne, 2002, 213)

In a strong conclusion, Osborne stresses that:

The argument here has been that literacy is not an additional element but an essential constitutive practice of science whose study is as vital to science education as sails are to ships, bricks are to houses or engines to cars. Improving the quality of science education, both in terms of the experience it offers to its students and its cognitive and affective outcomes, requires the restoration of language and literacy to the central position it occupies in its practice; nothing else will suffice. (Osborne, 2002, 215)

What is important here is the reference in Osborne’s essay to moving beyond vocabulary into textual structure and meaning.

In fact, this deeper analysis was sought earlier. Writing in 1984, Davies and Greene asked the questions: ‘How are the texts of science to be described; in what ways do they differ from texts in other subject areas; and how does the text influence the reading task?’ (Davies and Greene, 1984, 37) Here, they are asking how the ‘language’ differs from other subject areas.

According to the two authors, ‘The texts of history, geography, English and science are apparently different. We want to be able to describe the specific features which give rise to differences, and also to similarities, in texts across the subject range.’
(ibid. 37) However, in a shift from the already cited literature, Davies and Greene state that they:

...depart from tradition: our analysis does not start with the surface features of a text, like terminology, sentence length, or readability level, but with the underlying elements of meaning or information [a note is appended to the effect that the authors use the terms synonymously, but that meaning generally refers to narrative, and information refers to non-narrative texts] on which texts are based. (Davies and Greene, 1984, 37)

As can be seen, Davies and Greene take a much wider lens to begin a look at words in association with other words towards meaning. More precisely, within the science classroom, ‘...the writer’s intention is usually to inform: to describe, explain, and initiate readers into ways of observing, thinking about, and doing things,’ and they attempt to look at what is labelled, ‘information structure,’ which is defined as, ‘...the underlying structure of information communicated through text which we want our pupils to reach.’ (Davies and Greene, 1984, 38)

Here, the authors are (pace Osborne’s later work) looking at ‘more than vocabulary’ and define three criteria of a textual nature which distinguish writing in science from other school writing and language:

1: ...the presence or absence of certain information constituents (or slots);
2: ...the existence of certain relations amongst these constituents; and
3: ...the size and distribution of the language units in the text which represent the different constituents. (Davies and Greene, 1984, 76)

This work is an indication of attempts at migrating into linguistics or integrating research from linguistic theory. Such efforts have been few and far between, however, and perhaps indicate a weakness in this literature, opening the possibility of expanding that literature in a different direction in future.
One final area to consider when looking at the technical language of school science is metaphor. It was noted earlier that Wellington writes that, '...many of the terms of science are metaphors. For example, a field in science is not really a field.' (Wellington, 2000, 3. Emphasis added) This is a subject that will be detailed later in the chapter when linguistic, rather than educational, research is discussed, but elsewhere Wellington, this time with Osborne, comments that, '...learning science is as much learning to use the language of science as it is learning the facts and definitions of science or its experimental procedures. Learning a language requires opportunities to use that language and write science in its standard forms.' (Wellington and Osborne, 2001, 67, italics in original) This is an important area that takes the notion of technicality of school science language into the area of linguistics, which will be reviewed in some detail later.

So far, three specific areas have been covered: technical language, non-technical language used in a new context, and, briefly, metaphor. Note, though, that each of these (with the early exception of Davies and Greene and the later essay by Osborne) tend to hover around the word, or lexical, level. These lexical items are given grammatical terms, and reference is made to lexico-grammar, or language in use in context, though this deeper level of research or analysis is simply not present.

For instance, Rafferty refers to, '...frequent use of logico-grammatical items such as 'unless', 'whenever'...’ (O’Rafferty, 1987, 49-50), which are lexical instances of connectives between other sets of words. Osborne refers to these as ‘logical connectives’ and suggests they are, ‘...essential to the process of constructing an argument, generating the relationships between claims, warrants and data and contrasting and comparing similar and distinguishable phenomena...’ (Osborne, 2002, 210) Referring to logical-grammatical items and logical connectives in isolation, as both
educationalists do, means they maintain a discussion at the lexical level, something that
changes when linguists enter the picture.

In talking about the language of school science, of course, it is important to keep
actors relevant to the context present in any discussion. Here there are teachers and
students, who talk the language described above, but also textbooks and reading within
the science classroom.

There is a rather large literature in these specific areas. Studies that look at the
language of teachers in the classroom include Leach and Scott who write that, ‘...there
are relatively recent studies which do focus upon the teacher in the science classroom,
particularly with regard to the ways in which the teacher acts to guide the development
of the classroom talk.’ (Leach and Scott, 2004, 84) These studies focus on various
aspects of the role of the teacher. Such research includes: literacy in the science
classroom (Rowell and Ebbers, 2002; Leach, 1996); the awareness of science teachers
of language in their classrooms (Willis, 1995; Scott, 1993); teachers’ use of narrative
within the science classroom (Scott, 1993; Leach, 1996); the ‘art’ or ‘science’ of
teaching science (Wellington, 2000); and a host of other areas (see Yore, 2004 for an
extended overview).

Perhaps the best way to summarise this area of research is to quote Carré, who
writes:

What’s the message for a science teacher? If we adopt the attitude that
there is only one ‘right’ way of talking science, one universally-
accepted mode of defining terms then we exclude the most powerful
capacity of pupils to make sense through their own private bank of
experience, words and ideas. Meaning cannot be given by a teacher in
some predetermined set of words: individuals must have every
opportunity to re-sort, blend and shuffle their own ideas. (Carré, 1981,
46)

It is the pursuit of meaning that teachers should focus on for all students. But are all
students open to the exploration of meaning in the science classroom? The next section
looks at the issue of 'readability' from an educational perspective, and relates these to issues of technicality of the language of school science.

3.3.2.2 Readability in School Science

Having discussed the idea that the technical nature of school science language causes some students difficulty in learning science in schools, one approach to dealing with this as an educational issue has to be to quantify it. This has been done through the development of readability formulae, which seeks to label any particular text depending on level of readability for a student at a certain age or student cohort. It is readability and its application in relation to science texts which will be the next subject of discussion.

Readability may be defined as being ‘...concerned with the problem of matching between reader and text.’ (Johnson, 1998, 1) Readability is not a new phenomenon, and indeed has been explored for over a century. Harrison writes that, ‘...ever since the nineteenth century, when the first attempts were made to describe the comparative difficulty levels of books...’ (Harrison, 1983, 19) Slater notes that the history of readability includes four distinct areas of focus, ‘...starting from the first true readability formula of Lively and Pressey (1923).’ (Slater, 1987, 87) Drawing from the work of Klare (1963) the four areas can be broken down thusly:

- Formulae which were approximate and crude (1920-1934),
- Formulae where were more detailed and which aimed for greater accuracy and reliability (1934-1938),
- Formulae which were intended to be simple but nevertheless efficient (1938-1953),
- Formulae devised for special purposes (1953-1958). (Slater, 1987, 87)

More recent work seeks a rather more pragmatic and practical approach and can be summed up by Harrison who suggests it is important for, ‘assessing the difficulty of
books in school, and matching texts to individual children or groups of children.'
(Harrison, 1980, 1) More specifically, Johnson states that, ‘The term readability refers to all the factors that affect success in reading and understanding a text. These factors include:

- The interest and motivation of the reader.
- The legibility of the print (and of any illustrations).
- The complexity of words and sentences in relation to the reading ability of the reader. (Johnson, 1998, 1).

Johnson notes, with particular relevance for this thesis, that these factors are seen in the, ‘...results of research into school science textbooks.’ (Johnson, 1998, 1) While ‘interest and motivation’ may be psychological in nature and ‘legibility of print (and of any illustrations)’ may be physical, it is the third factor which will be explored here as it the one which highlights language. However, as the basis of readability formulae is statistical, this final factor is also, in the words of the author, ‘the most easily quantifiable.’ (Johnson, 1998, 3)

Johnson writes that there are various ways of testing for reading age. ‘Subjective assessment has been shown to be inaccurate, with teachers (perhaps because they are good readers) usually under-estimating the difficulty of the text (by up to 8 years). There are [however] four main methods of objective assessment.’ (Johnson, 1998, 4. Emphasis in original) These methods are broken into:

- Question and Answer technique: ‘Pupils of different ages are given the text to read...then questioned to gauge the level of comprehension and hence determine the reading age’, (Johnson, 1998, 4)
- Sentence Completion (the ‘cloze’ technique): ‘Sentences are taken from the text and every nth word is deleted. Often, n=5. These sentence completion exercises are then given to pupils to test comprehension and gauge the reading age’, (Johnson, 1998, 4)
- Comparison of text with a standard word list: ‘The percentage of words not included in the Dale [standardised] word list is determined and the reading age calculated from this’, (Johnson, 1998, 4)
Calculations involving the sentence length and number of syllables: 'These tests are concerned simply with the length of sentences and the number of syllables. They do not take into account the order of words in a sentence...'. (Johnson, 1998, 4-5)

Johnson comments that the first three of these are either 'unrealistic for practising teachers', 'time-consuming' or 'tedious' and focuses on the fourth. There are, '...well over 200 such tests!' (Johnson, 1998, 4. Exclamation mark in original.), including: Gunning 'FOG' Readability Test; Fry Readability Graph; Flesch-Kincaid Formula; Powers-Sumner-Kearl Formula; McLaughlin 'SMOG' Formula; FORCAST Formula (references for all can be found on Johnson's website on readability: www.timetabler.com; see also Long, 1991, 26-32)

The McLaughlin 'SMOG' Formula (for example) is calculated by, 'Select[ing] samples of 30 consecutive samples. In each sample, count the number of words with 3 or more syllables. Find the average number, N. Then grade level = (square root of N) + 3. Reading = (square root of N) + 8 years.' (Johnson, 1998, 6) For each of the formulae, the focus is on either number of words, or words and sentences, without identifying the level of real or perceived difficulty of any individual word in context.

Harrison notes that 'vocabulary has been considered the most important factor determining text difficulty...' and that, '...research studies consistently find vocabulary to be the surest single predictor of text difficulty.' (Harrison, 1980, 19) Harrison suggests that two common ways of identifying 'difficult' texts are word length and word frequency. In addition, Harrison notes that one source of difficulty is that, '...the most frequent nouns and verbs have a great many different meanings.' (Harrison, 1980, 21) Relating vocabulary and semantic difference to conceptual difficulty, Harrison points out that, while related, these should be considered separately. This is because of context, and the example offered is, *a black hole in space*, which, '...can only be fully understood by specialists in astro-physics.' (Harrison, 1980, 21) As it is difficult to
account for such contextual features, Harrison writes that, ‘Most researchers have therefore tended to go for vocabulary measures of the type which can be applied in a fairly mechanical way.’ (Harrison, 1980, 22) It will be seen later in this chapter, that while this may be true for educationalists, it is certainly not true for linguists.

In looking at how syntax contributes to readability difficulties, Harrison suggests that, ‘A passage can be difficult if it is very complex in structure, because it puts too great a load on short-term memory and information processing capacity.’ (Harrison, 1980, 22) In a table looking at syntactic features which may cause reading difficulties, Harrison lists five types:

- Active versus passive verb
- Nominalization versus Active verb
- Modal verbs
- Clauses per sentence
- Compression and substitution. (Harrison, 1980, 23)

Harrison then notes that, ‘although this section is about grammatical and structural difficulties, some points in [the table] are as much concerned with meaning as with syntax...for avoiding the nominalisations reduction and increase, the meaning of the sentence is changed by adding the more familiar you form of the verb. This has the effect of making the vocabulary similar to that of speech, and it increases the human interest of the sentence.’ (Harrison, 1980, 25) In some ways, Harrison is linking the teacher’s work with, and to, that of the linguist.

From Harrison and Johnson’s research, two key elements can be seen. The first it that readability is limited to word and weak grammatical structural analyses, without looking at or accounting for context of the text—this is the same as the section above on technical language. Nearly the entire focus is on the lexical item. Second, the varieties of readability assessment seem to have been designed with practicing teachers in mind.
While this second factor must never be dismissed, it suggests a limit in the analysis that
weakens the effectiveness of such analyses.

For instance, while readability assessment has been in place for many years,
Olsen and Johnson suggest that, ‘...even though currently used readability formulas are
widely seen among scholars to have serious problems.’ (Olsen and Johnson, 1989, 223)
One of the main problems with readability they suggest is that of empirical evidence
supporting its efficacy. Olsen and Johnson note that one study ‘...used four versions of
a text’:

1. the original version,
2. one with simplified vocabulary (substitution of easier and more
frequently occurring words),
3. one with simplified grammatical structures (containing only simple
sentences, no more than 2 phrases per sentence, and short sentences), and
4. one with the combined simplifications of vocabulary and grammatical
structures.’ (Olsen and Johnson, 1989, 224).

They state that, ‘the effect of the simplification was an approximate 6-grade drop in
reading level from the original text to the combined simplifications text. The readability
differences were maximised by using readers who were low-motivated, unfamiliar with
the topic, and widely varying in reading skills.’ (Olsen and Johnson, 1989, 224) This
extract seems to suggest a sort of ‘dumbing-down’ of the texts that can result from
readability work. Olsen and Johnson comment that, ‘any realistic model of language
comprehension must take into account at least the nature of the language processing
faculty, the reader’s knowledge of the language and of the ‘world’ (the domain of
discourse), as well as the structure of the text itself.’ (Olsen, 1989, 231)

Further critique comes from Slater, writing a bit earlier. In fact, Slater draws on
Kress (1954) in citing four specific problem areas within readability studies, stating that
this early study found that formulae:
1: ...tended not to agree in their methods of assessment of materials (note that figure of over 200 readability above),
2: ...take no account of reader variables (just age- or grade-levels),
3: ...take no account of meaning, and
4: ...were not designed to provide rules for writing (or to explicate how writing of students might be improved. (Quoted in Slater, 1987, 88).

Further, Slater notes that, ‘...all of the[se] criticisms could still be levelled at the formulae, and in addition, ...formulae give no idea of how their accuracy is influenced by sample size, ... make the unwarrantable assumptions that the relationship of word and sentence difficulty is linear, and that the same relationship between factors used in formulae and difficulty exists for all readers.’ (Slater, 1987, 88)

Finally, while Harrison in his study looks at the language of school science, O’Rafferty notes of readability studies that, ‘...due to the special features of scientific language, their use with science text is even more dubious than their use on less specialised text.’ (O’Rafferty, 1987, 48)

While this description and critique of readability does not negate its use in educational circles, particularly as a starting point in understanding how students do or not do not comprehend texts in school learning, it is to highlight its inadequacies. In particular, those inadequacies relating to detailed structures of language, and to lexicogrammatical patterns of language in use.

What does examining in detail the specific features of language beyond lexical items (the words used) and grammatical structures (the order of words used, which may also be referred to as syntax) offer in understanding the language of school science? The next section of this chapter shifts the focus from principally educational perspectives to a linguistic lens, and explores the language of school science in a more precise, detailed way. However, one must question if the section below is accessible to educators and teachers of science.
The previous section detailed the educational literature on the language of school science, and contained two focal points. The first was the technical nature of such language, and the second was a look at readability. Both of these reviews looked at how each of these elements focused almost solely on words in their own right. This can be seen clearly in O’Rafferty’s comments that, ‘…the English used in scientific writing uses no unique phonology, orthography or grammar…’ (1987, 48) In addition, while Osborne notes that, ‘knowing the vocabulary of science without understanding how it is used, or why, is akin to knowing the words of a foreign language with no understanding of its grammar…’ (2002, 21) However, what is known about the specific grammar of the language of school science?

The bulk of work within an educational context that considers language beyond lexis emanates from within the field of linguistic study known as Systemic Functional Linguistics (SFL). This area of linguistic theory has been used to explore the language of school science in some depth over the past four decades (Huddleston, et. al., 1968; Huddleston, 1971) and through the following years (Halliday, 2004 for a collected set of his own essays on science; Lemke, 1990; Halliday and Martin, 1993; Martin and Veel, 1998) In addition to science, SFL has been used to explore the specific language of school English (Christie, Derewianka); History (Coffin); Geography (Veel); and Maths (O’Halloran). While this thesis looks at school science, it is apropos to refer to this other research as a reflection of how much SFL has sought to contribute to analysing, and understanding, the language used in schools.

Hudson writes that, ‘linguistics has something important to offer that education needs.’ In detailing this comment, he continues by suggesting that
Non-linguists’ judgements may be penetrating and illuminating, and non-linguists may even be able to internalise the features of the text to the extent that they can imitate its style, so they must be analysing these features implicitly; but they cannot make the analysis explicit... What is needed here, quite clearly, is a linguist’s ability to relate global properties to specific linguistic patterns. (Hudson, 2004, p. 113)

In a related way, but focusing specifically on the contribution of SFL to language of schooling, Schleppegrell writes that, ‘...one of the major goals of [SFL] research has been to describe academically valued contexts of use, elucidating the linguistic features of the genres of schooling and showing the challenges that those features present to students who are developing advanced literacy.’ (2004, 19) While Scheppegrell looks specifically at school ‘literacies’, her comment is relevant to spoken school discourse.

What follows is a far more explicit description of the language of school science than described above, and will be based on Halliday’s SFL and include his own work in some detail.

That only one theoretical framework is being presented here does not suggest that it is the only theory to specifically explore the language of school science, only that it provides the most sustained and detailed look at that language. The use of this framework will allow for a clear distinction being made between educational perspectives and linguistic perspectives on the same phenomena: the language of school science. This contrast should help bridge to the subsequent and final section of this chapter looking at the classroom discourse of science.

3.3.3.1 Halliday’s Description of the Language of School Science

Starting with the sections above on the nature of the language of school science from educational perspectives, and taking into account that some did look at linguistics (the scientific study of language) to inform their work, it can be seen that the
bulk of the literature refers to issues relating to words, or language at the lexical level. Halliday notes that, ‘...science teachers usually think of the difficulties first in lexical terms: that is, as difficulties of vocabulary. This is what is implied by the term ‘jargon’, which means a battery of difficult technical terms.’ (2004, 160)

He continues by offering a contrasting view, one that opines:

...that science is totally dependent on scientific language: that you cannot separate science from how it is written, or rewrite scientific discourse in any other way. According to this view, ‘learning science’ is the same thing as learning the language of science. If the language is difficult to understand, this is not some additional factor caused by the words that are chosen, but a difficulty that is inherent in the nature of science itself. It is the subject-matter that is the source of the problem. (160)

Highlighting the focus on words/lexical items, Halliday is not suggesting that level be ignored. Rather, he writes that, ‘it is important to arrive at a balanced view on this question, because we not only need to identify what the problematic features of scientific English are; we also need to try to explain them...’ (161) In rather strong language, (and a rather long quotation) Halliday suggests, in improving science pedagogy:

...we shall need to get rid of our obsession with words. The difficulty lies more with the grammar than with the vocabulary...technical terms are not, in themselves, difficult to master; and the students are not particularly dismayed by them. It is usually the teacher who puts technical terms in the centre of the picture, because vocabulary is much more obvious, and easier to talk about, than grammar. But the generalisations we have to make, in order to help students cope with scientific [language], are mainly generalisations about its grammar. The problems with technical terminology usually arise not from the technical terms themselves but from the complex relationships they have with one another. Technical terms cannot be defined in isolation; each one has to be understood as part of a larger framework, and each one is defined by reference to all the others. (161-2)

Halliday then proposes seven headings under which he identifies ‘difficulties that are characteristic of scientific English...’:
(1) interlocking definitions
(2) technical taxonomies
(3) special expressions
(4) lexical density
(5) syntactic ambiguity
(6) grammatical metaphor
(7) semantic discontinuity. (162)

He stresses that this list is not 'definitive' and adds that these were arrived at through research into areas including '...the language of high school textbooks, with special reference to the problems of second language learners'; '...[a] discussion of writing in primary schools'; '...[an] analysis of geography textbooks at secondary level'; and '...[a] treatment of grammatical metaphor.' (162) While the focus of this is clearly the written language of school science, details relating to spoken school science will also be referred to here.

In looking briefly at each of these headings, more specific features of the language of school science can be seen, than in the above segments of this chapter. For instance, Halliday defines interlocking definitions as being, '...mutually defining: they are all used to define each other, through the intermediary of two other terms which are assumed to be already known.' (2004, 163) The example illustrating this aspect of the language of school science is taken from upper primary school. The extract includes the terms: circle, centre, radius, diameter, and circumference. Halliday states that, '...circle, centre and radius are mutually defining: they are all used to define each other, through the intermediary of two other terms which are assumed to be already known, namely distance and plane curve.' (163. Italics in original) The consequence of such interlocking definitions, Halliday posits, is that, 'the learner has first to reach an understanding of a cluster of related concepts, all at the same time, and then immediately use this understanding in
order to derive more concepts from the first ones...these relationships are set up by means of a grammatical construction which faces both ways: ‘\( a \) is defined as \( x \), ‘\( x \) is called \( a \)’—both of which may occur in the same clause...’ (164. Italics in original) He stresses that the, ‘...technical term poses no great problem in itself—there is nothing difficult about the word diameter...

...its definition twice the radius is easy enough to understand provided you know what the radius is—a technical construction of this kind, in which the terms interlock and are used to define each other, does present the learner with a considerable intellectual tasks.’ (164. Italics and bold in original)

Clearly here, the focus of the difficulty is wider in scope that individual words. After all, a definition itself is generally more than a single word.

The second characteristic of the language of school science, Halliday writes is, ‘...related to the [first] heading; but the complexity is of a different kind.’ (164) Here, language is being used within the learning of science to create taxonomies. This is done, according to Halliday in two ways: ‘...a technical taxonomy is typically based on two fundamental semantic relationships: ‘\( a \) is a kind of \( x \)’ (superordination) and ‘\( b \) is a part of \( y \)’ (composition).’ (165. Italics in original)

In detailing this using climate (lexical items here include: climate; tropical, sub-tropical, temperate, cold: boreal, polar, highland; dry || climate; solar radiation; temperature; pressure systems; atmospheric) Halliday notes that superordination is, ‘...an ‘either/or’ relationship: ‘every climate is \textit{either} tropical \textit{or} sub-tropical \textit{or}...”'; while composition is, ‘...a ‘both + and’ relationship: ‘every climate is \textit{both} temperature \textit{and} solar radiation \textit{and}...’’ He then adds that in such thinking, one has, ‘...to stretch the meaning of \textit{either} and \textit{both} here so that they are no longer limited to just two’ (165. Italics and bold in original)
Halliday suggests three ways to resolving such problems relating to technical taxonomies:

1) ...first introducing the terms in their taxonomic order (e.g. there are five kinds of climate, namely...),
2) ...then setting [the terms] out in lists or diagrams, and
3) finally, describing each category and, where possible, explaining it.

(166)

Halliday concludes, however, that, 'in practice, the first and third steps are usually taken together, with the second one being left out; as a result the way the taxonomy is presented is often grammatically very confusing, with no clear pattern of theme and information running through it.' (166) Halliday's suggestions (which must considered a form of pedagogical intervention), is a clear example of linking pedagogical concerns with linguistic theory.

The next category Halliday offers is 'special expressions' but is specified in relation to 'technical grammar' and not simply 'technical terminology.' For Halliday, '...it is not particularly problematic once it has been explained (provided the learner does not ask what happens [with a specific variable in the example]). This kind of grammar is more common in mathematics than in science; mathematicians have often had to stretch the grammar a little in order to say what they want.' (166-167) For an example, Halliday uses:

If $D$ is the domain of a variable in an open sentence, the process of finding the truth set is called solving the open sentence over $D$. (166. Italics in original)

Halliday suggests that, 'what is being illustrated here is not, in fact, a single phenomenon. It is a set of interrelated phenomena: features which tend to go together in

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5 These two terms, 'theme' and 'information', are being used by Halliday here in a grammatical sense, not the vernacular or colloquial one. So 'theme' refers to first element in a clause; and 'information' is contrasted with 'new' in the clause. Aspects of the grammar will be explicated in chapter 4, but references to all specific grammatical items are made throughout the thesis.
modern scientific writing, forming a kind of syndrome by which we recognise that something is written in the language of science.’ (167) The difficulty, for Halliday, is that:

...in order to understand the problems they pose to a student we will need to separate them out; and this will occupy the next three headings...[these] constitute a special mode of expression that evolved in scientific discourse, although we are now so used to them that we no longer think of them as special. (167-168)

The next feature is one at the wider textual level and is referred to as ‘lexical density’. This is a feature that Halliday considers a key distinction between written and spoken language, and is described as being, ‘...a measure of the density of information in any passage of text, according to how tightly the lexical items (content words) have been packed into the grammatical structure.’ (2004, 168) He has written about this notion extensively, specifically in relation to learning academic (i.e., school subject content) language. Perhaps the best detailed example of lexical density in Halliday’s writing (in relation to education) is not scientific as such, but looks at progressing from low to high lexical density.

The example comes from an essay originally published in 1996 (republished in 2004), in which Halliday discusses, ‘...two complementary types of complexity as ‘lexical density’ and ‘grammatical intricacy’:

...density measured as the number of lexical words per clause, intricacy as the length and depth of the tactic structures whereby clauses come together to make up a clause complex.... (2004, 33)

Halliday stresses that, ‘...when we move from common-sense knowledge into literature and then into technical knowledge, the semantic density of the text has to increase. And this makes considerable demands on one’s power of language.’ (29) And this ‘semantic density’ leads to an example of ‘lexical density’.
The next heading is ‘syntactic ambiguity’, as Halliday again uses an illustrative example. He begins the description by look at these three, similar pieces of text:

(a) Increased responsiveness *may be reflected* in feeding behaviour.
(b) Lung cancer death rates *are clearly associated* with increased smoking.
(c) Higher productivity *means* more supporting services. (2004, 169. Italics added)

Halliday writes that these have a simple enough structure: ‘a nominal group, functioning as Subject, followed by a verbal group, followed by another nominal group with (in two instances) a preposition introducing it.’ (169) He suggests looking at the verbal groups above (presented in italics). He further suggests that these are each ambiguous and looks at two reasons for the ambiguity.

In the first instance, ‘we cannot tell whether [the verbal groups] indicate a relationship or cause, or evidence. Is one thing said to be the *effect of* another, or is it merely the *outward sign of* it.’ (169. Bold in original) He asks, for instance, in a above, ‘does the feeding behaviour *demonstrate that* responsiveness has increased, or does it *change as a result of* the increase?’ (169-170. Bold in original)

In the second instance, Halliday writes

...supposing that we can identify a relationship of cause, we still cannot tell which causes which. In [c above], for example, is higher productivity *brought about by* more supporting services, or does it *cause* more supporting services to be provided? It may seem obvious to the writer, and also to a teacher, which meaning is intended; but it is far from obvious to a learner, and teacher and learner may interpret the passage differently without either of them being aware that another interpretation was possible. (170. Bold in original)

Furthermore, and looking at example b above, and focussing on the words, ‘lung cancer death,’ Halliday suggests ambiguity and asks what it means? He writes, ‘is it ‘how many people die from lung cancer? Or is it perhaps ‘how quickly people’s lungs die from cancer?’ (170) The latter part of that example, ‘increased smoking’ also poses
questions. Does it mean, ‘... ‘people smoke more’, or ‘more people smoke’—or is a combination of the two, ‘more people smoke more’? (170)

Halliday concludes that the ambiguity comes, primarily, from the fact that, ‘...clauses are turned into nouns. That is to say, something that would in spoken English be typically expressed as a clause is expressed as a group of words centring on a noun.... A great detail of semantic information is lost when clausal expressions are replaced by nominal groups.’ (171) At this point, Halliday notes that grammatical metaphor is the prime factor in this shift.

Referring to ‘grammatical metaphor’, Halliday writes that this characteristic is, ‘...in many ways the favourite grammatical patterns (‘syndrome’ of grammatical features) in modern scientific English.’ (2004, 58) In fact, Halliday goes so far as to state strongly that, ‘the birth of science..., from the union of technology with mathematics, is realised semiotically by the union of nominalisation with recursive modification of the nominal group.’ (Halliday & Martin, 1993, 15)

Perhaps the most significant aspect of grammatical metaphor is that it changes how ‘reality’ is construed via language. Halliday writes that:

Where the everyday ‘mother tongue’ of commonsense knowledge construes reality as a balanced tension between things and processes, the elaborated register of scientific knowledge reconstrues it as an edifice of things. It holds reality still, to be kept under observation and experimented with; and in so doing, interprets it not as changing with time (as the grammar of clauses interprets it) but as persisting—or rather, persistence— through time, which is the mode of being a noun. (Halliday & Martin, 1993, 15)

Elsewhere, Halliday writes that, ‘metaphor is a cross-coupling between semantics and the lexicogrammar, whereby a meaning that is congruently expressed by wording a is expressed by wording b.’ He continues a rather and long technical quotation by adding:

In rhetoric and stylistics, ‘metaphor’ is restricted to lexical metaphor, where a and b are lexical items. In SFL this is extended to include
grammatical metaphor, where \( a \) and \( b \) are grammatical classes and/or ranks, e.g. (congruent) *farms produce(d) wheat*, (metaphorical) *farm wheat production*... [this] involves semantic junction, whereby new meanings are construed from the combination of \( a \) and \( b \); e.g. *production* is both a process (from the congruent form *produce*) and an entity (from its metaphorical form as a noun)—in other words, it is a virtual entity, which 'exists' as an abstract tool for thinking with. (Halliday 2009, 245. Italics in original)

Taking into account the distinction between 'commonsense knowledge' and 'scientific knowledge' Halliday is seeking to explore how language is complicit in a gap that schooling (specifically the ever-increasing subject specificity of secondary schools) is always attempting to close or make explicit. It behoves schools to include more students, and making clear how grammatical metaphor works in the teaching and learning of science, could be an important part of the process of inclusion.

Halliday comments that grammatical metaphor,

...is like metaphor in the usual sense except that, instead of being a substitution of one *word* for another, as when we say *you're talking tripe* instead of saying *you're talking nonsense*, it is a substitution of one grammatical class, or one grammatical structure, by another; for example, *his departure* rather than *he departed*. Here the words (lexical items) are the same; what has changed is their place in the grammar. Instead of a pronoun *he* + verb *departed*, functioning as Actor plus Process\(^6\) in a clause, we have determiner *his* + noun *departure*, functioning as Deictic plus Thing in a nominal group. ... the underlying metaphor is in the grammar, and the lexical changes follow more or less automatically. (2004, 172)

Halliday suggests that the value of the use of grammatical metaphor in science is in two areas: 'the semiotic power of *referring* is being...exploited so as to create *technical taxonomies*: constructs of virtual objects that represent the distillation of experience...[and]...the semiotic power of *expanding*—relating one process to another by logico-semantic relation such as time—is being further exploited so as to create

\(^6\) Both Actor and Process are taken from Systemic Functional Grammar and will be defined in chapter five of this thesis.
chains of reasoning: drawing conclusions from observation.' (2004, 60-61. Emphasis in original)

It should be clear that the notion of grammatical metaphor as theorised by Halliday is both complex, as well as highly relevant to educational thinking and practice. When Halliday writes, ‘...knowledge advances through the combination of new techniques with new meanings,’ (2004, 95) he is looking at language as both an entity to theorise, as well as how teaching and learning take place (by combining new techniques/practice with new meanings/wording).

The final category (of a long and complex list) of the features of scientific language is ‘semantic discontinuity’. Halliday writes that, ‘...writers sometimes make semantic leaps, across which the reader is expected to follow...in order to reach a required conclusion.’ (2004, 177) The examples given by Halliday relate to the previous categories and they meaning is packed together in long nominal groups that are then strung together in texts.

Without looking at the sample text in its entirety (one which seems to have been taken from a late secondary school science or history textbook), Halliday looks at this third of three paragraphs:

However, strong anti-pollution laws over the last twenty years have resulted in cleaner factories, cleaner countryside and an increase in the number of light-coloured pepper moths. (2004, 177)

Halliday writes that this, ‘...is a typical example of the structure described [in the grammatical metaphor section above]: two processes, with a logical connection between them. The sense of ‘a happened’ so ‘x happened’, expressed metaphorically in the form of ‘happening a caused happening x’ (strong pollution laws...have resulted in cleaner factories...) (177. Italics in original.) He suggests that this might, rather, have been written this way:
Over the last twenty years, [the government have passed] strong laws to stop [people] polluting; so the factories [have become] cleaner...

At issue in this re-wording of the text is the insertion of actors into the sequence. So 'the government have passed' the 'strong anti-pollution laws over the past twenty years'; which has contributed to stopping 'people' polluting with the consequent result (in the sample text above: 'cleaner factories, cleaner countryside and an increase in the number of light-coloured pepper moths').

Halliday concludes this description of semantic discontinuity by suggesting that, 'of all the kinds of difficulty...this is the one a teacher can do least towards helping students to solve. The teacher can give a few illustrations, and warn the students to be on their guard; but every instance seems to be unique, and it is hard to find any general principles behind them all.' (2004, 178)

It is difficult to provide a synthesis to Halliday’s work above. This is for any number of reasons: the writings themselves are sufficiently clear (though a foundation in SFL/G does contribute to meaning); the material is meant for a variety of audiences, including linguists, academics, as well as educators; and the work has been taken into other areas and explored and developed.

Systemic Functional Linguistics is not the sole linguistic theory, but it is the only theory that has looked at the language of school science in such depth. As such, this is the only detailed linguistic view presented here.

3.3.4 Contextualising Systemic Functional Theory (B)

This section of the literature review has been in two distinct sections exploring the language of school science: the first was educational in orientation and highlighted a number of discrete features almost exclusively focusing on the individual word; the
second was a detailed lexicogrammatical perspective, which looked at words, but also considered features at the grammatical and wider textual levels.

This is the most significant distinction between the two perspectives. While the educational literature highlights specific features, for instance when O’Rafferty offers features of scientific prose (including, ‘long and complex noun-phrases’, ‘frequent use of logico-grammatical items’, ‘a high proportion of items of specialised vocabulary; ‘frequent use of auxiliary verbs in an uncommon setting’, ‘a high proportion of non-finite verbs’ and ‘frequent use of Greek and Latin affixes’ (O’Rafferty, 1987, 40-50)), it is noted that the bulk of identifiers are single words or nominal groups (phrases). There is little sense in her work, or the work of other educationalists, that language serves to make meaning beyond individual words.

This is also seen in Wellington and Osborne’s work when they articulate a broad taxonomy which includes four base types of words: Naming Words; Process Words; Concept Words; and Mathematical ‘Words’ and Symbols.’ (Wellington and Osborne, 2001, 20) While these authors do refer to the notion of grammatical metaphor (specifically the feature of nominalisation), this is not developed in their work, though it does draw from linguistic theory. This is exceptional within educational research.

In contrast, the details of Halliday’s identified features of the language of school science focus on words, linkages between words, substitutions for specific words and features at the syntactic and the semantic levels. This is work that could probably only be done with a highly detailed and specific linguistic theory to underpin it.

One focal element of this thesis is that Halliday’s work offers substantial insight into language used in the classroom and allows for explorations into how meaning is made in the classroom, and within specific subject areas. The first section of the chapter looked at generic classroom discourse and highlighted research the developed over the decades and included Berry, Ventola and Martin’s contribution from within a Systemic
Functional Linguistic perspective. In addition, it described Christie’s research into curriculum genres, again drawn from with SF theory.

This section highlighted the distinction between research that was lexical in nature and linguistic research that sought to explore wider levels of language in use (not neglecting words, but considering them on their own, and in use with wider textual resources). Halliday’s contribution has been used in science, but (as documented above) in other subject specific areas in schools as well. It is hoped that by exploring the literature from educational and linguistic perspectives, a distinction can be made between them (each having their pedagogical contributions to make) and the value of using a Systemic Functional approach can be seen.

The next section of this chapter will look at research that merges the first two sections, looks at the classroom discourse of the science classroom from various perspectives, and gets closer to the core research to be presented in this thesis.

3.4 Language of Science Classroom

3.4.1 Identifying Issues of Concern

This chapter so far has explored features of the language of the generic classroom (section 3.2), and two perspectives on the language of school science (section 3.3). The former section was generic in the sense that content, or subject, specificity, was not taken into account. Rather, this looked at the structure of language in the classroom at various levels. The latter section considered educational and linguistic perspectives of the language of school science, but this did not distinguish between spoken and written language. In some ways, this final section could be seen as combining the research interests of the sections so far, and looks in some detail at research highlighting the specific features of classroom discourse within school science. This research has looked at exploring the specific nature of both exchange structure, as
well as subject content of science in the classroom, and has been informed by educational theory, linguistic theory and is inclusive of scientific perspectives.

The specific focus of this section is the talk of the science classroom and how it has been seen by the research. This will highlight four theoretical articulations of the use of language in the science classroom, with each taking a slightly different ‘take’ on the proceedings.

The first, and arguably the most significant, is the extended research by Lemke in the mid- to late-1980s, culminating in a book titled, *Talking science: Language, learning, and values* (1990). This work is distinct in that the author can claim to be scientist (his PhD research area was in theoretical physics), linguist and educationalist. Lemke’s work focuses on ‘thematic patterns’ within the science classroom, using a Systemic Functional framework, and seeks to extend that framework in relation to classroom language to look specifically at science content. The second key work in the area of the language of science in the classroom is taken from work by Mortimer and Scott over the past decade in re-defining this area of research. These authors use what they refer to as ‘narrative patterns’ to explore how teachers teach and students learn science in the classroom. Next, this section will more briefly look at Christie’s work on classroom language as ‘curriculum genre’. While Christie’s multifaceted work includes more general classroom language, she includes examples of science in her analyses, and suggests the use of ‘classroom genres’ as a framework for thinking of learning content. Finally, Wells has accounted for subject specificity in his research framework and this will be described in relation to science, as his analytical framework has been applied.

It is hoped that looking at Lemke’s ‘thematic patterns’, Scott and Mortimer’s ‘narrative patterns’, Christie’s ‘classroom genres’ and Wells’ framework for analysis will allow for a comparative analysis of this research in order to provide a way of exploring deeper into the language of science in the classroom in the subsequent
chapters. Each framework will be described briefly, using the title as a reference point, and then a comparison of features will be provided in order to consolidate the research into science. The purpose of this section is to complete the literature review in the three discrete areas as documented.

3.4.2 Lemke: Thematic Patterns in the Science Classroom

Looking at any classroom discourse, in particular the subject specific language students must learn in learning subject content, it is important to draw language from the setting of the classroom. The most detailed research and analytical framework for looking at the language of the science classroom is Lemke (1990), and, as such, the bulk of the description in this section is principally drawn from that book.

What distinguishes Lemke's research, and others in this part of the chapter, is the specific focus on science. Looking at Lemke's research and framework will be done in three sections. First, there will be a brief review of an earlier, non-subject specific piece on classroom discourse. Then, there will be a detailed look at his development and articulation of Themes in the science classroom. Finally, there will an exploration of a set of recommendations Lemke offers for making clear for all students learn more science in the classroom.

Lemke's book, Talking science (1990) is the most detailed specific work looking at the language of the science classroom and provides a replicable set of categories and labels relating to the language used in the teaching and learning of science in secondary schools. At the outset, Lemke describes his book as being, '...about talking science. It asks how we use the specialised language of science to make sense of the world and to make sense of and to one another.' (1990, ix) He could have added 'in the classroom' at this point, as Lemke seeks to highlight the pedagogical advantage a more detailed understanding of language in the teaching of science can provide.
Lemke continues by noting that this statement, ‘...does not mean talking about science.’ Rather,

It means doing science through the medium of language. ‘Talking science’ means observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science. (ix. Italics in original)

The focus on language stems from Lemke’s belief that, ‘...language is not just vocabulary and grammar: language is a system of resource for making meanings...our language gives us a semantics.’ (ix. Italics in original.) Semantics, defined by Lemke is language’s, ‘...particular way of creating similarities and differences in meaning.’ (ix) He writes that, ‘in order to talk science, or any other subject, we have to express relationships between the meanings of different concepts and semantics is the study of how use language to do this.’ (ix-x)

The notion of semantics that is used in this book is developed through the opening chapters to some depth—and is principally based on Halliday’s Systemic Functional grammar (described above and to be detailed further in a later chapter of this thesis).

Lemke begins describing his framework by seeking to, ‘Find the science in the dialogue’ of the classroom (heading of section on page 11) He writes that, ‘a lesson is not just give-and-take between teachers and students...some science is talked about.’ (11) He notes that the structure of classroom discourse (reviewed in the opening section of this chapter), ‘...is important, but it does not tell us how to find the science in the dialogue...students also need to find the science in the [classroom] dialogue. If they don’t, many learn how to play the classroom game, but they won’t learn how to talk physics or biology.’ (11) This the first shift in content between the first section of this
chapter and this work, a focus on the specificities of subject content. In the context of this thesis, this means science.

Following Halliday, Lemke moves beyond vocabulary, and states that, 'classroom language is not just a list of technical terms, or even a recital of definitions. It is the use of those terms in relation to one another, across a wide variety of contexts.' (12. Italics in original) According to Lemke, 'students have to learn how to combine the meanings of different terms according to the accepted way of talking science. They have to talk and write and reason in phrases, clauses, sentences, and paragraphs of scientific language.' (12. Italics in original)

As he begins to detail his framework, Lemke writes that:

The pattern of connections among the meanings of words in a particular field of science I will call their thematic pattern. It is a pattern of semantic relationships that describes the thematic content, the science content, of a particular topic area. It is like a network of relationships among the scientific concepts in a field, but described semantically, in terms of how language is used in that field. There is science in the dialogue exactly to the extent that the semantic relationships and the thematic pattern built up by the dialogue reproduce the thematic pattern of language use in some field of science. (12-13. Italics in original)

Lemke then writes that the discourse structure described to this point in the chapter (focussing on the exchange but not content) is part of the organisational structure of the classroom ('people are interacting with one another, move by move, strategically playing within some particular set of expectations about what can happen next'), which he labels, 'the activity structure.' In addition, 'they are also constructing the complex meanings about a particular topic by combining words and other symbols (the thematic pattern).'</(13)

To establish a thematic pattern, Lemke draws from transcripts from a science class that has a set of terms:
Lemke writes that, ‘...these are semantic relationships.’ (14) He continues by stating that:

The thematic pattern of the dialogue is the pattern in which these relationships are joined together. If the relationships themselves and the pattern in which they are joined is the same as what we would find in a science textbook or the language of professional scientists, we can say that the thematic pattern of the dialogue is truly 'talking science'. We know that there is a larger pattern in this dialogue beyond just the relationships listed in the table because the dialogue has linked several of them together to tell us that the '1s [type of] orbital [can represent] the elements [known as] hydrogen and helium.' As the dialogue continues, the pattern becomes more complex, we can draw a thematic diagram to show how the terms combine semantically in this new field. (14)

Noting the repetition in the sequence of terms above, Lemke stresses that, 'it is an important characteristic of science dialogue that key semantic relationships...those that do not belong to the general thematic pattern of the subject matter, will be repeated again and again as they are used and reused in the dialogue.' (15) Lemke highlights a concern in the classroom, in that, 'it can be difficult or impossible to teach a thematic pattern one piece at a time because it often takes a mastery of the whole pattern before any of its parts seem to make any sense...Each piece of the puzzle makes sense only if you already have all the other pieces.' (17) For Lemke, the identification and recognition of such thematic patterns by teachers in the classroom help eliminate, 'one of the fundamental problems of science teaching, and indeed of teaching and communication generally.' (17)

The thematic patterns Lemke describes here comprise part of a set of thematic items. An example of a thematic item can be seen in another excerpt from the classroom transcripts. Looking at individual words, Lemke suggests that there may be difficulty
with specific words at the level of semantics. He notes that, 'they may be the same words, but when they are used with different semantic relations to other terms, they represent very different meanings.' (32. Italics in original) In the following extract, the teacher uses terms in specific ways. Consider:

1. Teacher: The ground is now creating heat energy, from the light energy.
2. Eric, you have a question?
3. Eric: Yeah, how can it be the grounds creates the heat energy,
4. if the sun creates the heat energy?
5. Teacher: Well, on the sun, and in the sun, the sun is creating a
6. tremendous amount of heat energy. But it’s sending most
7. of its energy as light, travelling through space.
8. Eric: But light is hot, light is heat. (1990, 28. Italics in original)

In this exchange, Lemke highlights, 'the semantics of the term create.' (34. Italics in original) In a long quote, he describes how teacher and student may be using the same term differently:

...it is actually necessary to treat CREATE as a semantic term in its own right, and not just as a link between other terms. Terms or phrases (e.g. heat energy) which must be treated this way, I will call thematic items from now on. So for Eric either the ground or the sun is the creator in a process that CREATES a result, heat energy, while for the teacher, the ground is only an agent in a process that CONVERTS a source, light [as a form of] energy, into a product, heat [as a form of] energy. Even though both use the words ‘heat’, ‘energy,’ and ‘create’ in ways that sound alike, what they mean by these words is very different. The meaning depends on the thematic pattern to which the words are fitted. (34. Italics and Upper case in original)

What Lemke wants to stress here is that, ‘...words do not necessarily ‘have’ meanings in themselves. A word in isolation has only a ‘meaning potential’, a range of possible uses to mean things. What it actually means as part of a sentence or paragraph depends
on which thematic item in some particular thematic pattern it is being used to express.'
(34-35)

The link between Lemke’s thematic patterns and thematic items are illustrated in
the book via diagrams showing the relations between words and other words and the
grammatical categories assigned to each. Both the student’s thematic items and the
teacher’s are shown, and contrasted, and then related back to the extract above. Lemke
describes the differences as semantic in orientation, not purely lexical. A key distinction
in this case is that there is a, ‘formal semantic relationship here... ‘light’ and ‘heat’ are
Classifiers of ENERGY (which is called simply the Thing classified). This produces the
‘hyponym’ relation (technically it is HEAT – ENERGY that is the hyponym of
ENERGY). (42. Upper case words as in original)

Lemke’s work leads him to write that, ‘...what seems most important here is
simply to recognise that what we mean by most curricular content is essentially a
mastery of certain ways of using language. Mastery of a thematic pattern, large or small,
means being able to mobilise a system of semantic relationships to talk your way
through a task. And that we do almost entirely by means of language, by ‘talking
science.’” (94)

Digging deeper into the language of the science classroom, and linking with
specific sections of parts 1 and 2 of this chapter, Lemke documents that, ‘it is very
common in scientific language to take a small thematic pattern, give it a name (e.g.,
‘orbital configuration’), and then link it to other thematic items as it were a single item
itself.’ (95) Here, Lemke uses the notion of thematic condensation, ‘...which makes
scientific language often seem so ‘dense’ and impenetrable to the nonexpert who does
not know how to expand these condensed items to recover their full meanings. So a
semantic relationship may connect simple items or condensed items. But while thematic
items are myriad, and condensation enables us to add new ones all the time, all semantic relationships tend to be variants of a relatively small number of basic ones.' (95-96)

Detailing the semantic relations takes us back to the sort of analysis provided by Halliday in section 3.3 of this chapter. Lemke writes that, 'these basic semantic relations can be roughly divided into five groups.' (96) He continues, in some length but truncated here:

...first, there are those, like Attribution, that typically relate qualities, quantities, and types to a central thematic item (Nominal relations).

Then there are those that relate an item to another that is being presented as its synonym, antonym, hyponym, and so on. These present one item as an example or instance of another, as a special case or part of another, or as equivalent to or contrasting with another. They are sometimes called the 'taxonomic' relations.

The third group are the relations between various processes or activities and the objects or agents that participate in them (Transitivity relations). In this group are the relations of Process to Agent, to Target (the affected thing or participant), to Medium (a single, essential participant), to Beneficiary, to Range or Extent, and so on.

The fourth group are the Circumstantial relations of an item (including a process item) to its location, time, manner, reason, material, means, and so on.

...the fifth group comprise relations that tend to occur between whole sets of linked (or condensed) items: Cause/Consequence, Evidence/Conclusion, Generalisation/Instance, and so on. (1990, 96-97)

This is much more detailed than any of the educational perspectives of the language of school science in section 3.3 of this chapter, and is very much in line with Halliday’s analysis of school science. Lemke focuses on spoken language in the classroom, and seeks to highlight how to teach taking such language features into account.

Lemke writes that, ‘Talking science is not the totality of doing science. But very little science gets done, or could get done, without the semantic resources of language,
and particularly the thematic patterns and genres structures specific to science.’ (123.
Italics in original)

Approaching his conclusion, Lemke writes that, ‘...the science curriculum begins from the needs of practicing research scientists; it organizes, presents, and teaches science from their extremely specialized viewpoint. It does not bring science to the student; it insists that the student come to it, and most students never get there.’ (155).

As part of his conclusion, Lemke lists a set of principles and comments that he, ‘...will mainly be talking about teaching methods and about attitudes to science and learning that have important social consequences. I will have much less to say about the topics of the science curriculum, though I do believe that the selection and priority of topics in most science subjects need changing, too.’ (168) Lemke then offers four major categories for teachers to take into account in teaching science:

Teaching students to talk science;
Bridging between colloquial and scientific language;
Teaching about science and scientific method;
Helping all students use science in their own interests. (168-181)

He continues by noting that his recommendations are:

...based on the research and arguments presented in the preceding chapters, but they are also based on my own values and convictions. I hope that you will share most of these values, and that you will want to try putting many of these recommendations into practice. I know that some teachers will not agree with some of the value-choices I have made here, but I hope that no one will dismiss any of these recommendations as being politically or practically unrealistic. I know that everything recommended here is possible because, somewhere, someone is already doing it. Everything here is part of the repertory of actual ways of teaching science.’ (180)

Lemke’s work is documented here in a rather brief way trying to highlight its key features. The next section will consider Scott and Mortimer’s alternative
framework, also based on patterns of language in use, but looking at their narrative sequencing, rather than using notions of 'theme' as Lemke does.

3.4.3 Scott and Colleagues: Narrative Patterns in the Science Classroom

To follow on from Lemke's use of Thematic Patterns in seeking to understand what happens in the teaching and learning in the science classroom via language, the next effort investigated uses a different metaphor—that of a Teaching Narrative. Unlike Lemke's overt linguistic framework, Teaching Narratives as developed by Phillip Scott, are influenced by neo-Vygotskian Cultural Historical Activity Theory (CHAT). Looking at Scott's contribution to the analysis and understanding of the language of school science also bring in his collaborative work with Mortimer (1998; Mortimer and Scott, 2000, 2003) and with Leach (Leach and Scott, 2004).

Scott clearly states the notion of narrative pattern in a 1998 essay in Studies in science education, in which he first looks at Lemke's work (previously described) and then the work of Mercer and Edwards (detailed in section 3.2 of this chapter). Scott describes his essay as one that, '...examines one aspect of the discursive turn in science education research by focussing on a selection of studies which investigate the ways in which meanings are developed in the interactions within science classrooms.' (46)

After looking at classroom transcripts, Scott, '...developed a framework...in which five forms of pedagogical interventions are identified.' (56) He suggests that, 'these five forms of intervention are conceptualised as forming a 'Teaching Narrative' or teaching performance through which the teacher directions and sustains interactions to make the scientific view available to students.' (56)

He continues by writing:

Teaching Narrative is intended to provide an overarching theoretical structure which acknowledges the fact that teaching and learning
science in the classroom occurs over an extended time line with beginning and end points, and involves the teacher in laying a 'language trail' from students cognitive starting points towards the learning goal of the scientific view. (56)

The categories that Scott offers include, 'three major strands:

1) Developing scientific knowledge;
2) Supporting student meaning making;
3) Maintaining the narrative. (56)

Scott then describes each major strand by including select 'forms of pedagogical interventions' that relate to each. He begins by writing, 'the first strand of the Teaching Narrative consists of those interventions directed towards scientific knowledge available on the interpsychological plane and is sub-divided into 'Developing the conceptual line' and 'Developing the epistemological line' of the narrative.' (57)

The first of these, 'Developing the conceptual line' contains, '...pedagogical interventions directed towards: 'Shaping Ideas'...; 'Selecting Ideas'... [and] 'Marking Key Ideas'’ (57), each of which are described. The second pedagogical intervention under this heading is labelled, 'Developing the epistemological line', and, '...are aimed at introducing to students aspects of the nature of scientific knowledge (such as the generalisability of scientific explanations).’ (57)

The remaining two major strands of the Teaching Narrative are subcategorised in a similar manner, with the pedagogical interventions listed (but not detailed) below:

- Supporting student meaning making:
  o Promoting shared meaning;
  o Checking student understanding.
- Maintaining the narrative:
  o Maintaining the narrative. (55-6)
In the latter category, Scott writes that, 'this is talk about the narrative rather than ‘talking the narrative.’ (58)

Later, Mortimer and Scott further explicate Teaching Narratives, and write that, ‘Our experience suggests that this ability to sustain chains of dialogue is something that student teachers can learn to do, once it has been drawn to their attention and the underlying teaching purposes have been discussed’ (Mortimer and Scott, 2003, 113)

The transcripts used by Scott (1996, 1998, 2008) and by Mortimer and Scott (2000, 2003) are all drawn from secondary science classrooms, and illustrate how the sequencing of teaching science according to the categories above map themselves out. Without looking directly at those transcripts here, it may be useful to look at how Scott (and Mortimer’s) notion of Narrative Patterns compares and contrasts with Lemke’s Thematic Patterns.

3.4.3.1 Comparing ‘Thematic Patterns’ and ‘Narrative Patterns’

The key distinction between Scott’s work and Lemke’s is in the level of detail. Scott, drawing from Vygotsky’s socio-psychology to analyse classroom language, while Lemke is using linguistic theory, and looks at layers of meaning embedded within language. This is not to suggest that one approach is specifically better or worse than the other, but that different approaches result in different outcomes.

Both are looking at whole class contexts and seeking to link the language used with the content of the science curriculum and syllabus. As Scott focuses more on exchange, he is looking at patterns of the overall classroom discourse to isolate how the teacher progresses each student to understanding science. The sequence of the Teaching Narrative is from Developing Scientific Knowledge, to Supporting Student Meaning Making, and Maintaining the Narrative (in the latter case, this is most likely to be an iterative process).
In Lemke’s analysis, the focus is in language at the level of words in the context of the science learning classroom. He uses the grammatical theory of Halliday to show how science in the dialogue can be found and suggests ways that students can be taught to learn to speak the same level of science as the teacher, as part of the learning process.

One critique by Scott about Lemke is the extent of the classroom analysis. Scott writes that, ‘The concept of the Teaching Narrative is intended to provide an overarching theoretical structure which acknowledges the fact that teaching and learning science in the classroom occur over an extended time line with beginning and end point...’ (1998, 56) He then writes that Lemke does not give prominence to, ‘this aspect of the extended timeline....’ (56) What is unclear here is whether Scott is referring to the single class session (with a beginning and ending point) or to a specific curricular/syllabi content section (specific content area).

Lemke’s analytical framework does provide analyses from entire class activities. In the first appendix of his 1990 book, Lemke has the categories of ‘Pre-Lesson Activities’; ‘Getting Started’; Preliminary Activities’; ‘Diagnostic Activity’; ‘Main Lesson Activities’; ‘Interpolated Activities’, each of which has several, or many, subcategories relating to the thematic pattern of learning science.

The terminology offers some insight to the differences between these two frameworks. Scott has a focus on Narrative (or performance) and this is clear when he writes that, ‘the first striking feature to emerge from watching teachers at work...was the way they introduced new scientific concepts by means of a public ‘performance’’. (1996, 327) This puts the focus on the exchange and is useful for all subject areas, not specifically science. For Lemke, the content is part and parcel of the exchange. He writes, ‘Everything that is said in the classroom must be made sense of according to some thematic pattern.’ (1990, 27)
Both of these analytical frameworks are useful for exploring what happens in the science classroom in different ways. There are two additional ways of researching science in the classroom and these are offered by researchers already detailed earlier in this chapter. This is the work of Christie (with her curriculum genres) and Wells (and his framework for analysing classroom discourse). These will be considered briefly in the next section which focuses on the specific aspects of their research referring to science.

3.4.4 Christie's Curriculum Genres and School Science

In an essay published in 1997, Christie applies the use of curriculum macrogenres to the science classroom. Her working definition of such macrogenres in this essay is, ‘...a cycle of teaching-learning activity in which a teacher and students engage with some ‘content area’, progressing from some introductory stage through a series of stages until a conclusion is reached.’ (1997, 154) In this specific essay, Christie was looking at the interaction in a late stage primary science class and she starts by setting up the three stages of curriculum macrogenres:

Curriculum Initiation
Curriculum Collaboration
Curriculum Closure. (157)

Within each she has several microgenres (sub-genres). In the case of Curriculum Initiation she has: Task Orientation; Task Specification; and Task Conference. (157) Further, within each of these are further sub-categories: Prelude; Expose; Consolidation; Contract; Direction; and Contract. Each is defined by Christie within the text, and then exemplified in use by looking at her transcripts.

Within the Curriculum Initiation, ‘...the teacher is defining goals and establishing with the students commonly understood purposes.’ (158) While the focus is science, the same process would happen in other subject area classes. In looking at
science, what Christie is looking at is, ‘...linguistic evidence for the claim that the
discourse changes as the students grow in understanding throughout the total
macrogenre.’ (160)

The science begins in the Exposé of the Curriculum Initiation macrogenre.
Christie notes here that, ‘this is a long and important phase, because it is here that
significant language is established specific to the second order field of machines.’ (162)
In providing one example, the teacher presents a taxonomy (not using this term in the
class) of machines. This exemplification, ‘depends upon a basic distinction...drawn
between levers and inclined planes.’ (162) Further, ‘within the group of levers a further
distinction was made between machines without a wheel, such a rake, and those with a
wheel, such as wheel and axle.’ (162)

Christie labels the various parts of the transcripts using the same grammatical
labels that Lemke uses above, Systemic Functional Grammar, so no details will be
provided here on those. She traces the grammatical features of the teacher in interaction
with the students, as the science is being introduced, talked through and worked through
in each stage of the classroom. This takes her to the Consolidation, where, ‘the teacher
moves the students forward to a new understanding, with a generalisation about the
instructional field: ... the mechanical advantage exploited in using machines.’ (165)

Without detailing the remaining macrogenres here (Curriculum Collaboration
and Curriculum Closure), the point that Christie identifies here is that classrooms have a
definitive beginning, middle and end, based on pedagogical principles. She writes that,
‘the learning of science in the manner outlined [through macrogenres] is a matter of
developing both an understanding of particular scientific fields of knowledge, and an
understanding of how those fields of knowledge may be applied.’ (174) The reason to
focus on the Curriculum Initiation and its various sub-stages here, is that this is where,
‘...the students’ subjectivity had been shaped, preparing them for the many learning
tasks that lay ahead.' (175) The learning tasks can be seen, in the context of the specific class, in the forthcoming Curriculum Collaboration; and in the context of the wider science (and total) curriculum, other content (and subject areas).

3.4.5 Wells’ Coding Scheme and School Science

Wells’ work, also introduced in the first section of this chapter also looks at how the language of science can be analysed. This framework (which is continuing to evolve), accounts for science (and other content areas) by offering labels at the level of Episode Task. This is probably akin to Christie’s Curriculum Initiation: Expose described above.

Wells has the labels: ‘Science Practical’; ‘Science Discussion’; and ‘Science Presentation.’ (2001, 10) While these are not used in an explicit way in looking at specific classrooms, Wells elsewhere writes that the development of this coding scheme, ‘...started in 1991 with a focus on science, because science lends itself very readily to an inquiry orientation.’ (Wells and Mejía Arauz, 388) As a result, there are no applications of this coding scheme (2001) to science in the classroom.

However, Wells has written on learning science, and draws from both CHAT (described above in relation to Scott’s work) with that of Halliday’s linguistic theory. In doing so, he is exploring details of language in a wider discourse sense, and contributing to a growing dialogue on the language of science. (see specifically. Wells, 2008 and 2000b).

3.4.6 Contextualising Systemic Functional Theory (C)

This section has taken this chapter into the specific domain of the science classroom. It does not exhaust the research, but does focus on key research into the specific language used in the science classroom.
Lemke’s work, published in 1990, is still regarded as a key work in looking at the discourse of the science classroom. This research used an extensive grammatical framework and offers an approach to looking at language both within science as well as other subject areas. Following on from that work, Scott and colleagues (Mortimer and Leach) have sought to extend the work on analysing the language of classroom science. Without looking at the specific lexicogrammatical features of teacher and students language as Lemke did, they provide a working framework for researching classroom discourse, and ways into finding the science in the classroom.

Christie’s Curriculum Macrogenres and Wells’ coding scheme likewise looked at ways into the language of school science in various ways. Christie does by using the same grammatical framework as Lemke but looking at the structure of classroom in a slightly different way; Wells by taking science content into account from the start within his coding scheme.

In some ways, it appears Lemke and Christie look for the science in the specific language (not limited to words, but exploring the grammatical structure of teaching and learning science) while Scott and Wells look for science in the exchange. Of course, it is in both places at once.

3.5 Conclusion

This chapter began with a quote from Kamler and Thomson suggesting that it is akin to ‘persuading an octopus into a glass’ (2006, 28) to write a literature review. At this point, the octopus is nearly in the glass—what remains is to see if the goals of this chapter, as stated from the outset, have been achieved. This conclusion will map out those goals and suggest they have been attained.

Here are the goals (and source of goals) as started in the opening of this chapter:
1: sketch out the nature of the field or fields relevant to the inquiry, possibly indicating something of their historical development and;
2: identify major debates and define contentious terms, in order to;
3: establish which studies, ideas and/or methods are most pertinent to the study and;
4: locate gaps in the field, in order to:
5: create the warrant for the study in question, and;
6: identify the contribution the study will make. (Kamler and Thomson, 28).

Taking each of these views into account, the following points will be made in relation to this chapter, to be followed by an articulation of how they have been achieved.

This literature review was in three distinct sections, reflecting the range of research focus in looking at classroom discourse, the specific features of the language of school science, and finishing up with the research looking directly at the classroom discourse of the science classroom.

The opening section looked at research into classroom discourse, and, starting with Sinclair and Coulthard's work in the mid-1970s, pursued work (from both educational and linguistic orientations) that identified features of exchanges within the classroom between teachers and students. This work has developed, and further specification has been added, with Systemic Functional theory being a significant contributor to this development.

Virtually all of the research into classroom discourse, however, is the content-free analyses provided. Little of the research described explores subject matter, or content, of the classroom. This was covered in the second section of this chapter which explored educational and linguistic perspectives of school science. In the first instance, this research looked at technicality and readability and tended to conflate any differences between spoken (classroom) science and written (textbooks, or student...
texts) science. Likewise, in the second instance was a review of a detailed linguistic perspective of the language of school science suggesting that the main point of school science (as far as language is concerned) is moving each student from a spoken to a written (or literature) world.

While some of the educational work did include linguistic perspectives (especially Wellington and Osborne’s detailed work) the bulk of this research did not and tended to look at the specific terminology in school science. A focus solely (not exclusively) on words restricts the intervention to teaching words outside of larger stretches of spoken (or written) texts.

This was contrasted with Halliday’s detailed view of the language of school science, based on research taken from primary and secondary texts, which provides a scope and breadth that few outside of his theoretical framework attempt. This leads to a set of features of learning science (learning to speak, and do, science) that has potential, but must be applied directly to the science classroom. This leads to the final section of this chapter.

The final section explored several frameworks drawn from taping talk within the science classroom, and brings together the first two sections. Lemke’s work looking at the language of school science and using Themes, based on grammatical labelling (using Halliday’s framework) is detailed and provides the first attempt at finding the science in the classroom discourse. The second approach, Scott and colleagues (Mortimer and Leach) use a different framework and focus on the content through the exchange without a strict linguistic orientation. They identify Narrative structures present in the classroom they analysed and offer a way of looking at both specific classroom activity and linking science content from class session to session. Finally, Christie’s work in Curriculum Genres and Wells’ theoretical framework both offer researchers ways of looking at how science is constructed in the classroom in the
language used by teachers and students. These latter two approaches differ in one key area: the depth of analysis at the level of the language.

Lemke and Christie both draw from a detailed linguistic approach and seek to locate the science in the language. In many ways, Scott and colleagues, and Wells, seek to locate the science in the exchange.

As can be seen in this conclusion, the first chapter section leads to the next. Each section seems to suggest a tension between educational perspectives and linguistic perspectives. This leads to differing starting points as well as varying ending points. The difference is almost how deep into the language do researchers wish to go. For Sinclair and Coulthard, Berry, Ventola and Martin, the research is linguistic, and a grammatical (or lexicogrammatical) view is used. This contrasts with Barnes, and Edwards and Mercer, whose prime focus is the language used by teachers and students, and how they look at the clausal level—where exchange is uttered in groups that are readily identified.

In addition, the second section explicitly contrasts educational and linguistic perspectives. The section detailing technicality and readability contains valuable insights, over some decades, in the lexical issues in relation to teaching and learning science. The subsequent section looks at the words and wider texts (in relation) to provide a much more detailed analysis of problems that arise in the science classroom.

The tension is minimised in the final section, as Lemke, Scott and colleagues, Christie and Wells all look at language in science classrooms, taking into account both educational and linguistic perspectives. While Lemke and Christie’s work may be more challenging for educationalists, each is looking in a detailed, and structured, manner at the exchanges of the science classroom. Scott and colleagues, and Wells, look differently at the exchanges (and Wells certainly considers linguistic theory), they offer
slightly easier ways into analysing the science classroom and should be accessible to teachers and non-linguists.

This tension tends to be weak and the bulk of the research above looks from the perspective of either education or linguistics (and within linguistics from one strand of linguistics). This point leads to goal 3 above, establishing which studies are directly relevant to this research. All the research is considered valuable from different perspectives, but the focus of this thesis will be how Systemic Functional analysis sees the discourse of a secondary school science classroom. In this context, Berry, Ventola, Martin and Christe from the first section; Halliday and Martin from the second section, and Lemke and Christie from the final section will be the key informants of this thesis.

If there are gaps in the above research, it is that detailed descriptive research into the language of school science classroom requires a detailed descriptive framework. Such a framework, as the one used here, may allow for a look at the verbal construction of science within the classroom in ways that Halliday’s work suggests, and that Lemke’s (and Christie’s) work seek to realise.

Each uses a lexicogrammatical analysis at varying levels to explore meaning being made (and taught/learnt) in school science. But a more specific lexicogrammatical focus is not included in either Lemke or Christie’s work (though such a focus is certainly implied). Such an approach, perhaps labelled ‘microlinguistic’ (see Rampton 2002 for use of this term) would be a next logical step in research.

The next chapter, the design of research methodology, will detail how the remainder of the research will progress.
Where children are most likely to be put off is in the early years of secondary school, when they first come face to face with the language of their ‘subjects’—the discipline. (Halliday and Martin, 1993, 3)

4 Research Methodology: Video/Audio Taping; Transcription; Data Analysis

4.1 Introduction

Following the thesis introduction, the second chapter of this thesis looked at the historical and contemporary state of play in Irish secondary schools in relation to science in the junior cycle (towards progression for the Junior Certificate examination), while the third chapter looked at the literature seeking to understand and analyse the language of school science with a focus on classroom discourse. This chapter will detail the methodology for the overall research and answer a series of questions relating to each aspect of the research. It will refer to some of the literature in the areas of the capture, transcription, and analysis of classroom discourse, but will not detail this literature. However, references to sources are contained in the bibliography which future researchers should find useful for doing their own work in this area.

In order, the specific areas to be covered in the chapter are:

- the approach and rationalisation of the precise data to be collected;
- the data collection itself and some of the practicalities and problems encountered throughout the process;
- the transcription of the data and some of the issues in completing this task;
- the analysis of the data with a brief description of the software used;
- and the approach of interpreting the data under analysis.

A final section will detail ethical concerns the research began with and any issues as they came up in the course of the research. At all times during this research,
the *Good Research Practice* document from the Trinity College, Dublin Board served as a guide in this regard. The purpose of the account in this chapter is to start moving directly to the linguistic analysis of the data as outlined herein, which will begin in the next chapter with at a brief section of the analysis.

### 4.2 Approach and Rationale of Data Collected

As detailed in chapter three, the language of school science has been studied extensively over the past few years. This research has covered two key dimensions of the language of science: those which look at the specific features of science language (both in school as well as professional domains); and those which focus on the interaction within the science (primary and post-primary/secondary level school) classroom. As detailed in chapter three, the research in the former area seems fragmented into one of two areas: those with linguistic foci, and those with educational foci. As well, in the latter category, it can be seen as those who are linguistically orientated and those which are educationally, or pedagogically, bound. As expected, the focus of the research discipline used in many ways determines the results found.

In looking at classroom discourse, the bulk of the research focuses on the sequence of events within specific classrooms (as do Sinclair and Coulthard, for instance, in their foundational work) which tends to focus on the exchange(s) between teacher and student(s). The majority of research in this area does not look at content, but at the structure and properties of exchanges in the classroom. Research looking at the language of the specific content area of science tends to blur the line between science language and the language of the science classroom. Key work in relation to language of the science classroom (as documented) stems from Lemke’s research. This draws from linguistic as well as scientific disciplines (Lemke notes that he received his PhD in the area of theoretical physics prior to commencing classroom research from a linguistic perspective: Lemke, 1995, 6).
Returning to the thesis research questions as stated in the Introduction, the following questions are key in the context of this chapter and the remainder of the thesis:

- Are there identifiable language patterns used in secondary school science classrooms that could add to Irish students' learning of science?;
- How would the use of a detailed linguistic theory illuminate such language patterns used in teaching science?;
- How might the use of such detailed theory be applied in practice in both curricular work and teacher practice?

The second and third chapters of this thesis addressed what is now known about language in contemporary Irish and international classrooms in relation to science teaching and learning. This thesis will explore more specifically, in a detailed manner, the use of language by a teacher and her students in one Irish post-primary/secondary classroom in order to seek to identify patterns used and search for ways those patterns can contribute to students learning science in future.

As detailed in this chapter, the use of Systemic Functional Linguistics and grammar (which has been applied to classroom research as detailed in chapter three) will be used in a way that will help make clear what such language patterns may be and how they might contribute to improving pedagogy.

In addition, it is hoped that this thesis will be open to reading by those involved in Irish curriculum development as they continue to search for ways to improve the teaching and learning of science in Irish schools. In order to proceed, it is important to look at the research process as it was undertaken, in all its practicalities.

To collect data schools had to be contacted, arrangements for both content and collection had to be agreed, and students had to agree to be filmed, which meant getting consent from parents. Each of these will be described here in turn.
As the researcher was based in Dublin, and did not drive a car, secondary schools from in the city were selected. Specifically, North-side and North county Dublin schools were searched for suitable sites. Through dialogue with thesis supervisor and other academic staff, four schools in this geographical area were selected. For the purpose of this research, it was important that schools not be ‘outlier’ schools (either privileged or disadvantaged) and all the schools chosen were non-fee paying schools in fairly ‘middle-class’ areas. What was sought were: ‘average’ schools, with students and teachers for whom the English language would be considered ‘typical’. Future research should be conducted into language activity in other classrooms.

Schools were contacted via telephone during October and November 2003 in order to arrange meetings with both principals and science teachers. From these meetings, one school agreed to participate in the research and plans were made to arrange this.

First, however, specific class sessions had to be decided and science content selected. In the former case, it was decided to look at Junior Cycle (see chapter two for details) as it is a general course of study intending to lay the foundation for further study in Senior Cycle. It was within this foundation that the focus of study would be located. In addition, it was believed by both the researcher and the teacher involved that second-year students would be ideal for this research. There were two reasons for this. First, was that students would have been in the school for over a year, it was felt that taping first year students still adapting to secondary school would be problematic for a number of reasons. Secondly, there was no immediate pressure of terminal examination on second year students. The Junior Certificate exams are after third year in the Irish school system.

Having settled on second year students, the teacher suggested specific science content. It was felt that content students would have been exposed to previously (in first
year as well as in primary schools) but not looked at in detail would be suitable. As well, it was important that the specific syllabus material for this content could be covered in two class periods (Irish secondary school classes are generally 40 minutes of duration). Via e-mail, with copying to the researcher, the teacher settled on Carbon Dioxide (CO₂) as content that could be covered comfortably in two class periods. What the researcher found useful is that CO₂ would both require previous knowledge as well as contribute to further learning in the science process over the next 18 months to Junior Certificate examination.

Having settled on the classes and content, next consent had to be agreed with students and parents. A consent letter (see appendix 1) was written, with assistance from staff and other post-graduates in the department and wider university, which was sent to the school for all students in the given classes. All students returned the forms with parental consent. This follows the Trinity College Research Ethics document and its reference to, ‘…informed consent by both participants and carers…’ (5) It was agreed that the letters of consent would be retained by the school, rather than the researcher, in the event they were needed in future. Letters were kept by the class teacher, to be later forwarded to the school principal for filing and storage.

It was decided that two class sessions would be recorded, where Carbon Dioxide was introduced in detail according to the Syllabus, and plans for this recording were then made. These are now detailed.

4.3 Data Collection: How was the language captured?

Once school, classroom and content were agreed, a plan for video-taping the two class sessions was devised. As the focus in this research was classroom discourse in secondary school science, it was felt that as accurate a record as possible of speech from the classroom be obtained. The literature in the area of recording in classrooms is quite extensive (see Lemke, 1998, Edwards and Westgate, 1994, Christie, 2001, Swann,
2001, Mortimer and Scott, 2003 for a sampling of this literature). Within this literature, academics have three prime concerns: technique of taping in the classroom; the presence in the room of the researcher during the taping; and problems that might arise in the course of the taping.

In order to obtain as accurate a representation of the language used in the classroom as possible, two key factors were taken into account. First, was the number of collection devices; second, was the specific placement of those devices around the classroom. Lemke writes that, 'it is often very difficult in whole class settings to hear individual students.' (Lemke, personal communication, 2003) That being the case, the researcher settled on a set of digital video cameras. One was placed fixed in the front of the classroom, facing the students at an angle that allowed for near complete coverage of student activity. The second was hand-held by the researcher in the rear of the classroom facing and following the teacher, or roaming the lens to students if necessary to follow flow of classroom discourse. In addition, a small, hand-held audio recorder was placed on the teacher's desk, and directed towards the students. In this way it was hoped to avoid Lemke's concern that, '...with classroom video the big problem is where to point the camera. If you are interested in what the teacher is doing it's easy, but then you miss what the students are doing. If you point to more of the class, then you can miss things the teacher writes on the board that students are responding to.' (personal communication) Both of these views were accounted for by the placement of cameras.

One obvious concern in video-taping is how the presence of the camera in a classroom affects both teacher and students. Swann suggests that, '...the mere act of observing people's language behaviour (or, for that matter, other aspects of their behaviour) is inclined to change that behaviour.' (2001, 324) She continues by noting that, 'when interpreting the talk you collect you will need to take account of the effect
your own presence, and the way you carried out the observation, may have had on your data.’ (2001, 324-325)

Accepting that the presence of the researcher does affect the research environment and process, it was decided that the camera would first be placed in a non-researched class—one that took place a week prior to the real taping. This contributed towards some sort of ‘normalising’ of the presence of the researcher in the room, and helped students (and teacher) acclimate to the cameras in the room. What this meant was that students looking at, mugging for, performing to the camera generally took place in that first class. When the researcher was taping the actual classes to be transcribed, the only instances of acting up by students was when there was a distraction (someone entering the room, or knocking to ask the teacher a question). There were, however, select instances of the teacher highlighting the camera.

At no time during the recording of either of the classes did the researcher make any verbal or other physical utterance contributing to the class directed at/to either the teacher or students.

There were several instances in each class when an interruption of some sort occurred. These did not impede the recording in any untoward way. Non-class noise in one class did deter the taping, and that was when an announcement came over the loudspeaker. When this did happen, the teacher went back a few steps, repeated the entire segment of discourse (almost as a matter of course in this situation) and the flow was entirely captured.

After the classes had ended, equipment was collected, and the researcher left the school. A Digital-Video-Direct disc (DVD) containing all classroom recordings and the interviews with students is contained within the appendix.
4.4 Transcribing: How was the language moved from tape to paper?

After the classes had been video-taped, the tapes were prepared for transcribing. This was done via two methods.

Initially, the digital tapes were transferred using a video-recorder to VCR and the researcher used the video-recorder to watch as he typed in classroom dialogue and activity. However, this lead to problems due to the technology (and nearly eight months spent with aging technology) and a decision was made to search for software that might facilitate the transcription process. This would help in two ways: first, by using the recordings in digital format the features of digital rather than analogue technologies could be taken advantage of; second, by locating software for transcribing, it was hoped that time would be saved in the transcription process.

The tapes were converted from Digital Video (DV) tape into Microsoft Windows MediaPlayer format. This facilitated the use of a multi-windowing environment and appropriate software. After locating and trying various packages, the researcher settled on using SoundScriber from the University of Michigan MICASE project. This computer transcription software allows for somewhat speedy transcribing as it provides a simple (i.e., using few computer memory resources) interface with sufficient tools for transcribing. The main programme window looks like this:

![SoundScriber screenshot](image)

Figure 4.1: Control Screen of SoundScriber Software.
The key features of the software can be seen here. These include:

- ‘Number of walk loops’ (the number of times limited segments of the tape would run continuously),
- ‘Walk pause length’ (the amount of seconds the programme would pause between loops),
- ‘Walk cycle length’ (indicating the length of the segment of the tape seen).

In using the software, it was possible to have three windows on screen: the above SoundScriber window; the video window (opening on-screen within the SoundScriber application) showing the view of the classroom from whichever angle (i.e., facing the students or facing the teacher as described above); and a Microsoft Word window for typing in the transcript. The transcription session began by looking at each 5-10 second section of tape, seeing each segment a number of (varying) times and typing in the discourse from each classroom.

It is important to note that software such as SoundScriber allows some speedup of the process, but does not eliminate the time-consuming nature of transcribing or the precise nature of an accurate-as-possible record of the language used. In other words, while the use of this software did make the effort easier, it should by no means be considered a panacea.

Difficulties in completing the transcript principally were in relation to picking up and hearing all that took place in the particular classroom. Despite there being three recording devices, it was extremely difficult to be certain of everything said in the classroom from the tapes. The transcription involved switching between student-focused and teacher-focused video tapes, and the accompanying audio tape for further backup. But there are still bits of student language, in particular, that are uncertain. In fact, there are times when the triadic feature of classroom discourse helped better understand student talk.
The Initiation-Response-Evaluation/Feedback sequence often meant that the teacher’s Evaluation/Feedback was repeating the student’s Response for any number of possible reasons. The teacher could have several motives such an action: clarifying she heard exactly what the student said; confirming what the student had said; ensuring other students in the room heard the student response; and wishing to use what the student said to extend the triadic dialogue as described in the literature review.

Using the above methods, the transcriptions of the two class sessions in which CO₂ was taught were brought into Microsoft Word.

As with recording classroom discourse, there is likewise a wealth of literature in transcribing. This literature tends to focus on specifics of formatting the transcription (see Edwards, 2003; Silverman, 2006) and the role of bias in transcribing (Ochs, 1999; Roberts, 1997). As the research is using a Systemic Functional Linguistic framework, it was decided to follow the work within SFL to settle on a format to transcribe.

Using the software the method of transcription was one of a, ‘...standard orthography and punctuation.’ (Halliday, 1985b, 29) While formatting the transcripts, care was taken not to distort any spoken utterance, and only occasional utterances were colloquial (e.g., ‘gonna’). In addition, punctuation was added simply as an aid in reading the transcripts at the text level. While there is a theorised link between intonation (or phonology) and meaning (see Halliday and Greaves, 2008, Tench, 1992, Cléirigh, 1998, and Thibault, 2004), this is not under review here, though it would certainly be worthy of future research.

In addition to what was spoken at each point, there were columns for interlocutor (with labels of T2, or ST [in the event of one individual student speaking] or STS [where more than one student spoke simultaneously]) and for comments. Teacher and students are unnamed, or names changed, for ethical reasons to assure anonymity. Comments included activity relating to non-content matters (interruptions to
the class, bell or announcement overhead) rather than class activity as this added activity is not part of the present research.

Once the transcripts for both the class sessions were completed, the files were saved, copied to backup in original state for inclusion in this easy to read format (see appendix 6a, 6b, 6c, 6d, 6e and 6f for original transcriptions) and then saved to hard disc in text (*.txt) format to import into the analytical software.

At this point in the research, the data from class sessions was in electronic form and ready for analysis. This is documented in the next section.

**4.5 Analysing: How was the language analysed?**

As the framework for analysis was using Systemic Functional Linguistics (SFL) as detailed briefly in chapter three, software for analysis was selected based on that theoretical framework. *Systemics 1.0* was developed by Judd and O'Halloran and is published by the University of Singapore. This programme contains coding using Halliday's functional grammar at the following levels:

- **clause** (indicating the neutrality between spoken and written text), with codings for Textual (THEM), Interpersonal (MOOD) and Experiential (TRANSITIVITY and ERGATIVITY) meaning as well as Lexis and Grammatical Metaphor,
- **analysis** (using the same areas as with clause, but at a different levels: so for Textual analysis there is more of an overview, with details at the clause level; for Interpersonal, the analysis offers SPEECH FUNCTION, Mood, MODALITY & MODULATION, MOOD ADJUNCT, TENSE and POLARITY codings; and for Experiential the view is of VOICE) as well as Lexical Items (which account for register and textual requirements of the speaker), and
- **the interclausal level** there are codings for the Logical and Interpersonal meanings (the former accounts for Logico-semantic relations and Taxis, while the latter looks at Exchange Structure).

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7 *Systemics* also provides for analysis at the discourse level taking into account Reference Chains and Lexical Strings. These are not being pursued as part of this thesis due to issues of the display of such material in a coherent form.
The software uses grammatical labels drawn from Systemic Functional grammar, principally from Halliday (1994) and related reference works (including Eggins, 1994; Martin; 1992, and Halliday 1998) and allows for changes to the programme for additional codings with reference to later editions from some of those references. The analyses using Systemics, which account for the lexicogrammatical levels of language in use, are included in their entirety in the appendices.

It is important to state that this thesis uses a linguistic framework to look at classroom and educational language. However, this thesis is not an introduction to the theory used. When explication of any grammatical notion is beyond the scope of this project, the references in the bibliography should be consulted.

The software used for analysis, Systemics, is a commercial product, developed ‘...to be used for both academic and postgraduate research and also for the teaching of SFL in undergraduate and postgraduate courses’. (Quotation taken from Systemics Documentation, Introduction to Systemics, contained on CD-ROM in HTML format.)

This thesis will examine the language of classroom discourse at the following levels:

- Clause: and label at Interpersonal, Ideational and Textual levels (both lexical and grammatical);
- Analysis: exploring details at each of the above levels;
- Interclausal: looking at Exchange Structure.

Each of these will be introduced briefly here and illustrated in the next chapter by the application of each to opening sections of each transcript. This introduction will be done without recourse to the literature, though instances of contentious labelling at each level will (in later chapters) rely on references for correctness and consistency.
4.5.1 Clausal Breakdown

The Clause is used as it has been described as being neutral between spoken and written language. In other words, Clause will be used as it more accurately reflects the potential to analyse language in use. There are specific Clause ‘types’ that will be identified in the transcripts. These will be illustrated here.

The first is a simple Clause, seen as principally aligned with what is commonly known as a sentence. An example is, ‘It’s carbon and two oxygens?’ (from transcript, line 14). Here, this interrogative is a standalone piece of language in use and will be identified and labelled as such in the analysis.

In addition, there are Clause Complexes which are sets of clauses operating in sequence towards meaning. These are particularly relevant in spoken language, which functions without explicit punctuation. An example of such a Clause Complex is, ‘So, before I show you how to make it, can anybody tell me anything about it, that you might know already?’ (transcript, lines 3-6) As part of the identification of clauses, this spoken piece by one teacher will be broken into Clauses in this way:

3. ‘So, before I show you
4. how to make it,
5. can anybody tell me anything about it,
6. that you might already know?’

Here, each line is a separate clause, functioning in various ways. Clause 3 contains the verb or Process ‘show’ which is being used to Project the subsequent Clause 4, ‘how to make it’. Projection is accounted for within Systemic Functional Grammar in the case of Mental or Verbal Process types when a separate Clause is being ‘thought’ or ‘expressed’. This can be seen to contrast with Clause 5, which also has a Process which can Project, but is not Projecting a separate Clause (which will be labelled in this as Verbiage—or something which is being expressed verbally).
In addition to Simple Clauses and Clause Complexes (from the standpoint of a clausal analysis, Clause Complexes will be labelled per clause. The relationships between clauses will be explored at Interclausal level), there are two other types of clauses used in this analysis: Interrupting Clauses and Embedded Clauses.

An Interrupting Clause is one that splits a clause into segments that need then be brought together. An example is, 'Carbon Dioxide's going to <<you know>> be produced.' (see transcript, line 147) Clauses such as this will be analysed within the specific line number (in this case, line 147) but at a sublevel of that clause.Interrupting Clauses are common in spoken language as a form of spontaneous communication.

Embedded Clauses are quite different in nature. Within SFL Embedded is the label for clauses which function as either Participant or Circumstance within a larger clause. An example of embedding can be seen here:

'Right, girls, OK— today we 're going to start [[our first of two classes looking at Carbon Dioxide]].'

Analysing this clause one might ask: WHAT are we going to start today? The answer, of course, would be, 'our first of two classes looking at Carbon Dioxide.'

The levels of analysis are further described in the next chapter, which illustrates how the Systemics software was used.

4.6 Interpretation

After the completion of the data collection, the transcription, and lexicogrammatical (clausal and interclausal) labelling, it will be possible to progress to an interpretation of each level. This follows Halliday when he suggests that, '...the
lexicogrammatical analysis is only a part of the task.' (Halliday, 1985b, 54) and continues by noting that for him:

It is an essential part; all text is made of language, and the central processing unit of the linguistic system is the lexicogrammar. But just as the grammatical system does not itself create text—text is a semantic creation, with the grammar functioning largely (though not entirely) as the automatic realisation of the semantic—so the analysis of the grammar does not constitute the interpretation of a text. (ibid., 54)

The interpretation at each of the levels was made by selecting samples from the school transcript in order to illustrate what is happening at each level.

4.7 Conclusion

This methodology chapter has been brief and personal. It has been brief to allow for a connection between the first three chapters (the introduction; the chapter detailing the development of science in Irish second level school; and the literature review looking at the language in science and the science classroom from different perspectives), and what remains in this thesis. It has been personal to highlight the work of the individual researcher in relation to the earlier chapters and the remainder of the thesis and invite the reader to join in the exploration of language. The researcher is neither a scientist nor a science teacher. It is hoped that not only those interested in science will find this thesis of value. Rather, the goal is to develop a linguistic tool that can allow those interested in seeing language at different layers and in different ways.

The journey into the language of school science in Ireland will begin in the next chapter with a sample from the transcripts being used to provide a walkthrough into the use of the Systemics software. This is being done prior to the subsequent analysis chapters which will be looking in depth at the lexicogrammatical labelling of the data; an analysis of that labelling; and a look at the interclausal analysis.
A discourse analysis that is not based on grammar is not an analysis at all, but simply a running commentary on a text: either an appeal has to be made to some set of non-linguistic conventions, or to some linguistic features that are trivial enough to be accessible without a grammar, like the number of words per sentence (and even the objectivity of these is often illusory); or else the exercise remains a private one in which one explanation is as good or as bad as another. (Halliday, 1994, p. xvi-xvii)

5 Looking at the data through Systemics software: Clause, analysis and interclausal labelling.

5.1 Introduction

The first four chapters of this thesis provided a starting point for situating the research within the realm of science in Irish education; for contextualising the research in relation to the academic literatures in which this research should fit; and providing for the reader the specific methodologies used during this research project. This chapter leads more directly to the detailed linguistic analysis of the remainder of the thesis by providing detailed illustrations of the software used for the analysis and offering a beginning point for the non-specialist, or non-Systemic Functional linguist, to understand the analyses in the remaining chapters.

In particular, this chapter is aimed at educationalists, to show how an elaborate set of linguistic tools for analysis may be applied in other classrooms, and other educational contexts. It is not expected that those educationalists will become linguists through reading this chapter, but it is hoped that by providing a 'way into' the theoretical framework for non-experts, this thesis will be open to a wider potential audience.
In addition, there are a good number of linguistic terms that are used in this chapter (and the remainder of the thesis), all of which are briefly defined, but not discussed in depth. Beginning with these caveats, it is hoped that those teachers and non-linguist academics will use references in this chapter and in the bibliography in relation to the analyses in later chapters.

The structure of this chapter will seek to illustrate, through a short, opening extract from the classroom transcript (contained in full in the appendices), how the analyses will proceed in subsequent chapters through the lens of the software used. In earlier chapters there were specific references to the use of Systemic Functional theory in educational research. There is no need to repeat that material here. Rather, it will be taken as accepted that in order to understand the entire grammar and linguistic theory underpinning the analysis of the data in this thesis, that references will be sought. For this chapter, and the remainder of the thesis, the theoretical framework, Systemic Functional Linguistics (hereafter SFL) and its associated grammar (hereafter SFG) will be shortened to initials.

The software used in this thesis was described briefly in chapter four as part of the research methods section. Here, details will be provided in using the software from the perspective of presentation of analysis at the various levels. The software has used the SFG of Halliday (1994) and complemented it with references to other supporting works, all of which are listed in the thesis bibliography. The hope is that by seeing how the software allows for labelling at the various levels of language accounted for in SFL that seeing screens in the subsequent chapters will allow heightened access to the research.

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8 Key references on SFG can be grouped into three categories: for the linguist; for the informed academic; and for the newcomer. For the linguist, see Halliday, 1994; Halliday and Matthiessen, 2004; Martin, 1992; Matthiessen, 1996; and Halliday and Matthiessen, 1999. For the informed academic, see Eggins, 1994/2004; and Martin, et.al., 1997. For the relative newcomer, see Bloor & Bloor, 1995/2004; Butt, et.all, 2000; Droga, et.al., 2002; Gerot et.al.; 1995; and Thompson, 1996/2004.
The sequence in this chapter detailing the specific levels of the grammar, and how *Systemics* displays them, will be as follows:

- Clausal segmentation;
- Transitivity and Ergativity;
- Mood;
- Metaphor;
- Interclausal segmentation;
- Exchange Structure.

The reason for this ordering is to introduce each level in a way that would allow for progression through each to the next level. Each section, therefore, will explain the term above, before discussing it in both linguistic and grammatical contexts, and illustrating its utility by examining a small sample of the transcript, by using images taken from *Systemics*.

Before introducing the levels of analysis, however, let’s look at the opening extract from the classroom, where the teacher is opening the class session.

### 5.2 Extract for illustration

At the point of the following opening extract, the teacher has begun the class. Before this sequence, she has taken roll for the day and is about to start a focus on subject content. Here is the opening extract:

1. Right, girls, OK—today we’re going to start [[our first of two classes looking at Carbon Dioxide]]
2. and learning about it.
3. So, before I show you
4. how to make it,
5. can anybody tell me anything about it,
6. that you might know already?
7. Johanna?
8. It’s in fizzy drinks.
9. It's in fizzy drinks.
10. It is.

From the opening exchange, all spoken clauses but for 8 are spoken by the teacher. From the outset, the teacher begins by addressing the entire class and informing the class that today's class is looking at Carbon Dioxide (1-4). The teacher also hints that Carbon Dioxide may have been mentioned in class previously, but not in detail. The teacher asks if anyone can tell her something about CO$_2$, that may have been introduced previously (5-6), and calls out a student by name (7). The student answers (8), the teacher repeats the answer (9) and confirms its validity (10). This is a straightforward opening sequence and will be used to begin illustrating the approach to grammatical labelling as seen through the Systemics software.

Within Systemics software, there is a Text window that contains the entire transcript split into segments as clauses (detailed in the next section). Here is a picture of the screen from the excerpt:

![Systemics Screen](image_url)

Figure 5.1: Text sample from within Systemics software.
Within the window, the letters in blue at the top are detailing comments from the researcher and helps set context and commentary as needed on the transcript. The numbers detailed to the left side of the window are the sequenced numbers of speech and refer to the clause on the right. References to speaker are marked as T2 (for this class teacher), ST (for individual student) or STS (not shown above--for multiple students).

The entire transcript is taken from two class sessions over two non-consecutive days (as detailed in chapter four). The transcript is in one file and begins in each class session after beginning non-educational tasks by the teacher (reading the register, news and announcements, etc.) and is otherwise inclusive of all class activity (i.e., interruptions to classroom are noted in transcript as comments, but not analysed). The entire transcript contains 1,634 clauses analysed at various levels according to SFG, and the levels used in this analysis will be detailed now.

5.3 Clausal segmentation

The first point to note is that this excerpt has been segmented by Clause. Here, Clause is being used as a term of grammatical neutrality. In other words, while sentence may be appropriate and relevant as a grammatical entity in written English, it is not clear where sentences begin and end in speech. So looking at the opening of this classroom extract, we have:

1. Right, girls, OK— today we 're going to start
   [[our first of two classes looking at Carbon Dioxide]]
2. and learning about it.
3. So, before I show you
4. how to make it,
5. can anybody tell me anything about it,
6. that you might know already?
The opening two lines are split into two Clauses and illustrate two key points. First, SFG uses Clause as an entry point for grammatical analysis, and defines it as, ‘(potentially) any stretch of language centred on a verbal group.’ (Thompson, 2007, 17) The use of Clause within SFG makes for a meaning orientated grammar which can account directly and differentially for spoken as well as written language. (See Halliday, 1985/89a; 1987)

The second item to note is that clause 1 contains an embedded clause. This term indicates a clause that functions within another clause as something other than a clause. Clause 1 begins, ‘...Today we’re going to start...’ and includes an Embedded Clause serving to complete ‘...going to start...’ with a clause [[our first of two classes looking at Carbon Dioxide]]. Embedded Clauses are included in the main clause in which they serve, but are also analysed as a separate clause. In the software being used for analysis, shown above, Embedded Clauses are marked (as above) with double brackets [[ ]], and analysed first as part of the main clause and then on their own. Each set of labels is included in the final analysis.

In addition to Embedded Clauses, the utterances in 3-4 and 5-6 illustrated cases of Projection. Projection occurs when Processes (detailed below) are either of Verbal or Mental subtypes. Each can be seen in this excerpt.

Looking at Clauses 3-4 and 5-6 with the Processes (or verbs) highlighted in bold type, the teacher states, ‘

3. So, before I show you
4. how to make it,
5. can anybody tell me anything about it,
6. that you might know already?

In Clause 3, the Process ‘show’ functions in a way that suggests the teacher will use either language or some other semiotic mode (maybe drawing on the board or looking
in a textbook) to indicate how to do something (in this extract, ‘to make it’). Within SFG, both Verbal and Mental Process types can project a clause to extend meaning. Such clauses will be shown on a separate line, and analysed in two ways. First in their own right as independent clauses, and secondly as projected by either Verbal (in which case it would be Verbiage) or Mental (then labelled Phenomena) Processes.

At this point in the chapter, the reader can see that grammatical terms and labels are being introduced at a rapid pace. Clause has been followed up by Process, Participants and then subtypes of Process (Verbal and Mental) and Participants (Verbiage and Phenomena). This is not being done to frustrate the reader, nor is it being done as an indication the such terms and labels are taken for granted and assumed known. Each term and label so far used throughout the analysis can be exploring by consulting the references terms are provided in the bibliography.

Following SFL theory, each piece of language in use has multiple (and simultaneous) functions, each of which relates to meaning in a different way. Halliday notes that, ‘...there are clearly three motifs running side by side in every clause, [though] a clause is still one clause.’ He then suggests that it is inherent in the theory and grammar that

\[
\text{It is a familiar problem for functional grammars that everything has to be described before everything else; there is no natural progression from one feature in language to another (when children learn their mother tongue they do not learn it one feature at a time!). (Halliday, 1994, 36)}
\]

The point Halliday appears to be making here is that in seeing language as having multiple, simultaneous functions, how is one introduced?; in which order are functions introduced and why?; and, how can one learning the grammar make sense without learning all of the grammar at one time? Of course, the latter question is impossible to answer. Rather, terms will be introduced in this chapter and explained briefly.
In order to proceed, here are two more screen shots from *Systemics*. Each will illustrate levels of labelling that will be detailed below. The first, Figure 5.2, shows the entire set of labels that SFG offers at the level of clause:

![Figure 5.2: Clause labelling in *Systemics* software.](image)

The second figure, Figure 5.3, uses the set of grammatical labels above as a starting point and begins an analysis at each level. Again, each will be detailed below:
Shifting away from looking at each clause as the entryway into the grammatical labelling used in this research, let us now move to seeing the elements of the clause in different ways. This requires a very brief look at how SFG establishes layers, or ranks, within its grammatical labelling.

### 5.4 Introducing SFG layers of meaning at clause level

In Figure 5.2 above, it is possible to see the various levels of labelling available within SFG. On the left side of screen shot is a set of initials that can be used to introduce the grammar. The set of initials visible, and their meaning within the grammar, are listed below:

<table>
<thead>
<tr>
<th>Tex1</th>
<th>Theme multiple textual-1</th>
<th>Theme multiple interpersonal-2</th>
<th>Topic marked --</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tex2</td>
<td>Theme simple</td>
<td>Topic marked --</td>
<td></td>
</tr>
<tr>
<td>Int1</td>
<td>SPEECH-FUNCTION Knowledge greeting</td>
<td>Mood declarative full</td>
<td>TENSE future</td>
</tr>
<tr>
<td>Int2</td>
<td>SPEECH-FUNCTION Knowledge statement</td>
<td>Mood declarative full</td>
<td>TENSE future</td>
</tr>
<tr>
<td>Lex1</td>
<td>Register scientific non-technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.1: Labels and meaning in Systemics.

Without providing in-depth definitions of the elements of the table, here is Halliday and Matthiessen with a concise description of the three metafunctions used within SFG:

The **ideational** metafunction is concerned with construing experience—it is language as a theory of reality, as a resource for reflecting on the world. The **interpersonal** metafunction is concerned with enacting interpersonal relations through language, with the adoption and assignment of speech roles, with the negotiation of attitudes, and so on—is language in the praxis of intersubjectivity, as a resource for interacting with others. The **textual** metafunction is an enabling one; it is concerned with organising ideational and interpersonal meaning as discourse—as meaning that is contextualised and shared. (1999, 7-8. Bold in original)

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9 Metafunction is a term used with SFL theory to reflect Halliday's notion of three distinct, simultaneous layers of meaning. Halliday and Matthiessen note: "... a natural language is functionally diverse: it extends over a spectrum of three distinct modes of meaning, ideational, interpersonal and textual. These highly generalised functions of the linguistic system are referred to in our theory as metafunctions." (1999, 7. Bold in original) In the above table, each of the labels Theme, Mood and Transitivity/Ergativity relate to one of the 'three distinct modes of meaning' noted. See also Halliday, 1994; Halliday and Matthiessen, 2004; Martin, 1992; Matthiessen, 1996 for further details.
This should be sufficiently clear for the non-initiate in following the three labels above (Theme, Mood and Transitivity) at a rudimentary level. In this thesis, there will be extensive use of Mood and Transitivity in analysing classroom discourse. In addition, Theme, or textual metafunction will be used in this research as it relates to longer stretches of speech, and is used to analyse mid-length teacher and student talk in order to explore how relative stretches of language are used differentially between them.

The next term to introduce here is that of Lexical item. There is a provision within Systemics for labelling segments of discourse that may be considered significant in some ways. The labels for lexical items at clause level concern their significance in relation to either of the Textual, Interpersonal or Experiential levels as noted above. This will be used where deemed appropriate in this thesis, but will not be a focal point of the research.

The descriptions so far have looked at what labelling will be taken into account in the clausal analysis and what will be used in this thesis. The figure above, however, looks at one approach to analysing the labels at clause level.

In Figure 5.2, there are three categories pictured. These are Tex, Int, Exp and refer to the labels in Figure 5.3 showing Th, Mo, and T and E. What the analysis labels show is the synthesis of labels at the clausal level and contribute to the analysis by consolidating them per clause. This will be illustrated below at the levels of Interpersonal and Experiential. In addition, Figure 5.3 shows Lex and this will be used to look at the register being used at the lexical level. Register here refers to the variety of language according to use. Particular attention will be paid to scientific and non-scientific language use in the classroom.

Each of these segments of grammatical labels and analyses will be illustrated below. However, these are limited to lexical and clause level analysis. Next, we will
look at interclausal level and exchange structure of the framework as seen within the *Systemics* software.

### 5.4.1 Introducing SFG layers of meaning at interclausal level

Beyond the clause, *Systemics* software also accounts for labelling at the Interclausal level and this will be seen now. The bulk of classroom discourse research (discussed in chapter three) involved looking at the exchanges taking place between teacher and student/s. Here is the screenshot in *Systemics* that will be used for introduction:

![Figure 5.4: Interclausal analysis in Systemics software](image)

Figure 5.4 shows the sample opening transcript in exchange mode. There are two key areas to look at here. First, in blue outline are the labels taken from Berry and Martin’s work as detailed in chapter three. The designators K1, dK1, K2 and K1f refer to the steps in the exchange as the class opens.

K refers to ‘Knowledge’ as opposed to ‘Action’; and the numbers 1 and 2 refer to teacher and student respectively (actually, 1 and 2 refer here to primary and
secondary knower). The letter following the final teacher utterance ‘f’ refers to ‘follow-up’. These labels are detailed in their entirety in chapter three.

The second key area of the interclausal analysis to look at, however, means returning to the clause analysis. Look at Figure 5.3 above, and settling on the Interpersonal analysis, note that the selection for the particular clause is, ‘Speech Function: Knowledge: Statement’. These descriptors are taken from the Systemics grammatical database for analysis as drawn from Martin (1992).

The next figures are used in the subsequent sections to illustrate the grammar more specifically at clause level. First, will be three figures, showing the complete labelling for three first three clauses spoken by the teacher.

<table>
<thead>
<tr>
<th>Clause: 1</th>
<th>Right, girls, OK— today we're going to start our first of two classes looking at Carbon Dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH1</td>
<td>Ext Conj Voc Int Mod Adj Voc Int Mod Adj Theme Theme Theme Theme Theme Theme Theme Theme Theme</td>
</tr>
<tr>
<td>M1</td>
<td>Subj Mood Fin Pred Mood-Residue Circ-Adj Residue</td>
</tr>
<tr>
<td>M2</td>
<td>T1 Time Actor Proc Mat Goal Range</td>
</tr>
<tr>
<td>T2</td>
<td>E1 Agent Proc Range</td>
</tr>
<tr>
<td>LEX1</td>
<td>Exp None Attrib</td>
</tr>
<tr>
<td>ME1I</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.5: Systemics clause level labelling, 1.**
The three figures above show the labels assigned to the first three clauses in the classroom transcript using SFG at the level of clause. Referring to the table above, it should be noted that not all words are labelled at each level. The reason for this is that not all words carry meaning at each level. In clause 1, for instance, the opening words spoken by the teacher are, 'Right, girls, Ok...' 

In this analysis, the first set of labels ‘TH1’ refers to Textual meaning and relates to how language flows textually from clause to clause. Using this analysis,
‘Right’ is labelled as being Textual: Conjunction: String: Theme. Deconstructing this allows us to see:

- **Textual** interpretation of word in context;
- **Conjunction**: situating the clause from the outset;
- **String**: beginning a sequence of utterances stating how class will begin;
- **Theme**: part of Theme of clause.

Theme refers to one of the three metafunctions noted above. Only one of its elements is obligatory, while others are used in various ways in both speech and writing to help structure and personalise the language used. So the first Thematic element here, ‘Conjunction: String’ contributes to meaning by starting the teacher off and leading to the remainder of the clause, ‘...girls, OK, today...’

The labels for the next two words (‘girls’ and ‘OK’) show INT, which points to their Interpersonal meaning orientation. Here, ‘girls’ is a Vocative calling attention to all students; and ‘OK’ is a Modal Adjunct focussing on what is to follow.

Finally, ‘today’ is the Topical Theme, or the key starting element in the clause. Halliday writes that, ‘the Theme is the starting-point for the message; it is the ground from which the clause is taking off.’ (Halliday, 1994, 38) The focus of course is that the teacher is looking at what will be done in class ‘today’.

Within a SFG analysis, what remains in the clause is labelled as Rheme. Note, however, that part of the Rheme of this clause is a long embedded clause, ‘...our first of two classes looking at Carbon Dioxide...’ (embedded clause is defined above). Note also that there is a label to the left of Figure 5.5, showing TH2, and this allows for labelling the embedded clause in its own right. That labelling includes the Topical Theme of, ‘our first of two classes...’
Theme will be used to analyse mid-length stretches of speech in the classroom, in order to show the various ways the teacher, and the students, develop meaning cohesively in their language.

Transitivity within SFG looks at Ideational meaning, and can be considered the 'content' of the clause. This level of analysis focuses on what might be seen as a 'verb' but referred to as Process with accompanying Participants and Circumstances. In the screen shots from *Systemics* above, let's look at each Process, Participant and Circumstance in sequence.

In Figure 5.5, clause 1, there are two Processes. The first is ‘...’re going to start...’ and the second (which is part of an Embedded Clause) is ‘...looking at...’ The first point to note that is SFG is not a word but a text grammar. The Processes here are expansive in that they look at complete pieces of meaning. The opening Process here is a Material Process (‘...’re going to start...’) in that an action in class is about to begin. Here, the students, with the teacher, are going to start a process of looking at specific science content.

Contrast the Material Process with the embedded clause whose Process is ‘...looking at...’ This is labelled a Mental Process of subtype Cognition. There are three subtypes to Mental Process: Cognition, Perception and Affection.

In Figure 5.6, the clause contains the Process ‘learning about’, which is also labelled Mental: Cognition. In Figure 5.7, the Process is ‘show’ which is labelled a Verbal Process.

Within SFG, there are six prime Process types. In addition to Material, Mental and Verbal, are Behavioural (where responses or reactions that are immediate, or without thought, are realised), Relational (where lexical items are linked with one another, and has two subtypes: Attributive and Identifying) and Existential. The
important point to note here is the Process types have different Participants, which we can see by looking at the Process introduced so far.

The opening Material Process ‘...[a]re going to start...’ has Actor as Participant; the Mental: Cognition has a Sensor as Participant; and the Verbal Process has Sayer as Participant. These labels are functional in nature and are associated with the particular Process type. However, there are other Participants (seen in Figure 5.5 as ‘Goal’; ‘Range’, and ‘Phen: Range’; in Figure 5.6 as ‘Phen: Range’; and in Figure 5.7 as ‘Rec’. Participant here is being used to reflect concrete or abstract active participation in the clause. Phenomenon, Receiver are designated in these examples.)

The only Circumstance in the three sample utterances here is in Figure 5.5, ‘Locn: Time’. In this utterance, ‘today’ is labelled as a Circumstance of Location and Time (within SFG, Locations situate Circumstances in Place and Time).

The next layer of labelling at clause level is the Interpersonal metafunction, which is an examination of the Mood of the clause. Halliday writes that, in addition to Theme/Rheme, and Transitivity, ‘...the clause is also organised as an interactive event involving speaker, or writer, and audience.’ (Halliday, 1994, 68) Butt, et.al. write that, ‘The two grammatical features that carry the main burden of interpersonal meanings are the SUBJECT and FINITE. They combine to make the MOOD of the clause.’ (2000, 88. Emphasis in original) This level of analysis is split into Mood and Residue, which will be introduced below.

Specifically, Mood involves looking at speech roles and focusing on the giving and receiving of knowledge on one hand, and action on the other. There are two aspects of this to consider. The first is seen in Figures 5.5-5.7 above. The second is at the level of Analysis and discussed below.
At the level of clause, Mood is realised by Subject (defined differently to Formal grammars) and Finite (marking for tense and polarity), in each clause, and is followed by Residue, containing features such as Predicate, Adjunct, Complement and Circumstance.

In the above screen shots from Systemics, each of these labels are used. For instance, in Figure 5.5, looking at M1 and M2, the sub-label in each area indicates whether or not the label is part of Mood or Residue. So in M1, the lexical items, ‘...we're going...’ comprise Mood, along with, ‘...girls, OK...’ and the remainder of the clause is Residue.

In Figure 5.6, the Mood, in which there is no separate Finite, the Mood and Residue are conflated (‘learning about’) and then followed by Residue (‘it’). And in Figure 5.7, there is a Adjunct: Comment (‘before’), Subject (‘I’) and the Finite again conflated with Predicate (show) and then the Complement (‘you’) in Residue position.

What should be obvious from the three clauses seen here is that each is a declarative made by the teacher to the students. However, the declaratives all share a common feature. In the first clause, the teacher is telling the students what work will be done today: ‘...we’re going to start our first of two classes looking at Carbon Dioxide...’; in the second clause, she continues, ‘...and learning about it...’; and in the third, ‘...before I show you...’ In each instance, the teacher is giving information to the students.

While the first three clauses are for illustration only, other exchanges in the classroom will consist of asking for, or demanding, information (interrogatives); giving services (again, declarative); and demanding an action (imperatives). Butt, et al draw attention to this Interpersonal aspect of language when they write:

English speakers and writers manipulate the Subject-Finite relationship of Mood to indicate whether they are giving or
demanding information or demanding goods and services. However, the relation between lexicogrammar and interpersonal meanings is not always straightforward—information can be sought using the imperative and declarative moods as well as the interrogative; and there is no 'normal' way of encoding an offer of goods and services. In spite of this, there are very few misunderstandings: listeners are perfectly able to distinguish between a demand for goods and services mapped onto an interrogative from a genuine question. (2000, 99)

The Interpersonal metafunction will be explored when the analysis of the classroom discourse explores the exchanges between teacher and student(s) during the teaching and learning of science.

There is a separate feature of the Interpersonal level of meaning making that can be shown now. Referring to Figure 5.3, where the Clause level analysis in Systemics is pictured, here are three new figures illustrating the Interpersonal analysis of the opening sequence from the teacher.

Figure 5.8: Clause analysis in Systemics, clause 1.
What these screenshots illustrate is the analysis of each of the grammatical labels discussed above. The labelling at clause level is then analysed in this screen, and particular attention should be paid to ‘Int1’ in the figures above. Each shows that the clauses are given the analysis of ‘SPEECH-FUNCTION: Knowledge: statement’, in Mood: Declarative (either Full as in clause 1 and 3, or ellipsed in clause 2). The relationship between the grammatical labels for Mood above; the analysis at Interpersonal layer here; and the Exchange Structure will be illustrated below. However, the labels for Exchange Structure are partly drawn from this analysis screen.
In addition to Speech Function and Mood, Tense can also be seen here. This is taken from either Finite or conflated Finite-Predicator in the grammatical labelling. Tense will not be a focus of analysis in this research.

5.4.2 Interclausal segmentation

This chapter has heretofore looked at clause labelling and analysis. Here, the focus will shift to the wider issue of what happens from clause to clause, or the interclausal level. This will involve two sections: the first will look at interclausal segmentation (which will be different from clause segmentation above), while the second section looks at labelling at the interclausal level within the Systemics software.

Here is another look at Figure 5.4 above:

![Figure 5.11: Duplication of Figure 4.](attachment:image)

There are two points to consider here, the first looks at how segmentation at the interclausal level will be handled. Rather than look at each individual clause this level of analysis groups clauses meaningfully by considering dependence. Martin (1992)
suggests that the unit of analysis should exclude, ‘…embedded and hypotactically\textsuperscript{10} dependent clauses…’ (40) In the above extract, clause 1-2, 3-4, 5-7 and 9-10 are grouped logically to reflect each as having one specific meaning. Figure 5.11 shows that each individual clause is numbered, but the analysis will be based on grouped clauses.

The second point to note here is the set of labels immediately to the left of the clause as shown in Figure 5.12. This is the Speech Function, and is taken from the labelling in the Analysis window as shown in Figures 5.8, 5.9 and 5.10. This will reflect the link between the grammatical labelling at clause level, the analysis based on that labelling, and the value of Speech Function at the interclausal level.

The next section will explore the final element of the interclausal level, the actual exchange as it happens in the process of teaching and learning.

\textbf{5.4.3 Exchange Structure}

The software contains the grammar as illustrated above as well as the analytical labels described. In addition, the grammar at interclausal level has labelling based on Berry (1981, 1984), Ventola (1984) and Martin (1992), and detailed in chapter three. Let’s consider the labelling that can be seen in Figure 5.11 above.

The teacher opens the class (this is after taking the register and making a set of brief announcements) by greeting the class and stating what will be covered in class on the day. Here is the first set of utterances by the teacher:

1. Right, girls, OK— today we ’re going to start [[our first of two classes looking at Carbon Dioxide]]
2. and learning about it.

\textsuperscript{10} SFG uses relations of clauses based on interdependency. The two types of interdependency are paratactic (elements of equal status) and hypotactic (relations between a dependent and a dominant clause). (Halliday, 1994, 218)
This opening is labelled a Greeting and is typical of how the class session begins. The teacher than shifts the focus from what will be done in the class, to stating to students what is to be done in class: ‘...first of two classes looking at Carbon Dioxide...’

The next teacher’s clauses prepare to ask students what they already know:

3. So, before I show you
4. how to make it,

Here, the teacher is seeking to work with students in establishing a common ground on which to begin. However, this is not the greeting. It is a different clause grouping which precedes the next. This is labelled Statement in the context of the class, and one must wonder why it is not grouped with the subsequent clause. After stating that the teacher is about to ask a question the next clause is:

5. can anybody tell me anything about it,
6. that you might know already?
7. Johanna?

This is a first a direct query to the class to find out what students ‘...might know already’ about CO₂, and then a focus to one particular student, ‘Johanna’. These are labelled separately, the former as Knowledge: Question; and the latter as Knowledge: Call.

Note that to the left of the Speech Functions in Figure 5.11 are a further set of labels, which are drawn from Berry’s extension of Sinclair and Coulthard exchange sequence and label for Primary and Secondary Knowers (K1 and K2), and also for Delayed Knower (dK1). Finally note that the student answers, the teacher replays the student answer, and then confirms it. Each of the labels seen here is part of the Interclausal labelling Systemics contains.
The key focus in the thesis regarding Exchange Structure is to show how the process works in science in an Irish post-primary school and see how that relates to the literature, as discussed in the third chapter of this thesis.

5.5 Conclusion

This chapter sought to provide introductory details of the use of Systemics software for the use of teachers and other non-specialist academics. At the outset, it was stated that it would be impossible to include all pertinent details in this chapter on the linguistic framework, but references were provided.

Details of the two distinct levels of analysis were provided: Clausal and Interclausal. A description of the starting point of analysis, the clause, was given and there was a look at the tri-stratal perspective used with Systemic Functional Linguistics. This will be relevant in subsequent chapters, when the classroom data is analysed for patterns of the language used by the teacher and students.

As well, descriptions and definitions of key terms of an Interclausal analysis were offered. This included details on Exchange Structure (which relates to Sinclair and Coulthard's work detailed in chapter three but draws more heavily on Berry, Martin and Christie) and how the dynamic structure of classroom talk can be mapped. There was also a look at the three-stranded approach of Systemic Functional Grammar, and how the software is used at each level.

The next four chapters will detail the analysis of the classroom transcript, and look at what happens in the teaching and learning in an Irish second-year science classroom when the subject is Carbon Dioxide.
...teachers don’t usually deviate from the Triadic pattern because maintaining it gives the teacher many advantages. In this structure teachers get to initiate exchanges, set the topic, and control the direction in which the topic develops. They get to decide which students will answer which questions and to say which answers are correct....in contrast, students have little or no opportunity for initiative, for controlling the direction of the discussion, or for contesting teacher prerogatives under Triadic Dialogue. (Lemke, 1990, 11)

6 Construing Science through Exchange Structure

6.1 Introduction

This chapter begins the analysis of the classroom data collected by looking at how a Systemic Functional lens sees exchange in the context of teaching and learning science. Exchange in educational contexts, of course, is a major part of pedagogy and needs to be analysed in a way conscious of its significance, sensitive to particularities of the classroom environment, and open to the subtleties of how teaching and learning happen.

This chapter, therefore, comprises four distinct sections. In the first, a sampling of exchanges is presented and then discussed. These begin to show the notion of exchange as detailed in chapter three (specifically, the IRE/F Triadic sequence, as the opening quotation illustrates) and variations of that sequence. One goal here is to establish the Triadic sequence as a sort of ‘norm’ within the classroom.

The second section looks at samples of longer stretches of exchange within the science classroom. These samples vary from between 15-20 utterances (with simple exchanges between teachers and pupils) to upwards of over 100 utterances between
teachers and students looking in more depth at particular aspects of the subject matter of science.

The next section looks at segments of exchange that seek to show details that matter in the science classroom from a pedagogical perspective. The segments here will explore in more depth the science being taught (or exchanged) between teacher and students, as well as identify instances where students either do, or do not, have potential to use the language of school science. These exchanges tend to be longer, and are synopsised in this section. The segments in their entirety are included in a readable format on the accompanying appendix disc.

As well, this latter section contains the analysis of a long sequence near the end of the class where the teacher pursues a particular pedagogical agenda and how that agenda begins, progresses and concludes. The goal here is to highlight how content knowledge in science is not introduced, but followed up within the classroom.

After this will be a short description of the benefit the use of Systemic Functional linguistic theory and grammar offers teachers in the context of teaching science. This section of the chapter will be repeated in the three subsequent analysis chapters.

### 6.2 Basic Exchanges in the Science Classroom

This first section looks at shorter segments of the exchange taking place in the classroom. Remember that in the chapter reviewing the literature on classroom discourse, the prime feature of the exchange is the Triadic Structure. This is called Initiation/Inquiry -> Reply/Response -> Feedback/Evaluation (IRF/E) and has been documented extensively in classroom research over the past few decades. One indication of the extent of this structure is Edwards and Westgate's comment that, "The frequency of those exchanges, and the overwhelming tendency of teachers to make the
first and third moves, is ‘essentially’ what makes classrooms so distinctive.’ (Edwards and Westgate, 1994, 125) In order to look at how this structure is enacted in one Irish classroom, this section looks at exemplars taken from the analysis of the classroom data, and uses the work of Berry, Martin and Ventola (documented in Chapter three) to illustrate how the flow of exchanges is realised.

Exemplars are used to look at patterns of exchange activity within the classroom, and not to quantify the amount of teacher dominance in the classroom. This exploration is to illustrate how teachers seek to engage pedagogically through language in the teaching and learning process.

Early in the classroom, the exchange sequence can be seen when the teacher opens the class session. The subject matter to be introduced in this class is Carbon Dioxide (as documented in chapter four, this was a topic selected by the teacher prior to recording in the classroom). The teacher first introduces the subject matter and begins the exploration of what students already know about CO2.

![Figure 6.1: Clauses 3-10.](image)

The teacher is quite straightforward here and asks the entire class what they know now about the subject matter. The labels in this figure are reflective of Berry’s contribution to exchange structure. The labels K refer to ‘knower’ and here one can see K1 being the teacher (or primary knower) and K2 being the student (or secondary knower). In addition, the teacher asking the question here is labelled ‘dK1’ for delayed
knower (in other word, the teacher presumably knows the answer but is not willing to state what it is at present). Note that the teacher asks the first part of the IRF/E sequence (clauses 5-6) and then calls one particular student (clause 7). The student answers appropriately, and the teacher confirms the answer prior to actually evaluating the answer (clause 10).

It might be indicative of the preponderance of such a dialogic structure that it happens in the very opening of the class and frequently thereafter.

A slight variation on this sequence can be seen in the following figure. Here, the teacher again asks the question, the student responds, but the teacher now changes tack:

The teacher follows the student by asking if the student is sure 'you think it’s clear' (clauses 48-49) before evaluating the answer in clause 50. Here, the teacher is trying to strengthen the students answer, or perhaps offering the student a chance to be more precise.

This is done in other ways by the teacher in a slightly later exchange, when the teacher changes the focus from one student to a second in pursuing a question. Consider the following segment:
Figure 6.3: Clauses 55-62.

The teacher begins by having one student answer (clause 56), and then progresses to asking the question again in a slightly different way (clause 57-58) and drawing another student into the sequence (clause 60). The student answers appropriately and the teacher replies with an evaluation of correctness. The same happens in the next sample. Here, in a slightly extended exchange, the teacher again pursues a question by changing student in mid-stream.

Figure 6.4: Clauses 79-88.

Here, the teacher is asking one student if she has heard of marble before (clause 79). The student answers and the teacher extends the question (clause 83) to include a second student in the exchange. This would seem to the social, or collective, nature of learning within the classroom through language. Then another student answers with an alternative (clause 86), which the teacher again evaluates as being correct.
As can be seen in this sample extracts, there are variations on the IRF/E sequence that allow for iteration, but also extension.

In one other exchange, the teacher takes advantage of a particular answer to a question, in a way that should explicate how extension of content can be introduced. Here, however, it goes nowhere:

Figure 6.5: Clauses 125-128.

The teacher follows up the student’s answer ‘for separating two liquids’ (clause 126) with an affirmation (clause 127). The teacher (in the same clause) uses an embedded clause (indicated with two square brackets) to extend the student’s answer (not just ‘two liquids’ but ‘two liquids that don’t mix’) and then introduces the technical term for phenomena: immiscible (in clause 128). One problem with this closing clause here is that goes nowhere. The next immediate clauses which are part of this exchange goes in a direction that continues the previous strand (here, the teacher is demonstrating the process of making some Carbon Dioxide for the students). So the term is literally thrown to the students, with no potential follow-up by them.

There is another instance of how the Triadic Structure can be altered for extension is here. The teacher is starting an experiment (in the front of the students who have full view of the entire process) to make Carbon Dioxide. In this extract, the teacher is going through the stages of preparing the experiment:
The teacher here explications the fact she is putting goggles on for the experiment (clause 166) and asks the students 'why'. The first student responds immediately with one answer, which the teacher seeks to extend for clarity (clause 168) from another student. The second student responds appropriately, and the teacher evaluates in the final clause by repeating what the student said, and adding 'up over my eyes' (clause 170). Here, there are two levels of extension: in the case of the initial student reply, the teacher redirects to a second student; and (without evaluating the first answer explicitly) accepts the second answer as being more appropriate.

In the above examples on extending the knowledge for students the teacher uses minimal language to either pose questions, or re-direct to a second student, or to introduce a term new for students. In another, longer, extract, the teacher extends what is being taught by offering more from her informed perspective (as Primary Knower):

<table>
<thead>
<tr>
<th>dK1 166</th>
<th>question</th>
<th>Why am I putting on the glasses girls?</th>
</tr>
</thead>
<tbody>
<tr>
<td>K2 167</td>
<td>answer</td>
<td>Because of the fire</td>
</tr>
<tr>
<td>K1f 168</td>
<td>call</td>
<td>Claire?</td>
</tr>
<tr>
<td>K2 169</td>
<td>answer</td>
<td>The acid might splash</td>
</tr>
<tr>
<td>K1f 170</td>
<td>acknowledge</td>
<td>The acid might splash up over my eyes.</td>
</tr>
</tbody>
</table>

Figure 6.6: Clauses 166-170.

| 273 | clarification | So there is n't much Carbon Dioxide, |
| 274 | statement     | there 's only less than 1% Carbon Dioxide, |
| 275 | statement     | so the thing would probably burn away |
| 276 | statement     | because it has plenty of Oxygen,      |
| 277 | statement     | But let 's say                        |
| 278 | statement     | I filled it up with Carbon Dioxide.   |
| dK1 279 | question | Then what would happen? |
| K2 280 | answer       | It would do away with the oxygen      |
| 281 | clarification | It would block out,                   |
| 282 | clarification | it would smoother all the Oxygen, and |
| K1f 283 | question | would it put out the fire, or?       |
| K2f 284 | answer       | Yeah                                 |
| K1 285 | acknowledge  | It would put out the fire.             |

Figure 6.7: 273-285.
The opening sequence has the teacher extending the previous exchanges by offering a clarification of the amount of Carbon Dioxide present in the atmosphere. She makes a set of statements to the students (clauses 274-276) and then poses a question to the students based on those statements (clauses 278-279). One student answers directly, which the teacher extends by adding details (clauses 281-282) and then asking a second question of the student, which the students responds to and the teacher evaluates (clauses 283-285). The engagement here has the student making an initial answer and then being prompted by the teacher to be more specific.

A similar action can be seen in the following sequence. Here the teacher asks one question that leads to another, more specific question:

<table>
<thead>
<tr>
<th>Clause</th>
<th>Type</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>368</td>
<td>statement</td>
<td>so if I put it into the jar with normal air</td>
</tr>
<tr>
<td>369</td>
<td>question</td>
<td>What have we got?</td>
</tr>
<tr>
<td>370</td>
<td>answer</td>
<td>Still burning</td>
</tr>
<tr>
<td>371</td>
<td>confirmation</td>
<td>It's still burning.</td>
</tr>
<tr>
<td>372</td>
<td>statement</td>
<td>So, is there.</td>
</tr>
<tr>
<td>373</td>
<td>question</td>
<td>what kind of Carbon Dioxide is in there?</td>
</tr>
<tr>
<td>374</td>
<td>answer</td>
<td>None</td>
</tr>
<tr>
<td>375</td>
<td>clarification</td>
<td>Right, just the average that is in air, which is less than one percent.</td>
</tr>
</tbody>
</table>

Figure 6.8: Clauses 368-376.

The teacher begins with one question (clauses 368-369), which a student answers appropriately. The teacher confirms the answer and then seeks more details. The succeeding query seeks to establish the amount of Carbon Dioxide in the jar. The question, 'what kind of Carbon Dioxide...' (clause 373) is potentially confusing. When the student answers, there is another potentially confusing bit. The evaluation the teacher offers, 'right' is extended with details on the amount of CO2 present. However, after telling the student she was 'right' (clause 375), the teacher then states that there is, '...less than one percent' (clauses 376). As with 'immiscible' above, the teacher does not pursue this. In two ways this may diminish what students could learn. In the first
instance, the actual presence (or not) of Carbon Dioxide in the jar being discussed; and in the second instance to allow students to speak the science they are to learn.

In a later exchange, the teacher, something similar may be happening. This comes at a time when the teacher is introducing new science content. The teacher asks a question about what the student already may know:

The question the teacher asks in clause 602 is, 'what did you learn about density...’ in a previous class session. The student responds 'density is mass over volume’ (clause 605) which the teacher evaluates this answer by stating, ‘that’s the formula for it [density] right...’ (clause 606). But is that the answer the teacher was prompting for? The following clauses in this wider exchange (clauses 607-649) pursue more specific details, and never returns to the formula the students here provides. This is not suggesting bad teaching at all, just a potential confusion by what the teacher asks to begin, and how the teacher pursues the content as it progresses in the exchange.

One final example from shorter extracts returns to the notion of extension introduced previously. Here, much later in the classes near the end of session two, the teacher is looking at acids:
This can be seen as a prototypical IRF exchange as the teacher asks a question, which is answered by two different students and the teacher confirms by repeating their answer. However, as with clauses 125-128 above, the teacher follows this exchange by introducing the term, ‘acid’ and continues (in clauses 1238-1242). Rather the detailing for the students what is already being discussed, the teacher mentions them and says, ‘there’s more to come about acids and bases later this year.’ (clause 1242). Students do not have the chance (at this point in the school year) to talk more about ‘acids and bases’ and learn to talk the science they are learning.

This look at the smaller exchanges suggests that there is learning teaching and learning taking place but that there may also be situations where more learning could happen. The notion of an ‘extension’ to the IRF/E sequence should perhaps be clarified in teacher education programmes where teachers are allowed to become more aware the language they use in their classroom.

But teacher talk is not only small segments of language. The next section will look at slightly longer instances of classroom discourse and begin to point to how meaning is made within teaching and learning science.

6.3 Varied (Longer) Exchanges in the Science Classroom

Beyond looking at the Triadic Structure of classroom discourse, this section explores somewhat longer extracts and seeks to understand what happens in such exchanges. The purpose of this section is to broker between short and much longer extracts in section four (below).

As with the previous section, there will be extracts presented, which are analysed based on the work of Berry, Martin and Ventola. They are longer than those already presented and offer a potential to explore stretches of classroom language that probe more deeply into the science to be presented. They also show how the teacher
directs the activity of learning in the classroom and seeks to engage all students. The reason for this is to locate the science in the classroom discourse. Such segments of text were referred to by Mehan as ‘topically related sets.’ (Mehan, 1979, p. 65)

The first extract has the teacher brokering between common sense and science knowledge. Here, the subject is the specific properties of Carbon Dioxide.

<table>
<thead>
<tr>
<th>K1 728</th>
<th>dK1 728</th>
<th>what colour Carbon Dioxide is?</th>
</tr>
</thead>
<tbody>
<tr>
<td>729</td>
<td>answer</td>
<td>There's no colour</td>
</tr>
<tr>
<td>K2 730</td>
<td>answer</td>
<td>clear</td>
</tr>
<tr>
<td>731</td>
<td>r-challenge</td>
<td>What colour is it?</td>
</tr>
<tr>
<td>732</td>
<td>r-check</td>
<td>Colourless isn't it?</td>
</tr>
<tr>
<td>K1f 733</td>
<td>r-confirmation</td>
<td>Right, colourless or clear</td>
</tr>
<tr>
<td>734</td>
<td>question</td>
<td>Emmm now, would you say</td>
</tr>
<tr>
<td>dK1 735</td>
<td>question</td>
<td>there is a smell off it?</td>
</tr>
<tr>
<td>K2 736</td>
<td>answer</td>
<td>No you can't smell it at all</td>
</tr>
<tr>
<td>K1f 737</td>
<td>r-confirmation</td>
<td>No smell off it.</td>
</tr>
<tr>
<td>dK1 738</td>
<td>question</td>
<td>OK, emmm, and what would it taste like?</td>
</tr>
<tr>
<td>739</td>
<td>answer</td>
<td>No taste</td>
</tr>
<tr>
<td>K2 740</td>
<td>answer</td>
<td>tasteless</td>
</tr>
<tr>
<td>dK1 741</td>
<td>r-challenge</td>
<td>Would it not taste like anything?</td>
</tr>
<tr>
<td>K2 742</td>
<td>answer</td>
<td>No</td>
</tr>
<tr>
<td>K1f 743</td>
<td>statement</td>
<td>No, OK so, no colour, no smell, no taste...</td>
</tr>
<tr>
<td>744</td>
<td>statement</td>
<td>now, we know</td>
</tr>
<tr>
<td>K1 745</td>
<td></td>
<td>that it's more dense than</td>
</tr>
</tbody>
</table>

Figure 6.11: Clauses 728-745.

The teacher begins this sequence with a straightforward question (clause 728) which two students attempt to answer (clauses 729-730). The teacher repeats the question, and then changes the approach by being more precise in her intent (clause 732). Using the term colourless in clause 733 allows the teacher to progress in the rest of the extract to direct students to answer in a particular way. But that really isn't achieved here at the student answers 'you can't smell it at all' (clause 736). This is confirmed by the teacher, who then progresses to 'taste'. Here the students answer, initially, 'no taste' (clause 739) and then 'tasteless' which would seem to be the way the teacher prefers the terminology (taken from clause 732-733). But why not challenge
(and extend) ‘no smell’ by offering ‘odourless’? This would seem to be more in line with what she wants.

Again looking at the differences between common sense and science language, this extract shows a focus, by the teacher, on extension again:

In this extract, the teacher relates what is to be introduced by asking students to remember a previous activity. She asks the students what happened when she (the teacher) ‘...dropped the acid on to the marble chips’ (clause 957). The exact progression here is from ‘fizzing...’ (clause 960) from the student; to ‘...kind of bubbled...started fizzing...’ (clauses 961-962); on to what the fizzing and bubbling represented, ‘...forming Carbon Dioxide’ (clause 966). The teacher leads the class (via her questions) to what she wants: that Carbon Dioxide is a ‘...gas’ (clause 970), from the student, which is confirmed by the teacher (clause 971). This is then elaborated on for the specific purpose of detailing the procedure for preparing Carbon Dioxide. This
extension takes the students from common sense terms ‘bubbling and fizzing’ to the formation of CO2, to the notion that Carbon Dioxide is a ‘gas’. This content relates to the previous exchange, which looks at the fact that Carbon Dioxide is ‘colourless’; ‘has no odour’; and is ‘tasteless’.

Something similar happens in a slightly later extract. In this case, the teacher begins with a mention of one acid and moves ahead to consider the link between the scientific, to the more common sense, and back to the scientific:

| K2 | 1024 | answer | Hydrochloric Acid |
| K1f | 1025 | r-confirmation | OK so OK so we had Hydrochloric Acid |
| 1026 | question | plus now what did I mix it with? |
| dK1 | 1027 | question | What was [[the name I told you last week]]? |
| K2 | 1028 | answer | Marble? |
| K1f | 1029 | r-challenge | Marble what? |
| K2f | 1030 | answer | Chips |
| K1f | 1031 | r-confirmation | Marble chips... |
| 1032 | command | OK so we’ll write that in. |
| 1033 | | And I’ll just put the scientific name underneath... |
| K1 | 1034 | statement | It’s Calcium Carbonate |

Figure 6.13: Clauses 1024-1034.

In response to an earlier question, a student answers, ‘Hydrochloric Acid’ that the teacher confirms (clauses 1024-1025). The teacher uses the scientific term to pose a question that draws the answer, ‘Marble’ (clause 1028); and, after being challenged by the teacher (clause 1029), ‘Chips’ (clause 1030); to the teacher offering the full answer ‘Marble chips’. She then progresses to the scientific name for marble chips, and refers to the ‘scientific name’ as ‘Calcium Carbonate’ (clause 1034). The teacher is again extending student’s understanding of science through language. But where do students get the chance to use this language?

The same issue returns later in the class when the teacher re-introduces the same content:
In this case, the teacher begins with the scientific terminology, before telling students ‘what else would you write there?’ (clause 1478). The answer is, ‘marble chips’ and the teacher evaluates this by confirming that, ‘marble chips is fine.’ (clause 1480) The shift here is from scientific to common sense language and telling students that the common sense language is allowed in learning the science. Students may be receiving conflicted messages here. They may feel that the science terms are important and to be valued, while at the same time being told they are not needed. In addition, the students do not have the opportunity to use the language of the scientific terms they are being given.

The same potential confusion would seem to crop up a bit later in this extract:

In this exchange, the teacher uses common sense language (‘fizzy drinks’) and relates that to the scientific term (‘carbonated drinks’); before asking why this name (which name?) is used? The teacher asks for answers in two different ways, and then calls directly to a specific student (‘Aisling’; clause 1554). The student provides the
correct answer, which the teacher evaluates in a confirmation and then a re-statement of the correct answer. So there, the link is clear between the common sense term and its relation to the scientific term (and which one is preferred and valued).

The longer exchanges began to explore the science in the science classroom through the language. As well, the sense of longer exchanges allowed for an explication of meaning of science in different ways beyond simple (Triadic Structure) exchanges.

This next section will delve deeper into the science in the exchanges by analysing a small set of much larger segments of classroom discourse at the exchange level. The goal here is to look how implicit or explicit the teaching of science through language is in such exchanges.

6.4 Extended (Pedagogical) Exchanges in the Science Classroom

This final section looks at longer exchange sequences and looks at how science is taught in such sequences. The focus here is not limited to individual words (which was the focus on much of the research in the language of school science) but in longer stretches with specific purposes. These purposes include introducing new topics or subject content; seeking to engage students in bridging between common sense knowledge and scientific knowledge through language; and seeking to heighten students' understanding of science and the 'real world' of nature. Each of these will be seen in the following extracts

The first segment is the teacher detailing to the students what it is they will be doing. They are about to start writing in their copybooks and the teacher is beginning to introduce the science to them:
OK, so, then, last week, we went through some of the properties of Carbon Dioxide and you wrote me a little list. So today I'm going to divide those into two types of properties. Now you have our list of properties we're going to divide them now into physical properties and chemical properties. So physical properties are kind of what they look like and feel like. And chemical properties is the chemistry of the Carbon Dioxide. So compare the physical or chemical properties and to write our list, we're going to draw ourselves a little table.

This is basically the teacher telling the students what they will be doing over the next short while in class. She begins by telling what was done in the previous class; then details two types of properties for Carbon Dioxide; and finally how to write them into their copybooks. The teacher states, 'we're going to divide them [the properties] now into physical properties and chemical properties...' (clause 1129)

This then moves to defining each property. In the first instance, the '...physical properties...' are '...kind of what they look like and feel like...' (clause 1130). Here, the notion of properties of Carbon Dioxide is given real and tangible connections to common sense thinking ('what they look like and feel like'). But the learning of scientific properties would more likely require a technical language to identify what those physical properties are and how to describe them.

In the second instance, the teacher states that, '...chemical properties is the chemistry of the Carbon Dioxide.' (clause 1132) In stating the obvious here, the teacher is again limiting the scientific (or perhaps technical) language which would allow students to learn the language of science to think through learning science.

The final piece of this exchange is perhaps most disturbing. A student asks a question that has nothing to do with the teacher has been introducing (properties of
Carbon Dioxide), but rather about protocol in writing in her copybook. This extract, where the teacher seems to be either distracted, or distanced, from the students is contrasted with a sequence just minutes before in the class, where the students were being pushed into using science language to learn.

The teacher opens this sequence (which is continued from a longer extract) by talking about an equation. She progresses to say that ‘...now we need the symbols’ (clause 1093) and moves ahead to the chemical equation. The first clear point of distinction between common sense and scientific language here is the term ‘limewater’. While the teacher states that, ‘...limewater, it’s perfectly fine...’ (clause 1096), but then
notes that, 'the really scientific word for limewater is Calcium Hydroxide.' (clause 1097) Before looking at 'Calcium Hydroxide' the teacher says that students will need to learn the word 'limewater' but need the '...symbol, as well, for Calcium Hydroxide.' (clauses 1095-1100)

The teacher moves through a set of questions asking students what Calcium Hydroxide is comprised of, and validating each step of the way.

In this section of the sequence (clauses 1102-1119) the teacher is directing the students to think through the learning of science by using the language of science. The focus is almost on individual words ('Calcium', 'Oxygen', and 'Hydrogen') before moving to chalk (clause 1113), and the technical term for chalk, before asking what elements are in chalk (clauses 1114-1119) in a way that helps students articulate using the language of the elements. This teacher is taking advantage of the knowledge students have to extend their learning in a highly positive manner here, in contrast with the previous extract.

The same happens in the next sequence which shows the teacher continuing with the properties of Carbon Dioxide. Here, in an extended sequence, the link between common sense and scientific language can be clearly seen:
Figure 6.18: Clauses 1187-1216.

The teacher is looking at the properties of CO2, and is asking students what happens when it is dissolved in water. The focus is on common sense terms, and the teacher and students agree that the water would taste fizzy. (clauses 1187-1196) The teacher continues with the chemical properties of Carbon Dioxide, and asks about limewater and the limewater turning milky. (clauses 1196-1201)

The teacher moves to another chemical property of Carbon Dioxide. Here the student responds, ‘it could put out fires’. (clause 1203—it is interesting that the student poses this answer in question format ending on a rising tone) The teacher evaluates the answer (clause 1204-1205) before looking for a ‘more scientific’ way of saying the same thing. (clause 1206)
The teacher repeats the notion of saying 'it puts out fires more scientifically' (clause 1209) and draws from the students the answer she wants: 'it extinguishes fires.' (clause 1212) The teacher seems to challenge that (clause 1213), before hesitating a bit (clauses 1214-1217), before concluding this segment with, 'no let’s say that.' (clause 1218) The teacher gets the students to utter the more scientific terms, but then almost seems to backtrack away from it...but doesn’t do this either.

Much of what has been seen in these longer extracts is bridging the common sense with the scientific language of the world. In the next extract, one of the most interesting of the transcript, the teacher takes this a bit further, by looking not at the language of science to engage students in learning, but via a thought process that is truly stimulating.

In this extract, the teacher is following up on photosynthesis and asking the students about plants and how the interact with Carbon Dioxide. The statement prior to this extract has the teacher saying, 'So plants use Carbon Dioxide to make their food, and then they release Oxygen, which humans use to respire.' (clauses 1351-1353).
This extract begins with the teacher pursuing a line of questioning about plants and their need for CO2. Then moves to ask an interesting question in clause 1385: ‘would we be in trouble if we had no plants?’ What makes this an interesting pedagogical exchange is how the students follow the questions.

The first student answers ‘yeah’ (clause 1360), to which the teacher issues a challenge: ‘why would we be in trouble if we had no plants.’ (clauses 1361-1362) This is seeking to extend the students cognitively rather than through language. The notion here is of the teacher trying to get her students to ‘think science.’
One student answers the question by saying, ‘Because there’d be no Oxygen’ (clause 1365) and another student replies, ‘there’d be more CO2 than Oxygen’ (clause 1367), to which the teacher responds in a command: ‘forget about Oxygen for a minute.’ (clause 1368)

The students seem confused and one answers, ‘they produce Carbon Dioxide’ to the question from the teacher ‘if there are no plants why would we be in trouble?’ (clauses 1369-1371) Here, the teacher changes her approach to the questioning and poses this to students, ‘What would we eat...if there was no plants?’ (clauses 1372-1374)

Students respond, ‘there’d be just meat’ (clause 1375) and the teacher asks, ‘and how do you think cows grow?’ (clause 1378) The teacher continues this give-and-take with students for another while and the exchange continues:

| 1385  | Like, if you think about what you have for dinner... |
| 1386  | question what do you have? |
| 1387  | follow-up Spuds carrots chicken. |
| 1388  | question What does chicken eat? |
| 1389  | answer feed... |
| 1390  | answer corn |
| 1391  | question What do chickens eat? |
| 1392  | follow-up Corn, seed, |
| 1393  | statement they all come from flower, plants. |
| 1394  | statement OK-- So we ’d be in trouble |
| 1395  | statement if there was no plants. |

Figure 6.20: Clauses 1385-1395.

In this concluding section, the teacher is more and more personalising the notion of science for the students by relating it to their evening meal. This is an excellent example of the teacher seeks to link the science content (introducing CO2) according to how the curriculum intends it, with how the science in everyday life might be
considered. Science is not solely in the school classroom, or the laboratory, but outside in the entire world.

The focus on this exchange is not language, but thought. The teacher is getting (or trying to get) the students to think about what happens in the outside world that relates to science, and vice versa.

The next segment has the teacher prompting students to write in their copybook. Here, the class is coming to a close and the teacher is seeking to complete introducing science content to the students.

Figure 6.21: 1597-1613.

The teacher starts by telling the students they will be writing down the experiment for making Carbon Dioxide. She starts by stating that limewater was not used, and then begins explicating the stages of the experiment (clause 1604).

The first piece of equipment (apparatus) is followed by step two (opening the tap), and then the third stage (letting the acid out) in clauses 1606 to 1615 in a way that seems like explaining the genre of a procedure to students. Here, the teacher is leading
the students through writing into their copybooks but also prompting the students what to write. These questions are taking the students to consider both the process (undertaken in this case to make Carbon Dioxide in the classroom) with the elements required to do this and how each works.

This sequence finishes the science in the classroom in the final extract:

| KH 1616 | statement | I opened up the little tap and let the Hydrochloric acid dribble down on to the Marble chips. |
| KH 1617 | statement | OK so we’re gonna say… |
| KH 1618 | question | what did we notice when we did that? |
| KH 1619 | answer | Bubbles |
| KH 1620 | answer | fizzing |
| KH 1621 | confirmation | Bubbles and fizz |
| KH 1622 | statement | OK, so at the same point you can say, a fizzing was noticed. |

Figure 6.22: Clauses 1616-1625.

The teacher is continuing to detail for students what to write in their copybooks, and does so here with the scientific language that has already been used. However, after introducing the Hydrochloric Acid (in clauses 1616-1618), and what happened when the acid fell on the marble chips, the teacher asks, ‘when did we notice when we did that?’ (clauses 1619-1620) Students respond, ‘bubbles’, and ‘fizzing’ (clauses 1621-1622) which the teacher accepts as is. Her final comment is, ‘…at the same point you can say, ‘a fizzing was noticed.’ (clauses 1624-1625)

There seems to be a constant shift from common sense to scientific language and back again, specifically in relation to terminology or individual words. This teacher is working her students through the learning of science with this shifting throughout her classes. The next section will explore the exchanges in a more detailed manner by looking at some of the grammatical features of how those exchanges were realised.
Exchange within the classroom was detailed in the literature review and can be encapsulated within a re-iterative triadic structure of Inquiry -> Reply -> Evaluation (Feedback). This was established in some detail in Sinclair and Coulthard (1975) and in subsequent work that established further nuances in relation to the structure (in particular Mehan, 1979; Berry, 1981a, b, c and 1987; Martin, 1992; and Wells, 1999a and 2000a). In addition, there is now a fairly strong critique of this exchange structure within educational theory (see Lemke, 1990; Wells, 2009; Alexander, 2006), where moves are being made to re-structure classroom talk into a more dialogic mode.

The analysis here, and its use of Systemic Functional theory, continues the work of Berry, Martin and Ventola by looking at variations of the exchange. Martin write that, ‘Berry has considerably elaborated this [triadic structure] framework within a systemic functional paradigm...[by] expand[ing] the pairs notion to allow for one, two, three and four move exchanges.’ (1995, p. 47)

What is highlighted in the analysis here in three differing sequences (basic IRE/F exchange as well as varied length and extended sequences of talk) is the sense of both iteration as well as extension. The exchange in Figure 6.12 in this chapter highlights that extension, and is indicative of how it can contribute to student’s improved understanding of the language of science.

However, following Lemke, the findings here suggest that students are given very little space within the classroom to actually use the science talk the teacher is offering. In the exchange in Figure 6.13, and again in Figures 6.14 and 6.15, there is terminology introduced into the classroom, but used only by the teacher. Lemke notes that it is important for students to have the opportunity to have ‘...more practice talking
science,' but also that students are taught, '…how to combine science in complex sentences' (1990, pp. 168-169)

The value of a detailed grammatical analysis, which follows in the next three chapters, is that it shows precisely how the triadic structure is realised through language. These points will be detailed in a similar section in the forthcoming chapters.

6.6 Conclusion

This chapter begins the process of looking at the discourse of the science classroom by exploring segments of that discourse at the exchange level. This level allowed for a look at the IRF/E sequence, which is ubiquitous in schooling, showing how it is not a static entity, but something that is iterative and can be used to extend the learning (or potential learning) taking place in the classroom.

The notion of the science in the exchanges were also looked at, and how the language of the science classroom bounces back and forth between the common sense language of students’ everyday lives with the specificities of scientific language. This back and forth offers students the opportunity of making links between the classroom and the outside world, and one of the extended exchanges looked at one detailed example of students being cognitively guided into recognising those links.

What was missing from these exchanges were students having any opportunity to use the scientific language they were being introduced to. The students were able to answer teacher questions using scientific (and common sense) language at various times, but not to engage in dialogue through that language. In addition to answering teacher question, it seemed the only other time scientific language was being used was to instruct students what to write in their copy books.

However important the exchanges between teacher and students is, there is more to language than exchange. The next three chapters look at specific grammatical
features of classroom discourse, with a focus on how the exchanges are realised through language. The next chapter looks at the Interpersonal level of language through a Systemic Functional lens, and details more precisely how the exchanges happen.
...the relation between lexicogrammar and interpersonal meanings is not always straightforward—information can be sought using the imperative and declarative moods as well as the interrogative; and there is no 'normal' way of encoding an offer of goods and services. In spite of this, there are very few misunderstandings: listeners are perfectly able to distinguish a demand for goods and services mapped on to an interrogative from a genuine question. (Butt, et. al., 2000, 99)

7 Construing Science Interpersonally

7.1 Introduction

This chapter will move from an exploration of the exchange structure of classroom discourse, to the more specific grammatical (or lexicogrammatical) features of language from the classroom. In the previous chapter, the focus was how questions are posed, answered and checked, from the perspective of how specific exchanges happen. The focus in this chapter shifts to a clausal one, and will begin by exploring features at the Interpersonal level of language in use. This move takes the discussion from an educational to a more linguistic level and challenges the reader to enter within that linguistic domain.

It is intended that this chapter will be made more readable for non-linguists (more specifically, non-Systemic Functional linguists) by limiting the discussion to several points within the Interpersonal level of language. There are two immediate definitions to establish. The first is the term 'lexicogrammatical'. This refers to, '...words and the way they are arranged.' (Butt, et. al., 2000, 7) The use of lexicogrammar is preferred in Systemic Functional work as it allows for a clear explication that meaning comes not solely from individual words (or lexis) but from words working and
acting together in context (lexicogrammar). This was introduced in the literature review in a discussion of Halliday’s writings on the language of science.

The second term is the use of Interpersonal\textsuperscript{11} in relation to the level of language under discussion. As detailed earlier in this thesis, SF grammar uses a tri-stratal view of language in use and refers to them as the Interpersonal, the Ideational and the Textual. The first refers to, ‘...language in the enactment of human relationships.’ (Halliday and Webster, 2009, 253)\textsuperscript{12} In the context of classroom discourse, the relationship between teacher and students is at the core (and this was partly explored in the previous chapter on exchange), but there is also the relationship of each to the science content being introduced. The focus of this chapter will be this Interpersonal level of language.

There will be three sections of analysis to this chapter. The first will look at the role of questions in teaching and learning, and a focus on the questions posed to the teacher (by students) and how they are analysed at the Interpersonal level of language. This involves looking at Speech Functions within the classroom, and how they become realised.

The second section will begin detailing the features at the level of lexicogrammar that contribute to the Speech Functions, but will focus more specifically at the labels of Subject and Complement. The reason for this focus is that in the science classroom, with the distinction between science and common-sense language (as detailed in the previous chapter) there is an opportunity to look at specifying how those languages are used by teacher and students by looking at the Subject and Complement of selected clauses.

\textsuperscript{11} Convention within Systemic Functional Linguistics is to use upper case for functional terms and categories.

\textsuperscript{12} The Ideational level of language refers to, ‘...language in the construal of experience’; and Textual refers to, ‘language in the creation of discourse, which is an enabling function with respect to the other two.’ (Halliday and Webster, 2009, 253) Each of these two will be further defined the next two chapters where they are used.
Finally, the third section will offer a look at Adjuncts in the analysis of the classroom and pursue the use of them by the teacher and students. Specifically, the Adjunct being explored will be Mood Adjuncts, which are ways for labelling certainty/doubt; positive/negative; and a sense of time. What is explored is the use of each of these by teacher and students as a way of understanding their relative roles within the classroom.

These three aspects of the Interpersonal nature of language will be illustrated by reference to extracts from the transcript seen through the use of Systemics software. The screenshots will be limited to the specific feature(s) under discussion as much as possible. Any technical, or linguistic, material will be detailed at the beginning of the relevant section (and serious effort will be made not to over-technicalise the discussion) being presented.

7.2 Interpersonal Analysis

7.2.1 Questions and Speech Function

Here, the questions asked by the teacher and students will be analysed and these will be looked at in relation to speech function. The key labels here will be Interrogative, which include WH- and YN-interrogatives. WH-interrogatives are questions that expect a specific answer (other than yes/no). These are almost entirely asked by the teacher in this classroom and directed towards students. YN-interrogatives look for a confirmation or negation of something and these are posed both by teacher and students (though in very few instances). Examples of each of these can be seen early in the classroom transcript:

13: 1 An/Intl/Mood/imperative/full  
14: 1 An/Intl/Mood/YN-interrogative/full  
15: 1 An/Intl/Mood/WH-interrogative/full  

T2 Say it again.  
ST It’s carbon and two oxygens?  
T2 How do you know?
This excerpt (like those below) is drawn from the analysis of the transcript, and is taken from the Search feature of Systemics, showing the full analysis of the labelling. One can see the number of the utterance (from the transcript) on the far left; the complete label for the utterance at the Interpersonal level (An = Analysis; Intl = Interpersonal; Mood = the system for Interpersonal meaning where the clause functions as exchange between two participants; and full (as opposed to ellipsed or abandoned)); and then the speaker (T2 and ST); followed by the clause as transcribed (including punctuation).

As can be seen here, the teacher is telling the student to repeat what was said (clause 13) which is followed by the student responding. This was formed as a declarative, but through intonation ended as if it were an interrogative. In addition, after the teacher challenges the student, the student again replies with an interrogative based on intonation.

In looking at other student replies, a good number of them are the same. For instance, here is an excerpt from a bit later in the class session:

The student here, in clauses 99 and 103 responds with an interrogative. In a set of clauses explored in Chapter 5, here are different students doing the same thing:
This pattern is encountered so many times that it appears to be a sort of standard for students in this classroom. The teacher is asking specific (WH- and YN- interrogatives) questions, and the students are responding with interrogatives. In addition, in looking at clauses 99 and 864, the students are not using full interrogatives. Rather they are answering in ellipsis form in both cases. While not as regular a pattern, this does happen in a few other cases (see clauses 258, 302, 321, 899, 1045, 1085, 1172 and 1255 for other examples). In each of those other clauses, the elided interrogative is also a response to a teacher question.

This is not to suggest the teacher does not use ellipsis in her own talk. She does, and does so quite frequently, but not in the form the students do. Generally her shortened clauses are either responding to a student or addressing a question (or follow-up) to a student or group of students. For instance:

In clause 22, the teacher is responding to the student by challenging her response. Is it possible that such challenges lead to students answering via questions? While the knowledge of content matter would be a factor in the relative lengths and depth of phrasing between teacher and student, it is important to allow students to begin developing longer phrasings in science.
Accepting that the teacher asks more questions, it is worth looking at the questions students ask the teacher. These are minimal in the classroom (5 out of 1633 analysed clauses) and focused on specific functions. The first is clarification of the science content, or directly relating to the science content. Mid-way through the opening class, a student raises her hand the teacher calls to her:

442: 1 An/Intl/Mood/mod-interrogative/ellipsed T2 OK— Yes, Leanne.
443: 1 An/Intl/Mood/YN-interrogative/abandoned ST Does it make the
444: 1 An/Intl/Mood/declarative/full ST does it make the marble ****
445: 1 An/Intl/Mood/declarative/full T2 Emmm... no, the marble is reusable...

Figure 7.5: Interpersonal Extract 5.

The student opens by stammering and abandoning her question, then progresses to asking most of her question (in fact, this utterance is obscured on the tapes) to the teacher, and the teacher’s response allows for an understanding of the question: ‘does it make the marble go off or some such. This is sole direct effort at a student seeking clarification (or curiosity) of an aspect of the class relating to science content.

The remaining questions by students all have do with matters of procedure or order within the classroom. Most particularly, the students are asking if they are do one thing or another, or clarification about some physical aspect of the lesson. Here the student clauses in full:

453: 1 An/Intl/Mood/declarative/full ST Are we drawing this?
484: 1 An/Intl/Mood/YN-interrogative/full ST Do you have to draw in the Carbon Dioxide...?
858: 1 An/Intl/Mood/YN-interrogative/full ST Do you write 1,2 3 beside it...?
1435: 1 An/Intl/Mood/WH-interrogative/full T2 What number is that?

Figure 7.6: Interpersonal extracts 6.

Considering that students respond to the teacher in interrogative mode (as illustrated above), and that students as so very few questions, it is pertinent to look at teacher questions and explore any differences between them.
Within the two class sessions and focussing on WH- and Y/N- interrogatives, there a total of 176 of the former and 159 of the latter-- the vast majority of which are teacher questions. The teacher asks the majority of questions with a close balance between WH- and Y/N- forms, and many of these questions are clustered together as part of specific exchanges.

In this sequence, early in the first class, the teacher is opening the subject matter of Carbon Dioxide, and asking the students what they are already know about it. Note the sequence and the succession of teacher questions in this sequence:

13: 1 An/Intl/Mood/imperative/full T2 Say it again.
14: 1 An/Intl/Mood/YN-interrogative/full ST It 's carbon and two oxygens?
15: 1 An/Intl/Mood/WH-interrogative/full T2 How do you know?
16: 1 An/Intl/Mood/YN-interrogative/full ST Cause it 's CO2?
17: 1 An/Intl/Mood/declarative/full T2 Right, so CO2 is the formula.
18: 1 An/Intl/Mood/declarative/full T2 So it must be made of carbon and two oxygens.
19: 1 An/Intl/Mood/YN-interrogative/ellipsed T2 Yes, Fiona.
20: 1 An/Intl/Mood/declarative/full ST Ya use it
21: 1 An/Intl/Mood/mod-interrogative/full ST when you breathe?
22: 1 An/Intl/Mood/YN-interrogative/ellipsed T2 Do ya.
23: 1 An/Intl/Mood/YN-interrogative/full T2 Is it useful
24: 1 An/Intl/Mood/declarative/full T2 for when you breathe?
25: 1 An/Intl/Mood/declarative/full ST Yeah... you breathe it out...
26: 1 An/Intl/Mood/declarative/full T2 Yeah... we breathe it out.
28: 1 An/Intl/Mood/WH-interrogative/full T2 Ciara... what do you think?
29: 1 An/Intl/Mood/declarative/ellipsed ST It 's a gas.
31: 1 An/Intl/Mood/declarative/ellipsed T2 It 's a gas.
32: 1 An/Intl/Mood/declarative/ellipsed ST It 's in fire extinguishers..
37: 1 An/Intl/Mood/declarative/ellipsed ST and make oxygen for us
38: 1 An/Intl/Mood/declarative/ellipsed ST to breath.
39: 1 An/Intl/Mood/YN-interrogative/ellipsed T2 Do they?

Figure 7.7: Interpersonal Extract 7.

The teacher is following up virtually each student answer with a question seeking to advance the student's talking or thinking about the science under discussion. This is a typical sequence in the classroom and always based on the specific subject content.
Just a few minutes later in this classroom, the teacher is beginning to prepare Carbon Dioxide and is describing the process for the students. The teacher again prompts the students for answers and follows up many responses with questions:

90: 1 An/Intl/Mood/WH-interrogative/full T2 What do I call this thing I 'm putting them into?  
91: 1 An/Intl/Mood/WH-interrogative/full T2 Have you seen anything like that before?  
92: 1 An/Intl/Mood/YN-interrogative/full T2 What does it look like?  
93: 1 An/Intl/Mood/WH-interrogative/full T2 Does it look like anything you've seen before]?  
94: 1 An/Intl/Mood/YN-interrogative/full T2 You think it looks like a conical glass?  
95: 1 An/Intl/Mood/YN-interrogative/full T2 it looks like a conical glass?  
96: 1 An/Intl/Mood/YN-interrogative/full T2 Except what's the difference?  
97: 1 An/Intl/Mood/WH-interrogative/full T2 Now this thing it holds up here?  
98: 1 An/Intl/Mood/mod-interrogative/ellipsed T2 It has a...?  
99: 1 An/Intl/Mood/declarative/abandoned T2 It has [a sort of arm coming out of it...]] hasn't it?  
100: 1 An/Intl/Mood/declarative/full T2 Like a spout or a tube coming out one side.  
101: 1 An/Intl/Mood/declarative/abandoned T2 It's like a conical glass except for that.  
102: 1 An/Intl/Mood/WH-interrogative/full T2 OK— so I had acid up here.  
103: 1 An/Intl/Mood/declarative/full T2 What was the name of that acid?  
104: 1 An/Intl/Mood/declarative/full T2 You remember this...  

As the teacher is probing with her questions, she also continues to talk science (as she is demonstrating the procedure), and here compares (clauses 100-102) and contrasts (clauses 109-112) various points with the students. As detailed in the previous chapter on exchange, the teacher here is brokering between the science to teach and the students' own (or common sense) knowledge.

In another example of brokering through questioning, the teacher shifts direction when her question is not answered:

458: 1 An/Intl/Mood/declarative/full T2 OK— so I had acid up here.  
459: 1 An/Intl/Mood/WH-interrogative/full T2 What was the name of that acid?  
460: 1 An/Intl/Mood/declarative/full T2 You remember this...
The teacher moves from, ‘what was the name of the acid...’ (clause 459), to ‘where did I say it was in your body...’ (clause 463), and returns to ‘what is the name of the acid...’ with students seemingly making the connection the teacher wants through her questioning.

The two key points in relation to questions in this science classroom relate to the relative amount of questions posed by the teacher and students, and the purpose of the questions posed by students. As discussed here, the teacher (however pedagogically sound) is asking a lot of questions and clusters them together, and the students are asking very few. While student questions (at least in this set of two classes) were both few and mostly not relating to science content (with the one exception noted above). One wonders if it is the amount of teacher questions posed that almost drives the students to answer in the form of interrogatives. This question, however, returns the issue to intonation, which (as commented on earlier) is beyond the scope of this thesis.

**7.2.2 Subject and Complement**

As noted above, many of the student responses to teacher questions are in the form of interrogatives. In addition, there are many responses answered in a very simple way and with one or two words. In order to explore this notion, it is worthwhile to look at Subject and Complement, as used within Systemic Functional theory to elaborate on how the science in the classroom is talked about.
Within SF grammar, at the Interpersonal level of language in use, there are specific terms for labelling. The terms include Subject, here defined as, ‘...the thing in which the proposition can be affirmed or denied. It provides the person or thing in whom is vested the success or failure of the proposition, what is ‘held responsible’.’ (Eggins, 2004, 151) This is defined from a semantic perspective, suggesting the Subject (at Interpersonal level) has a distinct functional role within the utterance.

The Complement, not a term used in traditional (or formal) grammar, is defined as, ‘...a non-essential participant in the clause, a participant affected by the main argument of the proposition.’ (Eggins, 2004, 157) As noted in this quotation, there is a relationship between Subject and Complement, and that relationship will be explored here in student utterances from the transcript.

First, however, let’s look at one instance from the classroom data analysed with Subject and Complement shown, before progressing to the student talk.

This clause (one individual clause) is one which has a student responding to a teacher’s question in full:

The student is responding to the teacher question, ‘Before I show you how to make Carbon Dioxide, can anybody tell me anything about it that they might know already?’ (clauses 3-7), which also includes a call on this particular student.

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14 There are other grammatical terms used at Interpersonal level analysis within SF grammar not relevant to this discussion. The analysis does account for them, but they are not used in full here. Other labels include: Finite, Predicator, and various Adjuncts, as well as components Mood and Residue. See Eggins, 2004; Halliday, 1994; Halliday and Matthiessen, 2004 for further details.
The student answers this question in full, with the Subject ‘It’ and Complement ‘in fizzy drinks’ as parts of a full clause.

The reason to consider looking at the presence (or absence) of Subject and Complement in student talk is to explore how much time students are speaking in the full language of science. Of particular importance here will be three cases: when a student has both Subject and Complement are they fully stated?; when a student has only Subject or Complement, which is missing?; and a student speak in a stream of clauses missing either Subject or Complement, what is happening in the class? The answer to these questions will partly contribute to understanding the language used in learning science.

A scan through the entire transcript shows 53 student clauses having both Subject and Complement, with 199 student clauses being without either Subject or Complement (eliminated from this tally are student yes/no replies and replies sounding like interrogatives). From the beginning, a set of student utterances has students responding to the teacher with both Subject and Complement. Consider these clauses:

```
14: 1 Cl/M1/Comp/Residue ST It’s carbon and two oxygens?
1 Cl/M1/Subj/Mood ST It’s carbon and two oxygens?
15: 1 Cl/M1/Pred/Residue T2 How do you know?
1 Cl/M1/Fin/Temp/Mood T2 How do you know?
1 Cl/M1/Comp/WH/Residue T2 How do you know?
1 Cl/M1/Subj/Mood T2 How do you know?
16: 1 Cl/M1/Comp/Residue ST Cause it’s CO2?
1 Cl/M1/Subj/Mood ST Cause it’s CO2?
```

Figure 7.11: Interpersonal Extract 11.

Shown here are the abbreviated labels for Complement (Comp) and Subject (Subj) from the search file taken from Systemics. In both student replies there are full clauses used. This is taken at the beginning of the class (the teacher is asking what students already know about Carbon Dioxide). While there are such instances where students are using
both grammatical elements in their language, and these will not be ignored, the more prevalent utterances by students do not do this.

Before considering those instances, it may be good to look at other developed student responses. In the two utterances below, each student is again responding to a question by the teacher and each provides a full sentence. But is there any difference between these responses?

605: 1 Cl/M1/Comp/Residue ST Density is mass over volume.
    1 Cl/M1/Subj/Mood ST Density is mass over volume.

691: 1 Cl/M1/Comp/Residue STS It 's more dense than oxygen...
    1 Cl/M1/Subj/Mood STS It 's more dense than oxygen...

Figure 7.12: Interpersonal Extract 12.

In clause 605 the student is making a clear statement of scientific fact: 'density is mass over volume' that has both Subject and Complement in place. In the second class, the Subject is less clear: 'It'. A look at the clauses leading to 691 allows for an understanding the teacher asking the students why Carbon Dioxide puts out fire. The student answers as above, but the teacher is not satisfied.

Within the sequences of clauses at this point the teacher asks, 'more dense than oxygen?' (clauses 693-699) before accepting the answer:

697: 1 Cl/M1/Comp/Residue STS Than air.

Figure 7.13: Interpersonal Extract 13.

This answer is changed (from oxygen to air) and does not include a Subject. But is the Subject in this clause complete in making meaning? The lexical item 'it' is not directly referencing the science under discussion.

This can also be seen later in the class when an extended exchange takes place between teacher and pupils. Here is the exchange:

863: 1 Cl/M1/Comp/Residue T2 anything else?
864: 1 Cl/M1/Comp/Residue STS It has no smell?
1 Cl/Ml/Subj/Mood  STS It has no smell?
865: 1 Cl/Ml/Comp/Residue  STS Tasteful...
866: 1 Cl/Ml/Comp/Residue  STS It has no taste?
1 Cl/Ml/Subj/Mood  STS It has no taste?
867: 1 Cl/Ml/Comp/Residue  T2 OK — now number two
868: 1 Cl/Ml/Subj/Mood  T2 now the word for no smell,
1 Cl/Ml/Subj/Mood  T2 I heard
870: 1 Cl/Ml/Comp/Residue  T2 someone saying it there...
1 Cl/Ml/Comp/Residue  T2 someone saying it there...
871: 1 Cl/Ml/Comp/Residue  STS Odourless...
872: 1 Cl/Ml/Comp/Residue  T2 Odourless...
873: 1 Cl/Ml/Circ-Adj/Residue  T2 very good...
875: 1 Cl/Ml/Comp/Residue  T2 OK, so it has no colour,
1 Cl/Ml/Subj/Mood  T2 OK, so it has no colour,
876: 1 Cl/Ml/Comp/Residue  T2 has no smell
877: 1 Cl/Ml/Comp/Residue  T2 it 's odourless.
1 Cl/Ml/Subj/Mood  T2 it 's odourless.
878: 1 Cl/Ml/Comp/Residue  STS It 's tasteful...
1 Cl/Ml/Subj/Mood  STS It 's tasteful...
879: 1 Cl/Ml/Comp/Residue  T2 OK — good.
1 Cl/Ml/Subj/Mood  T2 OK — what else have we learned about it
882: 1 Cl/Ml/Comp/Residue  ST It 's a gas
1 Cl/Ml/Subj/Mood  ST It 's a gas
883: 1 Cl/Ml/Comp/Residue  ST and it 's more dense than air?
1 Cl/Ml/Subj/Mood
884: 1 Cl/Ml/Comp/Residue  T2 Right— that 's two things,
1 Cl/Ml/Subj/TH/Mood  T2 Right— that 's two things,
885: 1 Cl/Ml/Comp/Residue  T2 so number four: it is a gas.
1 Cl/Ml/Subj/Mood  T2 so number four: it is a gas.
887: 1 Cl/Ml/Comp/Residue  STS It 's more dense than air...
1 Cl/Ml/Subj/Mood  STS It 's more dense than air...
888: 1 Cl/Ml/Comp/Residue  T2 It is more dense than air.
1 Cl/Ml/Subj/Mood  T2 It is more dense than air.
889: 1 Cl/Ml/Comp/Residue  T2 OK— anything else?

Figure 7.14: Interpersonal Extract 14.

There is nothing wrong in any way with what the students are saying, or how they are answering here. Rather, the focus on the nature of the Subject each student uses. Looking at clauses numbered 864, 866, 877, 878 and 882 clearly shows students using a Subject but in each case it is ‘It’. Here it is clear that ‘it’ is Carbon Dioxide, but students are either not being given the opportunity to use the scientific term, or have learnt not to say it and truncate it instead. Another instance of this in the transcript is later in the class:
In clauses 1365, 1367 and 1371 students use ‘There’ and ‘They’ without producing the scientific terms relevant to the classroom science content. This seems to be a common occurrence within the classes.

In addition to students not speaking the language of science, and using null identifies as Subjects in clauses, is the amount of student clauses that have only Subject or Complement but not both. Two instances near the beginning of the class session are:

58 1 Cl/M1/Subj/Mood anywhere?
59: 1 Cl/M1/Adj/Pol/Mood
60: 1 Cl/M1/Voc-Adj
61: 1 Cl/M1/Circ-Adj/Residue
62: 1 Cl/M1/Fin/Pred/Mood-Residue
  1 Cl/M1/Subj/Mood
63: 1 Cl/M1/Comp/Residue
  1 Cl/M1/Subj/Mood
64: 1 Cl/M1/Pred/Residue
  1 Cl/M1/Comp/Residue
  1 Cl/M1/Subj/Mood
65: 1 Cl/M1/Comp/Residue pieces?
  1 Cl/M1/Circ-Adj/Residue pieces?

T2 Would you find it in your body anywhere?

STS Yeah...
T2 Hannah?

ST In your stomach.

T2 You would.

T2 You'd find it in your stomach.

T2 You would find it in your stomach.

T2 And what does it do in your stomach?

T2 And what does it do in your stomach?

ST Break down your food into small pieces?

ST Break down your food into small pieces?

81 1 Cl/M1/Subj/Mood
82: 1 Cl/M1/Comp/Residue
83: 1 Cl/M1/Voc-Adj
84: 1 Cl/M1/Comp/Residue

T2 Would you have it in your house somewhere?

STS Yeah... fireplace...

T2 Where, Fiona?

ST Fireplace.
In the first set of clauses (58-65) the teacher asks where a substance would be found in the human body, and the students answers correctly with, 'in your stomach' (clause 61) and in response to the teacher followup (clause 64), the student again responds correctly with, 'break down your food into small pieces.' (clause 65). In neither case is there a Subject either present in the stomach or doing the breaking down of food.

Likewise, in the next sample, the answer is simply, ‘fireplace’—again, correct, but without a Subject. As above, the relevance of the missing Subject in these clauses has to do with the student not using complete clauses to describe what is happening when they speak.

For instance, the next sequence shows limited student responses:

| 1564: | 1 Cl/M1/Subj/Mood | T2 OK-- so what 'll I start off with? |
| 1565: | 1 Cl/M1/Comp/Residue | STS Apparatus… |
| 1566: | 1 Cl/M1/Comp/Residue | T2 Apparatus. |
| 1567: | 1 Cl/M1/Comp/WH/Residue | T2 Now, OK, so what did we use… |
| 1568: | 1 Cl/M1/Comp/Residue | STS Hydrochloric acid… |
| 1569: | 1 Cl/M1/Comp/Residue | T2 Hydrochloric Acid, or HCL. |
| 1571: | 1 Cl/M1/Comp/WH/Residue | T2 What else did we use? |
| 1572: | 1 Cl/M1/Subj/Mood | T2 What else did we use? |
| 1573: | 1 Cl/M1/Comp/Residue | STS Pure clear flask… |
| 1574: | 1 Cl/M1/Comp/Residue | T2 Pure clear flask… |
| 1575: | 1 Cl/M1/Comp/Residue | STS Marble chips? |
| 1576: | 1 Cl/M1/Comp/Residue | T2 Marble chips… |
| 1577: | 1 Cl/M1/Comp/Residue | T2 Anything else? |
| 1578: | 1 Cl/M1/Comp/Residue | STS A dropping bowl… |
| 1579: | 1 Cl/M1/Comp/Residue | T2 A dropping bowl. |
| 1580: | 1 Cl/M1/Comp/Residue | STS Gas jar? |
| 1581: | 1 Cl/M1/Comp/Residue | T2 Gas jar. |
| 1583: | 1 Cl/M1/Comp/Residue | STS Delivery tube. |
| 1584: | 1 Cl/M1/Comp/Residue | T2 … Delivery tube. |
| 1585: | 1 Cl/M1/Comp/Residue | STS Stopper. |
| 1586: | 1 Cl/M1/Comp/Residue | T2 Stopper. |

This sequence is nearing the end of the second class session. The teacher is completing an activity with students writing in copybooks following teacher prompts. Here, in...
response to the teacher prompts, each student, or students, uses a single word or brief phrase. Looking at clauses 1565, 1568, 1572, 1575, 1577, 1579, 1581 and 1584, every student utterance is without a Subject. With the Subject missing in each clause, the students are repeating something the teacher wishes them to write, but are they really learning science? Science requires getting heads and mouths around specific language as well as hand and pens. This would seem to be missing in this instance, which is common on this class.

<table>
<thead>
<tr>
<th>Time</th>
<th>Type</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1606</td>
<td>1 Cl/M1/Subj/Mood</td>
<td>T2 what did we use to start off?</td>
</tr>
<tr>
<td>1607</td>
<td>1 Cl/M1/Subj/Mood</td>
<td>STS The apparatus was set up...</td>
</tr>
<tr>
<td>1608</td>
<td>1 Cl/M1/Subj/Mood</td>
<td>T2 OK—the apparatus was set up as shown.</td>
</tr>
<tr>
<td>1610</td>
<td>1 Cl/M1/Subj/Mood</td>
<td>T2 Then what did I do,</td>
</tr>
<tr>
<td>1611</td>
<td>1 Cl/M1/Comp/Residue</td>
<td>T2 after I had it set up?</td>
</tr>
<tr>
<td>1612</td>
<td>1 Cl/M1/Comp/Residue</td>
<td>T2 after I had it set up?</td>
</tr>
<tr>
<td>1613</td>
<td>1 Cl/M1/Subj/Mood</td>
<td>STS Opened up the tap...</td>
</tr>
<tr>
<td>1614</td>
<td>1 Cl/M1/Pred/Residue</td>
<td>STS Let the acid out...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2 Right... we let</td>
</tr>
</tbody>
</table>

Figure 7.18: Interpersonal Extract 18.

Again, the students are responding to the teacher but what is missing are not Subjects—they are present. But they appear not to be doing anything in the clauses. Instead the clause 1607 has a Subject with no Complement (for instance, by whom?); clause 1612 has an action with no actor; and clause 1613 likewise has no actor (Subject).

There is not a single thing untoward about this sort of talk in this classroom; it fits in with the pattern throughout the two sessions. It suggests that students are not either being given, or taking, a real chance to speak the language of science in a connected way.

### 7.2.3 Mood Adjuncts

The final area to be discussed here is the notion of Mood Adjunct. This is within the Interpersonal domain on language according to SF theory and refers to the use of language to reflect perspective. There are two specific Mood Adjuncts to explore here:
Comment Adjuncts (which reflect attempts to express the speaker's attitude); and Polarity Adjuncts (which principally serve to flag positive or negative meanings). Each will be explored in relation to both the teacher and students’ talk in the classroom, as they tend to give some indication of control and confidence in the room, or lack of same. Speakers with little knowledge of the specific subject matter will have far less room to manoeuvre in speaking about any topic. Whereas a speaker with strong content knowledge will not only have confidence, but confidence to control way s/he talks about that knowledge. In the classroom, it would be expected that the teacher would use far more Mood Adjuncts than the students.

Looking first at Polarity Adjuncts, which indicate the positive or negative nature of any proposition in language, a scan through the analysis shows that the teacher used 102 Polarity Adjuncts and students 44. This is reflective of the fact that the teacher (as discussed in the section on exchange) is the Primary Knower in the classroom, and would be expected to have the authority to declare something decidedly positive or negative.

Many of the student Polarity Adjuncts are simple responses to teacher questions. A range of them happen in fairly limited, single-word responses, many of which are by groups of students. For example, the following clauses are quite typical:

50: 1 Cl/M1/Adj/Pol/Mood STS Yeah.
56: 1 Cl/M1/Adj/Pol/Mood STS No.
59: 1 Cl/M1/Adj/Pol/Mood STS Yeah...
80: 1 Cl/M1/Adj/Pol/Mood STS Yeah...
82: 1 Cl/M1/Adj/Pol/Mood STS Yeah... fireplace...
174: 1 Cl/M1/Adj/Pol/Mood STS no...
182: 1 Cl/M1/Adj/Pol/Mood STS Yeah...
188: 1 Cl/M1/Adj/Pol/Mood STS No...
199: 1 Cl/M1/Adj/Pol/Mood STS Yeah... it could...
272: 1 Cl/M1/Adj/Pol/Mood STS Yeah...
406: 1 Cl/M1/Adj/Pol/Mood STS No...

Figure 7.19: Interpersonal Extract 19.
This is just a small sampling of the Polarity Adjuncts used by students in the classroom but that pattern can be seen quite clearly. In only two of those clauses (82 and 199) is any detail added to the polar answer of yes/no. This is probably typical of young people who are still coming to terms with specific content. They will answer simply in groups to a global question from the teacher.

For the teacher, there seem to be several functions for using Polarity Adjuncts. Five specific settings in which they were used by the teacher can be seen in the transcripts. Each of these five areas will be introduced in turn.

7.2.3.1 To Evaluate Student

The first teacher use of Polarity Adjuncts is when she is evaluating a student’s response to a question within the classroom. This is perhaps the most typical instance of their use by the teacher. In looking at these extracts from the analysed transcript, what can be seen is a definite sense of being correct on the part of the teacher:

17: 1 Adj/Pol/Mood T2 Right, so CO2 is the formula.
25: 1 Cl/M1/Adj/Pol/Mood ST Yeah... you breathe it out...
117: 1 Cl/M1/Adj/Pol/Mood T2 It does n’t really matter.
305: 1 Cl/M1/Adj/Pol/Mood T2 Right, it was respiring,
967: 1 Cl/M1/Adj/Pol/Mood T2 Right, Carbon Dioxide was being formed.

Figure 7.20: Interpersonal Extracts 20.

In each case, a student was making a point (generally in response to a teacher question) and the teacher was taking on the third stage of the Triadic Dialogue sequence discussed in the previous chapter. One way that evaluation can take place, of course, is via the correction that is seen above.
7.2.3.2 To Call on Specific Student

The second use by the teacher of Polarity Adjuncts is generally accompanied by a Vocative (calling label). This is when the teacher is highlighting specific student for any purpose.

19: 1 Cl/M1/Adj/Pol/Mood T2 Yes, Fiona.
35: 1 Cl/M1/Adj/Pol/Mood T2 Yes—em, Aisling?

Figure 7.21: Interpersonal Extract 21.

Such calls to students is either in the form above, or in the form of a question posed directly to one student. In each of the above samples, the teacher is actually responding to attention being sought by students as the student tries to extend something said by another student in the area of science content.

7.2.3.3 To Challenge Response of Student(s)

One interesting function of the Polarity Adjunct in this classroom was the teacher challenging a student in relation to a previous utterance. Looking at these requires looking beyond the individual teacher utterance/clause and showing some of what came before:

55: 1 Cl/M1/Pred/Residue T2 Have you heard of that before?
56: 1 Cl/M1/Adj/Pol/Mood STS No.
57: 1 Cl/M1/Adj/Pol/Mood T2 No?
58: 1 Cl/M1/Pred/Residue T2 Would you find it in your body anywhere?
152: 1 Cl/M1/Pred/Residue T2 Because if we don’t have that
153: 1 Cl/M1/Pred/Residue T2 It’ll disappear into the air.
154: 1 Cl/M1/Adj/Pol/Mood T2 Won’t it?

Figure 7.22: Interpersonal Extract 22.

In the first short sequence, the teacher asks a question of the entire class (clause 55) which is then answered by a group of several students. The teacher challenges with a Polarity Adjunct (clause 57 in bold), and follows that up with a question to prompt the students to reconsidering.
In the second sequence, the teacher is following up the students by making a sort of statement of fact (clauses 152-153) before asking, via the use of a Polarity Adjunct, whether the students believe the statement is true or not. ‘Won’t it?’ in this latter clause is actually part of a sequence, as the next clause is, ‘Or will it?’ (clause 154) provokes the students to re-consider what has been said to this point.

7.2.3.4 In Making a Statement of (Scientific Fact)

The teacher also uses Polarity Adjuncts in making statements of fact within the classroom. This happened on a number of occasions and seems to be as a follow up to another part of the science content. The Polarity Adjunct seems to be way for the teacher to solidify the fact she has just stated. In these sequences, the Polarity Adjunct is emboldened for ease of reading:

247: 1 Cl/M1/Comp/TH/Residue T2 that I definitely I know
248: 1 Cl/M1/Adj/Pol/Mood T2 I 'm not collecting Carbon Dioxide in there...
249: 1 Cl/M1/Resp/Residue
250: 1 Cl/M1/Adj/Pol/Mood T2 Well, there 's definitely oxygen in there,
251: 1 Cl/M1/Adj/Comm/Mood T2 is n't there,
334: 1 Cl/M1/Pred/Residue T2 because there 'd be air in the tube
335: 1 Cl/M1/Adj/Pol/Mood Dioxide T2 and it 's just not the purest of Carbon
984: 1 Cl/M1/Pred/Residue T2 It would just go out
985: 1 Cl/M1/Adj/Comm/Mood T2 OK— because nothing...
986: 1 Cl/M1/Adj/Pol/Mood T2 things ca n't burn in Carbon Dioxide.

Figure 7.23: Interpersonal Extract 23.

The teacher, in each case, is either making a statement to extend the validity of the statement before (as in clause 248, and again in clause 986); confirming what she just said (clause 260); or re-stating for clarification the statement just made (clause 335).
7.2.3.5 Answering Teacher’s Own Question (Rhetorical)

The final functional category identified in the analysis of the classroom transcript was when the teacher was answering her own question—this appears to be some rhetorical trick. This happens once in the transcript and stands out as such:

161: 1 Cl/M1/Pred/Residue T2 Would you draw the duster in, girls, on your diagram...
162: 1 Cl/M1/Adj/Pol/Mood T2 No.
163: 1 Cl/M1/Pred/Residue T2 OK—so I’m going to let the...

Figure 7.24: Interpersonal Extract 24.

Here the teacher is in the middle of showing the students the experiment for making Carbon Dioxide and it is the first five minutes of the class. She seems almost distracted when she is asking this question and it would seem that it is not meant for the students to answer as much for the teacher to manage time in some way.

It would be most interesting in a wider classroom discourse sample, to see if these teacher functions of the use of Polarity Adjuncts are part of the patterns of talk. What is most interesting here, however, is that the teacher seems to have several specific uses for her choice in language. Just how conscious of this specific feature of language the teacher has would require further research.

7.3 Exploring the Value of Systemic Functional Theory (2)

This chapter looks at the Interpersonal level of language within Systemic Functional theory and provided detail on the use of specific features of the grammar used by the teacher and students in the classroom. More precisely, how the teacher uses a more full set of the grammatical resources available to her while the lack of such use by students was quite evident.
By looking at interrogatives and types of questions posed by both the teacher and students, it is seen that variability exists. The grammar accounts for two specific interrogative types: WH- (who, what, why, when, etc.) and YN- (expecting definitive yes or no) questions. As noted in this chapter, the teacher asked virtually all of the WH—questions, expecting detailed answers, and that YN- questions (which close off more options for answers) are split evenly between the teacher and students. This would imply that the teacher is asking more specifically detailed questions and that is something students would do well to learn in classrooms.

As well, at this level of the grammar, the labels Subject (differing from the common subject of formal grammars) and Complement suggested that students are speaking in shorter clauses, missing either Subject or Complement. As both are significant factors in longer clauses where all objects of learning matter are taking into account, it suggests that students have either not learned to use both parts of the clause, or simply have been discouraged from doing so.

For Mood Adjuncts, another aspect of the Interpersonal level of language, it was shown that the teacher uses Polarity Adjuncts (indicating the positive or negative nature of any proposition) for a number of specific purposes. Among those are 1) to evaluate students; 2) to call on specific students; 3) to challenge the response of students; and 4) making statements of (scientific) facts. It would be most interesting to see if this is established in future research.

However, establishing such features of language in use requires the use of such a grammar as Systemic Functional theory has to offer. The value of this grammar would suggest it allows for the explication of the specific features of language used to make meaning at this Interpersonal level in a strong way. In other words, if students were made aware of the full set of grammatical resources, students might begin getting more opportunities to fully talk science in the classroom.
7.4 Conclusion

This chapter is the first of three using a grammatical framework, that of Systemic Functional theory, to look at classroom discourse. In this chapter, the focus was the Interpersonal level of language in use and specific features of that grammar were highlighted.

The first was a look at questions as part of the Speech Function. The question types of WH-interrogatives and those of Y/N-interrogatives were explored and the different use of each by teacher and students was discussed.

The second section looked at Subject and Complement in the classroom talk, with a specific focus on student talk. It was shown that students had a preponderance to talk in clauses with either Subject, or Complement, but not frequently with both. This, of course, could be down to the fact that students are learning new material in the classroom, and are still coming to terms with how to speak that science. This discussion also highlighted occurrences when students did use both Subject and Complement but one or the other was vague (‘It’; ‘There’) rather than specific.

Finally, the last section looked in some detail at Adjuncts, in particular focussing on Mood and Polarity Adjuncts. After describing and illustrating these, it then stated that not only does the teacher in this classroom use more of each type, but also that the teacher use of Polarity Adjuncts, in particular, seems to serve several functions. These functions were introduced and examples given of instances of them.

The next chapter will look at the second of the levels of language in use from a Systemic Functional perspective, this one being the Ideational. It is now time to shift from the Interpersonal level and focus on meaning and content in this science classroom.
What the grammar does, in its ideational guise, is to transform human experience into meaning. The grammar construes a universe of things and relations, imposing categories on our perceptions of phenomena; in other words, it sets up a *theory* of experience, modelling the immensely complex interaction between the human organism and its environment. (Halliday, 2004, 51. Emphasis in original)

8 Construing Science Ideationally

8.1 Introduction

In the previous chapter, the analysis and labelling at the level of clause began by looking at the Interpersonal level. It noted that this level of analysis provides details on the interlocutors and their relations. This chapter moves to the Ideational level and is more concerned with how language allows us to make meaning from experience (internal or external) of the world. This task merits serious consideration in teaching and learning science.

Halliday describes the Ideational focus as, '...a way of representing patterns of experience.' (1994, 106) In that same chapter, he also notes that Ideational meaning is based around, '...Transitivity. The transitivity system construes the world of experience into a manageable set of Process types.' (ibid. 106) This is the starting point for this chapter.

There are three specific focal points in this chapter. The first is looking at Process types and the various Processes used by the teacher and the students. In general, Processes are realised by types, and sub-types, of verbs and associated other grammatical labels. Here, the focus will be looking at the discrete Process types used by
the teacher and students through dialogue in the classroom. The hope is that by looking at Process types, the role of science in the classroom can be placed centre stage.

The second section considers Circumstances. These are words (or groups of words) that are used to allow for the extension of meaning in any dialogue, and this allows for looking at how the teacher tends to build meaning within the science in the classroom. Circumstances in Systemic Functional theory allows for probing what is happening within a clause, by asking questions such as, 'where?’, ‘how?’ ‘when’, and ‘why’ but does so in a fairly particular and detailed way.

Finally, there is an analysis of the scientific technical language used in the classroom, compared with the scientific non-technical and common-sense language used by the teacher and students. In many ways, this is an arbitrary judgement on behalf of the analyst. What is scientific for one is not for another; and there have been shifts in the language considered as scientific over the past few decades with increasing use of technology within society. The purpose of this section is to explore the relative use of scientific as opposed to non-scientific language used in the teaching and learning of science. The presumption is that the use of scientific language will increase by students as the class progresses. It is hoped, that, in looking at the instances of the use of each form of language can help illuminate this notion.

This chapter continues looking at samples from the analysed transcript and specific terms and labels are described as they are introduced.

### 8.2 Process Types in the Science Classroom

Starting with Process types requires a brief outline of the possible Process types (and subtypes) used for analysis of the classroom discourse. Within Systemic Functional theory, there are several and they begin with the typical ‘doing’ verb. This is referred to as Material and can be the starting point for the description here.
Material Processes are those that involve specific doing actions and are quite easy to mark out. In addition, there are two Process types one would expect to hear in a classroom: Mental (thinking; feeling; and perceiving), and Verbal (which accounts for speech and writing as well as other forms of semiotic activity). There are two Process types under the term Relational: Identifying and Attributive (where the former simply identifies something clearly; and the latter shows attribution of quality to something). Finally, there is a category referred to as Behavioural and this relates generally to physiological actions (for instance, breathing, respiring, and responding in an innate way to stimuli).

For the purpose of this chapter, the focus will be on Mental, Verbal and Material, with some mention of Behavioural. The reason for selecting Mental and Verbal should be clear. The teacher will constantly be asking students, 'do you know...?', or 'tell me...', or other like clauses. As well, the teacher will constantly be looking to see what students know now, in order to teach more. For Material Process, this selection was based on the fact that there are more Material Processes labelled in the class sessions and this generally allow for giving entities such as Carbon Dioxide features of action. This will be explored below.

Behavioural Process types will also be looked at briefly, and the differences between how teacher and students use them will feature here.

8.2.1 Mental Processes

Mental Processes are those verbal groups that reflect meanings related to thought, feeling or perception. Grouping all Mental Process that were labelled in the transcript, there are 316 clauses, of which students used a total of nine. The vast majority of Mental clauses are the teacher asking, telling, or calling on students in relation to content. Examples of teacher Mental clauses can be seen here:
In each of the above sample, the Mental Process is emboldened to stand out. In the first three examples (clauses 6, 15 and 28), the teacher is asking students what they think or know. The focus here is seeking to understand content. In the next two extracts (clauses 55; and 93, 95 and 97) the teacher is still within the Mental domain, but here is looking at asking students if they have seen or heard of the specific entity under discussion in the classroom. Finally, in the last two examples (clauses 143, 145 and 1131) the teacher moves to the more affective field and is expressing hopes and feelings. Each of these three Mental Process types is used by the teacher throughout the classroom.
For students, however, there are quite few instances of the same Processes. As mentioned above, there is a total of nine times when a student uses Mental Processes and four of them are in one sequence (a dialogue with the teacher).

Instances of student use of Mental Process are below:

411: 1 Cl/T1/Proc/Ment/Perc

778: 1 Cl/T1/Proc/Ment/Cogn
    ST I think

779: 1 Cl/T1/Proc/Reln/Attr/Int
    ST the balloon is more dense than...

792: 1 Cl/T1/Proc/Ment/Perc

794: 1 Cl/T1/Proc/Ment/Aff
    T2 Listen

795: 1 Cl/T1/Proc/Reln/Attr/Int

853: 1 Cl/T2/Proc/Ment/Perc
    T2 Start off with [[what it looks like]].

854: 1 Cl/T1/Proc/Ment/Perc
    STS You can't see it.

855: 1 Cl/T1/Proc/Reln/Attr/Int
    T2 It's colourless...

1193: 1 Cl/T1/Proc/Ment/Perc
    T2 Would it taste fizzy or not?

1195: 1 Cl/T1/Proc/Ment/Perc
    STS It would...

Figure 8.2: Ideational Extracts 2

In each of the above cases, the student is making a comment about what she thinks in relation to specific science content or phenomena. Here, as can be seen, there are both Mental: Perceptive (clauses 411, 794, 854 and 1195) and Mental: Cognitive (clause 778). Another instance of a student using Mental Processes is an exchange with the teacher near the end of the second class session:

1516: 1 Cl/T1/Proc/Exist
    T2 This is [[because an insoluble compound called.]].

1518: 1 Cl/T1/Proc/Ment/Cogn
    ST Did n't get that one...

1519: 1 Cl/T1/Proc/Ment/Cogn
    T2 Could n't get that one?

1521: 1 Cl/T1/Proc/Ment/Cogn
    ST Could n't get that

1522: 1 Cl/T1/Proc/Ment/Cogn
    ST ...anyone get that one?

Figure 8.3: Ideational Extracts 3

Here, the teacher is seeking an answer to a question in the textbook, when the student responds (in clause 1518) that she, 'didn't get that one.' The teacher queries and the student replies 'Couldn't get that one.' (clause 1521) At this point, the teacher opens the question to the entire class.
While there are very few instances of students using Mental Processes (of any type) the situation is similar in relation to Verbal Processes.

8.2.2 Verbal Processes

Of the total 115 Verbal Process clauses uttered during these two class sessions, students use a mere single Verbal Process. This clause is when a student is asking the teacher how a task is to be done:

858: 1 Cl/T1/Proc/Verbl  
ST Do you write 1, 2, 3 beside it...?

Figure 8.4: Ideational Extract 4

The focus here is not science content at all, but protocol about what to do at a particular moment in the classroom.

The teacher uses the remaining Verbal Process and the bulk of those are when she tells the students what she had already said; if she is seeking to understand if students remember something that was said; and to explicitly ask students to tell her something.

One significant point to consider with Mental and Verbal Process types is that each has the potential to project meaning. In other words, the speaker can open with the statement of saying/thinking and follow that with Verbiage or Phenomenon. Two examples from the teacher talk in this classroom illustrate this:

196: 1 Cl/T1/Proc/Ment/Cogn  
197: 1 Cl/T1/Proc/Reln/Attr/Poss  
T2 So you think  
T2 we might have some sort of a colour.

277: 1 Cl/T1/Proc/Verbl  
278: 1 Cl/T1/Proc/Mat  
T2 But let’s say  
T2 I filled it up with Carbon Dioxide.

299: 1 Cl/T1/Proc/Ment/Cogn  
300: 1 Cl/T1/Proc/Verbl  
301: 1 Cl/T1/Proc/Mat  
T2 …do you remember  
T2 what it says up here girls, the worm,  
T2 and what was the worm doing?

Figure 8.5: Ideational Extract 5.

In each of these utterances, the teacher is projecting meaning after a Mental or Verbal Process. In the first case, ‘so you think...’ (clause 196) is followed by what it is
that was thought. In the second instance, 'But let’s say...' is followed up with what it is that could have been said. The use of Mental and Verbal Processes allows the teacher to introduce science content (in clauses 197 and 278) through projection. In last example here, the teacher uses both Mental and Verbal Processes to project the point being made (in this case, what happened in a previous class using a worm—see clauses 288-312 of the transcript for this entire sequence).

Each of these could be expected in the classroom, as the teacher does the bulk of the talk. However, is the disparity of instances of these first two Processes types typical of other classrooms? This remains for future research.

### 8.2.3 Material Processes

Material Processes are actions that are performed and cause some physical change in or to the world. There are total of 650 Material Processes in the classroom transcripts. Again, the teacher speaks the bulk of these. What makes the 65 utterances by the students interesting (aside from any action being spoken of) is the apparent function of these utterances. They can be broken into several categories: an imperative (telling the teacher to do something); a short response to a question (these very brief two or three words); and explicit statements of action (either as full statements or elided). Each is illustrated below.

#### 8.2.3.1 Imperative to Teacher

The first of these categories seems to be a type of imperative or order to the teacher. It is not the students taking a position of authority in the classroom, rather it is generally in response to a teacher query or comment. Consider these instances:

- 314: 1 Cl/T1/Proc/Exist T2 if there was Carbon Dioxide in there
- 315: 1 Cl/T1/Proc/Mat T2 would be to do what?
- 316: 1 Cl/T1/Proc/Mat STS Limewater... put limewater...
- 318: 1 Cl/T1/Proc/Mat ST Put limewater...
In each of these instances, the students (in each case groups rather than individuals) are seemingly ordering the teacher to do something. In each case, the student 'imperative' follows either a query (clauses 314-315; 529; 1446) or a comment by the teacher after something tried had failed (clauses 722-723). This happened several times in the classroom and seemed like one of the prominent instances of students using Material Process types.

### 8.2.3.2 Explicit Statement of Action

A second category is when students' use of Material Process is cases of an explicit action being described or spoken about. Here are examples of those instances:

- **309: 1 Cl/T1/Proc/Ment/Cogn**
  - T2 How do we know

- **310: 1 Cl/T1/Proc/Mat**
  - T2 it gave out Carbon Dioxide?

- **311: 1 Cl/T1/Proc/Mat**
  - STS Because the limewater turned milky...

- **312: 1 Cl/T1/Proc/Mat**
  - T2 Because the limewater went milky

- **558: 1 Cl/T1/Proc/Ment/Cogn**
  - T2 So, how will I know again?

- **559: 1 Cl/T1/Proc/Mat**
  - STS Flame goes out?

- **560: 1 Cl/T1/Proc/Mat**
  - T2 Flame goes out.

- **561: 1 Cl/T1/Proc/Ment/Cogn**
  - T2 Let 's just check.

- **701: 1 Cl/T1/Proc/Mat**
  - T2 what happened?

- **702: 1 Cl/T1/Proc/Mat**
  - STS It sunk...

- **703: 1 Cl/T1/Proc/Mat**
  - T2 It su... it, it sunk down,

- **704: 1 Cl/T1/Proc/Mat**
  - T2 so it sank
As can be seen from these examples, the students (or single student in clause 1321) are making very clear and explicit use of Material Process types to follow-up on teacher questions.

8.2.3.3 Short Response to Question

Happening far less frequently, but perhaps something to explore are instances of Material Process used by students to answer a question. The one instance found here is elided and the meaning has to be added (and here it is, by the teacher):

In response to the teacher question, ‘would it put out the fire...’ the students are basically answering, ‘yeah... [it WOULD put out the fire]’. It would be worth looking for this in other classroom discourse analyses.

Material Processes are relevant for further looking at in school science. Taking into account that the teacher is introducing Carbon Dioxide in these lessons, the notion of CO2 needs to be made into something that can either act (in the above instance, by putting out fires) or have something act on it (in another example above, by adding limewater into it). Each of these actions is indicative of the need to use language resources such as grammatical metaphor in order to make meaning in school science.
Giving CO₂ the ability to do something as part of a Material Process is a key aspect of talking science (seen Halliday, 2004 and Halliday and Martin, 1993).

### 8.2.4 Behavioural Processes

In taking the science content of these two classes into account, it is interesting to look at the Behavioural Processes to see how they are used. In total, there are 44 Behavioural Processes used in the transcript, and 17 are spoken by students. Behavioural Processes are those that reflect physiological behaviours, or actions that are either innate to the performer, or in direct response to specific stimuli. In the case of the student’s Behavioural Processes, a total of ten are used to talk about how Carbon Dioxide occurs in the physical world. In looking at these examples, it is clear what the living process is:

20: 1 Cl/T1/Proc/Mat  
21: 1 Cl/T1/Proc/Behl  
25: 1 Cl/T1/Proc/Behl  
296: 1 Cl/T1/Proc/Behl  
297: 1 Cl/T1/Proc/Mat  
299: 1 Cl/T1/Proc/Ment/Cogn  
300: 1 Cl/T1/Proc/Verbl  
301: 1 Cl/T1/Proc/Mat  
302: 1 Cl/T1/Proc/Behl  
303: 1 Cl/T1/Proc/Mat  
304: 1 Cl/T1/Proc/Behl  
305: 1 Cl/T1/Proc/Behl  
897: 1 Cl/T1/Proc/Mat  
901: 1 Cl/T1/Proc/Behl  
902: 1 Cl/T1/Proc/Behl  
903: 1 Cl/T1/Proc/Behl  
904: 1 Cl/T1/Proc/Reln/Attr/Int  
905: 1 Cl/T1/Proc/Behl  
906: 1 Cl/T1/Proc/Behl  
1330: 1 Cl/T1/Proc/Ment/Cogn  
1331: 1 Cl/T1/Behav

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ST Ya use it  
ST when you breathe?  
ST Yeah... you breathe it out...  
ST And... emm... when it breathed out Carbon Dioxide,  
ST it turned the limewater milky.  
T2 ...do you remember  
T2 what it says up here girls, the worm,  
T2 and what was the worm doing?  
ST Breathing in?  
T2 Beginning with ‘r’...  
ST Respiration...  
T2 Right, it was respiring,  
T2 OK— it is found in fire extinguishers.  
STS And when you exhale.  
T2 And when you exhale, yeah, why not.  
T2 And when you exhale.  
T2 What ’s exhale mean?  
STS Breathing out...  
T2 Breathing out.  
T2 Does anybody know any other uses for Carbon Dioxide?  
ST You exhale...?
In each of these clauses (and the focus here is on students), the Process is Behavioural, and relates to respiration. There are several terms used (breathing; exhaling) and the teacher can be seen trying to get students to distinguish between the common sense and scientific terms (see clauses 304, 904, and how students use ‘exhale’ in clause1130). It would be difficult for the students to talk about Carbon Dioxide without using Behavioural Processes at some point. And it is relevant to ask what other areas in school science are keyed to specific grammatical features.

This brief look through the Process types used by the teacher and students is the first part of this chapter. The next will focus on Circumstances, which serve to situate events around the Processes described and detailed above.

8.3 Circumstances in the Extension of Meaning in Science

The final aspect of Ideational grammar discussed here is a set of Circumstances used by teachers and students. As Processes are at the core of clauses (and is the focus of nearly all clauses), Circumstances are an element that describes the environment in which the Process is situated. Butt, et. al., write that, ‘...Circumstances function to illuminate the Process in some way. They may, among other things, locate the Process in time or space, suggest how the Process occurs, or offer information about the cause of the Process.’ (2004, 64) For the sake of this chapter, two specific Circumstances will be explored: those of Manner (including Quality and Comparison) and Cause (specifically Reason). The reason these are being highlighted is that the teacher is working in these classes to introduce Carbon Dioxide to students as an entity within the science curriculum that is like other things, but has specific properties. This will be
covered in Manner. In addition, students will be expected to learn how to test for Carbon Dioxide and this will cover Cause. In the two sections below, examples of how students use Circumstances and Reason to talk the science of Carbon Dioxide.

The reason to look at Circumstances (these two types in particular) is to indicate how much science students are able to speak, and with how much depth. The more depth used, using Circumstances, the more comfortable the speaker is with specific content. The lack of Circumstances suggests limited comfort with the content.

Within Systemic Functional theory, there are other Circumstances (including those of Extent, Location, Contingency, Accompaniment, Matter, Role, and Angle) but looking at each of these is beyond the scope of this thesis.

8.3.1 Circumstances of Manner

From the entire transcript, there are a total of 94 Circumstances of Manner. These include three subtypes: Quality (which answers the question: How?) and Comparison (answering the question: What like or not like?). The third is Means (which answer the questions: How?: focussing on technique; and What with?). Of the total Circumstances of Manner, students only used Quality and Comparison.

Of the Manner: Quality Circumstances used by students, there are three that are indicative of students’ limited control of science language. In these examples, it should be clear that the Circumstances fill in details in the clause:

296: 1 Cl/T1/Behav ST And... emm... when it breathed out
297: 1 Cl/T1/Mann/Qual ST it turned the limewater milky.
792: 1 Cl/T1/Proc/Ment/Perc T2 Listen
794: 1 Cl/T1/Mann/Qual STS Oh, yeah... it sounds hollow...
1198: 1 Cl/T1/Accom/Comt T2 OK— so what do we know about its effect on limewater...
1199: 1 Cl/T1/Mann/Qual STS It turns limewater milky...

Figure 8.10: Ideational Extracts 10
Each of these instances is part of an exchange with the teacher. In the first case, the teacher has prompted the student to remember what happened in a class the previous year. The student is providing the answer, by stating what happened, and then (in clause 297) what the result of the action was. The student does this by using the Circumstance of Manner: Quality, 'milky' as being the state of the limewater after the 'breathing out.'

In the next sequence, the teacher prompts with, 'listen' (clause 792) and the student's utterance is, 'oh—yeah...it sounds hollow' again through the use of a Circumstance of Quality. In the third example, the teacher asks about the effect on limewater (which is identical to the originating question in the first case) and the answer is, 'it turns limewater milky,' the same Circumstance used in the first example.

In the case of Manner: Comparison, the same applies. Students use such Circumstances on only one occasion, and that is driven by the teacher. Here is the sequenced instance:

881: 1 Cl/T1/Phen/Range T2 OK— what else have we learned about it today?
882: 1 Cl/T1/Token ST It 's a gas
883: 1 Cl/T1/Mann/Comp ST and it 's more dense than air?
884: 1 Cl/T1/Token T2 Right— that 's two things,
885: 1 Cl/T1/Token T2 so number four: it is a gas.
886: 1 Cl/T1/Token T2 Number five: what 's number five?
887: 1 Cl/T1/Mann/Comp STS It 's more dense than air...
888: 1 Cl/T1/Att T2 It is more dense than air.
889: 1 Cl/T1/Value T2 OK--- anything else?

Figure 8.11: Ideational Extracts 11

Here, the teacher begins by asking what else has been learned today (clause 881) and the first response is, 'It's a gas' which is followed by a comparison, '...it's more dense than air'. The teacher re-directs the class, acknowledges that two correct replies have been offered and prompts for the comparison (see clause 886), which is answered, again, using a Circumstance of Comparison. As in the above discussion, this Circumstance is used on this one occasion.

15 'Token' is a grammatical label contained in Relational Processes. It is shown here from the analysis, but is not part of the Circumstances described.
The fact that students are not using more Circumstances of Manner: Quality, or Manner: Comparison to talk about science should be of concern. As noted above, the more Circumstances, the more comfort one has speaking, and presumably learning, about the subject content.

8.3.2 Circumstances of Cause

Circumstances of Cause provide space for talking the reason behind an act. In this science class, it would be imagined that the students would be talking about processes relating the changing state of Carbon Dioxide as a gas, in its preparation, in its interaction with other elements, and in its life in the atmosphere. Of the 42 Circumstances of Cause: Reason, the students uttered a total of six. These examples are shown below:

166: 1 Cl/T1/Proc/Mat T2 Why am I putting on the glasses girls?
167: 1 Cl/T1/Caus/Reas STS Because of the fire...
15: 1 Cl/T1/Mann/Means T2 How do you know?
16: 1 Cl/T1/Caus/Reas ST Cause it 's CO2?
1412: 1 Cl/T1/Caus/Reas ST They use it for smoke in concerts...
1487 1 Cl/T1/Caus/Reas T2 Why is it important [[to have tight-fitting cap on a bottle of fizzy drinks]]?
1488: 1 Cl/T1/Caus/Reas ST Emmm... because the fizz would go?
1490: 1 Cl/T1/Proc/Mat T2 Why would the fizz go?
1491: 1 Cl/T1/Caus/Reas ST ...emm... because the Carbon Dioxide would escape...?

Each of these clauses by the students explains, via a Circumstance, what the reason for some specific event was. As well, all were prompted by a question from the teacher, which is an indication that the teacher is driving language in this classroom.
As stated above, the relevance of looking at Circumstances in classroom language is that Circumstances are where meaning is extended in clauses and how looking at Circumstances of Manner; Quality and Comparison and Cause: Reason probably could have been used more in science, particularly in classes about Carbon Dioxide.

More research looking at Circumstances can provide details on other classrooms, other science content classes, and other subject areas.

8.4 Technical and Non-Technical Science Language

This final section will look at the use of technical and non-technical science language as used in this classroom. In some ways, what is technical and non-technical is a bit arbitrary. One consideration for this analysis is that Carbon Dioxide (and other gases) as terms were coded as non-technical given the fact that CO2 is constantly in the news as the result of reporting and dialogue on climate change. However, when terms such as Carbon Dioxide were used in tandem with an idea or in the process of something happening to it, the label technical was used.

Overall, there were a total of 338 terms labelled in the transcript as being scientific technical. Of these students uttered 64 of them. A sample of these student clauses follows below:

259: 1 scientific/non-technical T2 Well, there 's definitely oxygen in there,
260: 1 other T2 is n't there,
261: 1 scientific/non-technical T2 cause it 's just normal air,
262: 1 scientific/non-technical T2 like what we 're breathing in.
263: 1 scientific/non-technical T2 And normal air contains how much of everything?
264: 1 scientific/technical STS Twenty percent oxygen...
265: 1 scientific/technical T2 21 percent oxygen...
266: 1 scientific/technical STS 78..79 percent nitrogen...
267: 1 scientific/technical T2 78 percent nitrogen, and...
268: 1 scientific/technical ST One percent other gases...
269: 1 scientific/technical T2 ...1 percent other gases
270: 1 scientific/technical T2 and Carbon Dioxide is one of those other gases.
949: 1 scientific/technical  
T2 I had an acid in here

950: 1 scientific/technical  
T2 what was the name of the acid?

951: 1 scientific/technical  
STS Hydro...

952: 1 scientific/technical  
T2 Hydro--

953: 1 scientific/technical  
STS ...chloric...?

954: 1 scientific/technical  
T2 ...chloric acid...

1099: 1 other  
T2 I'm afraid

1100: 1 scientific/technical  
T2 you'll have to know this symbol as well, for
Calcium Hydroxide.

1101: 1 scientific/technical  
T2 What do you think

1102: 1 scientific/technical  
T2 Calcium Hydroxide is made out of?

1103: 1 scientific/technical  
STS Calcium...

1104: 1 scientific/technical  
STS Oxygen...

1105: 1 scientific/technical  
T2 Calcium... oxygen...and

1106: 1 scientific/technical  
ST ...and...Hydrogen...

1107: 1 scientific/technical  
T2 Hydrogen... how many oxygens and hydrogens...

1108: 1 scientific/non-technical  
STS Two

1109: 1 scientific/technical  
T2 And how many calciums?

1110: 1 scientific/non-technical  
STS Four...

1111: 1 scientific/technical  
T2 OK— Carbon Dioxide... CO2... turns into water...
H2O

1112: 1 scientific/technical  
T2 and the chemical symbol for chalk is Calcium...

1113: 1 scientific/technical  
T2 or the name for chalk is Calcium Carbonate...CACO3...

1114: 1 scientific/technical  
T2 what do you think

1115: 1 scientific/technical  
T2 elements are in chalk?

1116: 1 scientific/technical  
STS Calcium...

1117: 1 scientific/technical  
STS Carbon...

1118: 1 scientific/technical  
STS Oxygen...

1119: 1 scientific/technical  
T2 Carbon...

1120: 1 scientific/technical  
T2 Calcium...

1121: 1 scientific/non-technical  
T2...how many oxygens?

1122: 1 scientific/non-technical  
STS Three...

1123: 1 scientific/non-technical  
T2 OK— so, then, last week, we went through some
of the properties...

1562: 1 other  
T2 OK— so we need to write the words in now

1563: 1 scientific/non-technical  
T2 to go with that experiment.

1564: 1 scientific/non-technical  
T2 OK-- so what 'll I start off with?

1565: 1 scientific/technical  
STS Apparatus...

1566: 1 scientific/technical  
T2 Apparatus.

1567: 1 other  
T2 Now, OK, so what did we use...

1568: 1 scientific/technical  
STS Hydrochloric acid...

1569: 1 scientific/technical  
T2 Hydrochloric Acid, or HCL.

1571: 1 other  
T2 What else did we use?

1572: 1 scientific/technical  
STS Pure clear flask...

1573: 1 scientific/technical  
T2 Pure clear flask...

1574: 1 scientific/non-technical  
STS Marble chips?

1575: 1 scientific/non-technical  
T2 Marble chips...

1576: 1 other  
T2 Anything else?

1577: 1 scientific/non-technical  
STS A dropping bowl...
In the samples above, one can see the labelled technical science language used by the students. In the first extract above (clauses 259-270) the students seem to be well grounded in the specific amount of gases in the atmosphere and are reflected in the precise percentages used following prompts by the teacher. Note, however, that each of the clauses (numbered 264, 266 and 268) are single items. There is no Process involved, nor are there Circumstances in any of the student clauses.

In the second and third samples (clauses 949-954, and clauses 1099-1123) the same applies. Each of the students’ answers to the teacher prompts is correct (and
validated by the teacher) but none of the student replies is more than a single lexical item. The students appeared to know the name of the acid in the earlier episode; and the specific percentages and composition of the gases later, but only in an apparently unconnected way. Responding the way the students do seem to disconnect the answer (or the science) from any meaningful engagement.

In the final excerpt above, near the very end of the second class session, the teacher is talking students through her earlier work preparing Carbon Dioxide. She begins the sequence by telling the students they need to write down the experiment in order to learn it. She begins by asking what they started with (clause 1564). Students then respond, again prompted by the teacher in classic IRE/F format, with almost single words in nine clauses (1565, 1568, 1572, 1574, 1577, 1579, 1581, 1584 and 1587). The only exception to these simple clauses is near the end then the teacher returns to the opening and asks how to begin writing the experiment (what must be written down at the beginning of an assessed experiment).

Here the teacher prompts (clause 1606) and the students (having apparently been well-versed in such language) recite, ‘The apparatus was set up...’ (clause 1607) only to have the teacher extend that with, ‘...as shown.’ (clause 1608)

Students are engaged in this long excerpt using both scientific technical and non-technical language (and words that might otherwise appears non-technical are coded as technical when they are part of a larger process with other terms) but do so in a limited way as shown here and discussed in a previous chapter.

In looking at non-technical language, the two sequences seem to illustrate the same process happening. In these excerpts, note how many of the student utterances are single words (or single nominal groups):
The teacher opens (clause 529) by making a comment on what she has been doing at her desk (for the class to observe). The final note from the teacher is a question about her statement. The students tell the teacher (in a semi-imperative as discussed above) to add ‘more marbles’ (clause 530). Not only this a non-technical science term, but the teacher needs to tell the students (after first using the term ‘marbles’ in clause 531) that they are ‘not marbles’ (533) to which the students offer the corrected label.

Shifting to the second sequence, the same terms come up and teacher again has to prompt the students with, ‘Marble what?’ (clause 1029) to which the students do not repeat the full term, but simply add ‘chips’ (clause 1030). The teacher continues with ‘Marble chips’ (clause 1031) and then proceeds to introduce the scientific label for Marble Chips.

The students seem as unwilling to use the non-technical words in these sequences in anything other than simple ways (not in full clauses but in single words or noun groups). One must wonder how much time students get to use the language of the science they are being taught.
Again, this is not necessarily bad teaching. Students can respond when the teacher asks scientific questions and can walk (or talk) through the experiment in the above extract. But looking at the level of language learned (or used) by students does call the extent of their learning into question. This is a point that will be discussed in detail in chapter ten.

8.5 Exploring the Value of Systemic Functional Theory (3)

As this section explored the Ideational aspect of meaning, it allows for specific focus on science content in a way the previous chapter did not. This level looks at Processes, Participants and Circumstances, labels for specifying experiential meaning and is a way to highlight how speakers create (or construe) meaning in context. Specially, here, the context is the science classroom. More precisely, the chapter looked at Processes and Circumstances, and detailed how the teacher and students used them differently in talking science. It also looked at technical language in the science classroom.

Value added by using the Systemic Functional framework here can be seen when looking at the Process types of Material, Mental and Verbal (described earlier in the chapter) and, to a lesser extent, the Behavioural Process.

The use of Mental (thinking verbs) and Verbal (communicating verbs) in the classroom would seem to be self-evident. What happens in the classroom through talk is the stimulation of thought. In this context, Mental and Verbal Processes would be essential to realising positive teaching and learning. But in these two classes, of all Mental clauses, a total of 316, students used just nine. Likewise, of Verbal Processes, which totalled 115, students used just a single one.

The use of Systemic Functional grammar to identify such Process types adds to the development of a pedagogical approach based on language, and how language is
used in the classroom. If teachers were more aware of the Processes they use in class and how their use differs from students, it is possible that science learning could be enhanced. This would support Lemke’s call for more discussion in class of ‘…student’s commonsense theories of each [science topic].’ (1990, 170) More specifically by focussing on what students think (Mental Processes) and say (Verbal Processes), students could be given the chance to talk more based on what they currently think about any element of science in a more commonsense manner.

For Circumstances, and the role they have in making meaning, it was shown that analysing for Circumstances of Manner (including Quality and Comparison) and Cause (specifically Reason) can also contribute to enhanced student speech in the classroom. Each of these Circumstances, as documented in the chapter section, allow for expanded making of meaning and the fact that students use very few Circumstances of Manner, and a small percentage of Circumstances of Cause (a mere nine out of a total of 42) suggests students are not aware of the power of Circumstances in learning science. This sort of awareness can only come about through the use of a tool such as Systemic Functional grammar applied to classroom discourse.

In looking at technical versus non-technical science language, which was detailed in the third chapter, it was found that of 338 terms labelled ‘scientific technical’, students used only 64. While the labelling of any term today being referred to as scientific or technical is arbitrary at best (due to the changing technical nature of society), it is a useful designation for showing how much, or how little, science talk takes place in classrooms.

This use of grammar at the level of meaning, the Ideational level, builds on the previous chapter and allows for one final level of analysis, the Textual layer. This will be looked at in the next chapter.
8.6 Conclusion

This chapter explored the Ideational level of grammar within Systemic Functional theory as applied to the classroom data. The first section looked at Process and Processes types and compared the use of Mental and Verbal Processes (and projection) between teacher and students, and analysed instances of Material and Behavioural Processes by the students. The point was to explore how much varied meaning students could put into the science to be learnt in this class.

The second section looked at Circumstances. In particular it examined Circumstances of Manner and Cause and, again, looked at instances of student language in the classroom. Here, the issue was much meaning could be added to existing science in the form of Circumstances that would be deemed relevant for learning Carbon Dioxide. Again, students did not appear to have much opportunity for extending meaning based on the meagre use of Circumstances.

Finally, the chapter looked at technical and non-technical words, moving away from the grammar for a short while to consider lexical items in context. What was stressed in this section is that in relation to both scientific technical and non-technical words, students seem to only use them in single words or noun groups. In only one of the sample clauses in that section did students actually utter a complete clause and that one was corrected (or extended) by the teacher.

After looking in the last two chapters at the Interpersonal and Ideational aspects of language from a Systemic Functional perspective, the next chapter offers a brief look at the Textual level, exploring how language connects and works from clause to clause.
...the textual strand of meaning, while not adding new reality nor altering interpersonal dimensions of the clause, is concerned with the potential the clause offers its constituents to be organised differently, to achieve different purposes...textual meaning in English is expressed largely through the ordering of constituents. We will see below that it is what gets put first (and last) in an English clause that realises textual choice. (Eggins, 2004, 298)

9 Construing Science Textually

9.1 Introduction

The preceding two chapters looked at the Interpersonal and Ideational components of the language used in the classroom under analysis. This chapter moves to examine the Textual component and the flow of that language. Here, the focus shifts from the individual clause (as with the previous two chapters) to looking at relations between clauses in sample student talk with the teacher and with extended samples of teacher monologue.

The Textual component provides a focus on the opening gambit contained in each clause and how that opening contributes to both structure and content within the overall classroom discourse. It is hoped that by highlighting the relations between selections of clauses through the transcript, and by looking at Theme and Rheme (detailed below) can begin showing how the separate sections of the classroom dialogue of the classroom holds together.

Theme and Rheme are labels used within Systemic Functional theory for segments of each clause in order of progression. Butt, et al, write that, '...they are grammatical resources to signpost the way through the clauses...from the beginning to
the end of a text. The first signpost must be at the beginning of a text, paragraph or clause: it tells readers and listeners what the speaker or writer has in mind as a starting point.’ (2004, 134) The term Theme, as used within Systemic Functional theory, refers to the first word, or group, in each clause that contains Ideational meaning (in other words, it is a Process, Participant or Circumstance\textsuperscript{16}).

The Theme of relevance here, or the opening word, or group, with Ideational meaning in each clause is called the Topical Theme (it carries the ‘topic’ of the clause). To find a Topical Theme, it is important to identify the preceding elements and label them according to the relevant roles in the clause.

In the opening clause of the classroom discourse, the teacher begins with what might be considered typical spoken interjections. These can be seen in the full Textual analysis of the clause below, with details to follow:

\begin{figure}[h]
\centering
\begin{tabular}{|l|l|l|l|l|l|l|}
\hline
Clause 1 & \textbf{Right.} & \textbf{girls.} & \textbf{OK'} & \textbf{today} & \textbf{we're} & \textbf{going to} & \textbf{start} \\
\hline
\hline
\textbf{TH1} & Text & Int & Int & \textit{Topic} & & & \\
\hline
\textbf{Conj} & Voc & Mod & Adj & & & & \\
\hline
\textbf{Str} & Theme & Theme & Theme & Theme & & & \\
\hline
\textbf{Rheme} & & & & & & & \\
\hline
\end{tabular}
\caption{Textual Analysis of Clause 1.}
\end{figure}

The first words in the transcript are relevant in functioning with discourse, but do not offer the Topical Theme. When the teacher says, ‘right’ she is probably starting to settle the students into starting the class on her terms. Then is a Vocative (call) to the students, to highlight that they are all being addressed. Finally, the teacher utters, ‘OK’, which probably has the function of connecting the settling down of the students and the call to them all, to the next bit—the purpose of this class. Within Systemic Functional

\textsuperscript{16} While Process and Circumstance were introduced in chapter eight, Participant was not. Participants are generally directly involved in the Process and would be akin (but not identical to) a grammatical subject. See Halliday (1994, 30-32) in relation to distinguishing ‘various interpretations’ of the Subject.
grammar, the labels given to these opening utterances (as shown in the figure above) are either Textual Theme (‘Right’), or Interpersonal Theme (‘Girls’, and ‘OK’).

Textual Themes tend to be structural words or groups that indicate beginning or continuation with texts. Interpersonal Themes, on the other hand, reflect Interpersonal meanings, and can be Vocatives (as in this clause), or other forms of personal perspective, such as Modal Adjuncts (discussed in chapter 6), Finite elements (the part of the verbal group accounting for tense, polarity or certainty) and Modality metaphors (not analysed in this research). Each of these is considered part of the Mood aspect of the clause.

However, after those opening moves, the Topical Theme enters the picture. For instance, here the teacher said: ‘Today, we’re going to start [[our first of our two classes looking at Carbon Dioxide.]]’ The focus begins with the word, ‘today’. But there are at least two others ways meaning could have been changed by altering the Topical Theme. Consider these two possible options:

We’re going to start [[our first of two classes...]] today.
[[Our first of two classes...]] is what we will start today.

In the actual extract of clause 1 the teacher begins with the focus being ‘today’, or perhaps, ‘today’s class session’. If, however, she chose to begin with either of these two constructed alternatives, would her focus have been any different? Does opening the clause with ‘we’re’ change meaning at all? Is the focus more directed on what the class as a whole will do or the day on which it will occur? Does opening with ‘our first of two classes...’ change the meaning of the focus at all? Is the main point now that this the first of two classes, or the first of two classes on Carbon Dioxide”? The Topical Theme seems to be the determining factor of the focus in clauses. The Topical Theme is the first of the Ideational elements (‘today’ being a Circumstance of Location: Time), but there are other possibilities.
Look at these two clauses from the transcript:

5: 1 Cl/TH1/Rheme T2 can anybody tell me anything about it,
    1 Cl/TH1/Int/Fin/Theme T2 can anybody tell me anything about it,
    1 Cl/TH1/Topic/Theme T2 can anybody tell me anything about it,

6: 1 Cl/TH1/Rheme T2 that you might know already?
    1 Cl/TH1/Topic/TH/Theme T2 that you might know already?

Figure 9.2: Textual Extract 1

Clause 5 has labels for Theme (‘...anybody tell me anything...’) and Interpersonal: Finite: Theme (‘can’) with the Topical Theme as ‘anybody’ (here emboldened for ease of reading). The next clause is a Projection (discussed in Chapter 7) of the previous Verbal Process (‘tell’) and ‘that’ (also emboldened) serves as a TH-Theme. There are also WH-Themes, which generally occur in interrogatives.

Without going into extreme detail, the above should be sufficient to follow the two discussions below on student utterances (grouped by multiple clauses) and teacher monologue. The focus on each will be on Theme (specifically Topical Theme) and what is called Thematic Progression. This means being able to follow the thematic progression from clause to clause in any given text. The excerpts below will be formatted with only Topical Theme indicated and it will be marked in bold for ease of demarcation.

9.2  **Interpersonal Analysis**

9.2.1 Theme and Rheme in Student Utterances

It is somewhat problematic looking at student utterances with Theme in mind, due to the fact that most of the student speech in the transcript is single words, or groups, or simple clauses. This has been discussed in previous chapters, but here, the
challenge will be to identify several student utterances, however short, and link them with the teacher talk preceding and following.

This discussion will focus on three select excerpts between teacher and students as part of normal classroom activity. As might be expected in such exchanges, the teacher begins the process of interaction. In each exchange, all the Topical Themes (if present—and this will be highlighted below) are emboldened and should stand out. The focus here will be identifying the flow of meaning by following the Topical Themes through the dialogue.

In the first excerpt, the teacher is seeking to determine (with the students) just how much Carbon Dioxide is in a container, that may or may not contain much CO2, and whether or not something else would be inside the container. She begins the discussion:

259: 1 Cl/TH1/Topic/TH/Theme
260: 1 Cl/TH1/Topic/Theme
261: 1 Cl/TH1/Topic/Theme
262: 1 Cl/TH1/Topic/WH/Theme
263: 1 Cl/TH1/Topic/Theme
264: 1 Cl/TH1/Rheme
265: 1 Cl/TH1/Rheme
266: 1 Cl/TH1/Rheme
267: 1 Cl/TH1/Rheme
268: 1 Cl/TH1/Rheme
269: 1 Cl/TH1/Rheme
270: 1 Cl/TH1/Topic/Theme
271: 1 Cl/TH1/Topic/Theme
272: 1 Cl/TH1/Topic/Theme
273: 1 Cl/TH1/Topic/Theme
274: 1 Cl/TH1/Topic/Theme
275: 1 Cl/TH1/Topic/Theme
276: 1 Cl/TH1/Topic/Theme

T2 Well, there's definitely oxygen in there, T2 is n’t there,
T2 cause it's just normal air, T2 like what we're breathing in.
T2 And normal air contains how much of everything?
STS Twenty percent oxygen...
T2 21 percent oxygen...
STS 78..79 percent nitrogen...
T2 78 percent nitrogen, and...
ST One percent other gases...
T2 ...1 percent other gases
T2 and Carbon Dioxide is one of those other gases.
T2 Is n’t it?
T2 So there is n’t much Carbon Dioxide,
T2 there’s only less than 1% Carbon Dioxide,
T2 so the thing would probably burn away
T2 because it has plenty of Oxygen.

Figure 9.3: Textual Extracts 2

The focus on the words in bold has the teacher beginning with Topical Themes: There (simply making a statement of fact); Is (confirming the statement); It (referring to the container, now justifying the statement); What (comparing what is in the jar to what
is being breathed in the classroom); Normal Air (stating precisely what is in the jar, and the room, and moving to a prompt to find out what is contained in 'normal air'.

Then there is a set of clauses with no explicit Themes by both the students and teacher (clauses 264-269). However, if we inserted 'there is/are' before each clause, and 'normal air' (or 'atmosphere'? ) following the clause, would the meaning be clearer?

Finally, the teacher takes what is the Rheme (final position of the clause, or everything following the Theme) and brings it into Theme position in clause 270. This is typical of much spoken (and written) language. If Theme can be labelled the focus, and if followed through can be accepted as Given, the Rheme can be considered New (look at clause 270 to check this) and what is now New can then be made Given.

This is exactly what happens (Textually speaking) in the remaining clauses. The teacher bring the focus back to a question confirming what she has said (clause 271, with 'it' as Topical Theme) and then continues to confirm that statement, before returning to the container and what might or might not burn (in clauses 275-276).

This is a rather nice and clear example of Thematic Progression, or being able to follow the flow of the discourse by tracking the Themes and considering New/Given (which are not applied in this research).

In the second sample extract, the teacher is asking the students more about what has already been covered in the class about Carbon Dioxide. Again she begins with a question that establishes the Theme of the dialogue:

881: 1 Ci/TH1/Topic/WH/Theme T2 OK— what else have we learned about it today?
882: 1 Ci/TH1/Topic/Theme ST It 's a gas
883: 1 Ci/TH1/Topic/Theme ST and it 's more dense than air?
884: 1 Ci/TH1/Topic/TH/Theme T2 Right— that 's two things,
885: 1 Ci/TH1/Topic/Theme T2 so number four: it is a gas.
886: 1 Ci/TH1/Topic/WH/Theme T2 Number five: what 's number five?
887: 1 Ci/TH1/Topic/Theme STS It 's more dense than air...
888: 1 Ci/TH1/Topic/Theme T2 It is more dense than air.
The starting point in the opening clause here is a question, seeking to determine 'what else' has been learned and we can follow the 'what else' from the students' perspective. First to notice here, is the teacher's use of 'it' in Rheme position in clause 881. Of course, this is Carbon Dioxide and the students pick up on it by making two complete statements (clauses 882 and 883) with 'it' in Theme position. Following on from the previous discussion, here is another instance of Rheme (or New) in one clause, turning into Theme (or Given) in a subsequent clause.

This continues in the entire exchange as the focus is 'That' (clause 884) referring to the previous two student responses; the 'it' (clause 885) picking up the Themes in the students replies and the pattern shifting to Rheme -> Theme to Theme -> Theme in the remaining clauses. So the 'What' of the teacher (clause 886), is carried on by the student in a response (clause 887) and then by the teacher in the confirmation (clause 888). The sequence ends as it began, with the teacher repeating the opening question but this time in shorter form (clause 889).

The two patterns of Thematic Progression suggested here (Rheme -> Theme, and Theme -> Theme) help trace what is being talked about in the classroom in a quite explicit way. It does require filling in gaps (particularly for student talk) but contributes to seeing how meaning is made within the classroom, and in these excerpts, how the science continues through the exchanges between teacher and students.

The final excerpt here is where the teacher probes if 'we would be in trouble without plants' in the classroom—this has been analysed at both Interpersonal and Ideational levels in this thesis. Here, the focus will shift to exploring Themes in part of that extract:

T2 Would we be in trouble
There is no issue following the flow here. The teacher is continuing to question about the need for plants and personalises the discussion in the first two clauses by highlighting 'we' as being the ones in trouble if 'we' had no plants (clauses 1358 and 1359). The teacher first asks 'would' we be in trouble, and the progresses to 'why' would we be in trouble without plants (clauses 1361-1362). Students answer, in the case first incorrectly (clause 1365) that the teacher queries (clause 1366); another students answers (clause 1367), in a way the teacher does not want (1368) before a string of teacher questions. These questions (highlighted by the leading WH- Themes) are almost like an interrogation, and almost border on aggression on the teacher's part.

What can be seen here is that the Themes are a combination of Topical Themes (basically plants or 'us' as species), TH- Themes (statements or questions of fact), and WH- Themes (questions of a more open nature). Of course, the teacher is using all the WH- Themes in this case.

Again, following Theme in texts, even such short texts as teacher/student exchanges can offer insight into how meaning is being made. The next section will detail Thematic Progression in a longer teacher monologue.
It is much easier to analyse teacher talk for opposite reasons than it is difficult to review student talk. The teacher talks more, controls the discourse, and speaks in some extended monologues on a particular topic or subject matter. One extended dialogue will be analysed here from the perspective of Theme.

Again, Thematic Progression refers to how Topical Themes are managed (and this is not always conscious on behalf of the speaker) in particular segments of text (written or spoken). The focus here will be a teacher monologue in which the Topical Theme is identified and tracked through the discourse.

As this extract is quite long, it is broken into three discrete sections for ease of reading and following the analysis:

497: 1 Cl/TH1/Topic/Theme T2 Now, I 'm going to try this, girls,
498: 1 Cl/TH1/Topic/Theme T2 but I 've got a feeling
499: 1 Cl/TH1/Topic/Theme T2 it won't work,
500: 1 Cl/TH1/Topic/Theme T2 but would we chance it anyway?
501: 1 Cl/TH1/Topic/Theme T2 I 'm going to take this jar of Carbon Dioxide,
502: 1 Cl/TH1/Topic/Theme T2 cause I 'm going to show you something about it in a minute.
503: 1 Cl/TH1/Topic/Theme T2 But, I 'm going to see
504: 1 Cl/TH1/Topic/Theme T2 if I can put Carbon Dioxide into this balloon.

Figure 9.6: Textual Extract 5

In this extract, the teacher is seeking to shift Carbon Dioxide from the container, to a balloon. Looking at each of the Topical Themes in this opening, it can be seen that six of the eight are personal pronouns, referring to the teacher. This is perfectly appropriate as she is the one doing the work. Among those clauses, however, the teacher brings the students into the picture with 'we' (in clause 500). The girls, of course, are sitting and watching. The only non-personal reference here is to the act the teacher is performing in clause 499.
The next sequence has the teacher continuing:

505: 1 CI/TH1/ Topic/Theme  T2 I don’t think I’ll...
506: 1 CI/TH1/ Topic/Theme  T2 ...like do you know
507: 1 CI/TH1/ Topic/Theme  T2 the way like if you’re blowing up a balloon
508: 1 CI/TH1/ Topic/Theme  T2 you really need to blow hard at the start.
509: 1 CI/TH1/ Topic/Theme  T2 Don’t you?
510: 1 CI/TH1/ Topic/Theme  T2 You know the way,
511: 1 CI/TH1/ Topic/Theme  T2 like, if I was to blow it up,
512: 1 CI/TH1/ Topic/Theme  T2 I’d have to give a really hard breath at the start,
513: 1 CI/TH1/ Topic/Theme  T2 then it’s not really too hard, you know,
514: 1 CI/TH1/ Topic/Theme  T2 once I kind of like stretched it out.
515: 1 CI/TH1/ Topic/Theme  T2 So, it might n’t work too well,
516: 1 CI/TH1/ Topic/Theme  T2 because the Carbon Dioxide won’t be able to give it that force.
517: 1 CI/TH1/ Topic/Theme  T2 Sure it wo n’t.
518: 1 CI/TH1/ Topic/Theme  T2 But, we might get some Carbon Dioxide in here.

Figure 9.7: Textual Extracts 6

Again, with the focus on the teacher (not the work she is doing), the teacher moves back and forth between herself (‘I’ in clauses 505, 511, 512 and 514) and ‘you’ (506, 508, 509 and 510) or ‘we’ (clause 518). The non pronouns in the remaining clauses refer either to ‘the way’ (clause 507), which leads into the next clause; ‘it’ (clause 515) talking about the process under way; ‘the Carbon Dioxide’ (clause 516) addressing the task she is performing (and referring back to 501); and, again, ‘it’ (clause 517), in which the teacher is posing a rhetorical question to the students—almost a Mood Tag.

The sequence ends with the teacher moving deeper and deeper into the process underway and Themes are beginning to change slightly:

519: 1 CI/TH1/ Topic/Theme  T2 So, now have I got a lid... Yeah...
520: 1 CI/TH1/ Topic/Theme  T2 So I’m going to take this out,
521: 1 CI/TH1/ Topic/Theme  T2 and I’m going to capture the Carbon Dioxide in here.
522: 1 CI/TH1/ Topic/Theme  T2 Into there, there’s my jar of Carbon Dioxide.
523: 1 CI/TH1/ Topic/Theme  T2 And I’m going to attach the balloon on here,
524: 1 CI/TH1/ Topic/Theme  T2 to catch any more Carbon Dioxide
525: 1 CI/TH1/ Topic/TH/Theme  T2 that might come out.
526: 1 CI/TH1/ Topic/Theme  T2 It’s pretty limp—
The teacher continues at the outset talking in the first person (clauses 519-521). The next Topical Theme is a Circumstance of Location, ‘into there...’ (clause 522), and with a short interruption of another personal pronoun (clause 523), the focus shifts to the task or the result of the task. So in clause 524 it is extending the previous clause; clause 525 is a further describer of the previous clause; 526 again extends the previous clauses; and a return to the personal pronoun, in this case with the teacher referring again (as above) to ‘we’ (clause 527).

The focus shifts to the task at hand in the next two clauses (528-529) as the teacher poses a question about the result. The students offer their suggestion (clause 530); and the teacher immediately responds with another personal pronoun.

But notice the Rheme in clause 531, referring to Marbles. This is doing two things. It is following up from the Rheme in the previous clause; but it also becomes the Theme in the subsequent clause. Again, following the Theme allows for an exploration of meaning from clause to clause and through wider spans of discourse. In these extracts, the teacher is moving the focus between herself (as the person doing the actions) and the process or results of that process.

9.3 Exploring the Value of Systemic Functional Theory (4)

This final analysis chapter looked at the Textual level of language through a Systemic Functional lens, the level that suggests how meaning is made across clauses and structured in certain ways. Of particular value here is the use of Thematic Progression through identifying Theme in the talk of the teacher and students. This
reflects the cohesion of the flow of ideas in extended clauses used in the classroom and illustrates the different levels of cohesion made available for the teacher compared to the students.

Thematic Progression allows for following the key idea in a clause (contained in the Theme, or opening parts of speech), and how they continue over longer stretches. As shown, the teacher is much more adept at keeping her Themes connected, while students tend to weak Thematic Progression as they are not given the opportunity to develop the ideas of science through language in the classroom.

Further Thematic analyses in this area of classroom discourse might point to ways for teachers to become more conscious in structuring their lessons. As shown here, it can be made clear how the content is progressing and whether or not it is easy to follow that progression. The point would not be to have teachers become conscious of all their talk in the classroom. Rather, the goal might be to help teachers become more and more aware of the language used in the classroom, and how understanding the linguistic resources available for use, could contribute to potentially more meaningful pedagogy.

Systemic Functional theory has been used in education and pedagogy for classroom research, for curriculum development and for specific pedagogical approaches to both language in the classroom, and literacy development. These analysis chapters sought to continue its use in education and shown ways that a detailed, explicit, grammatical analysis of the talk of teacher and students in the classroom might inform educators in future.

9.4 Conclusion

This brief look at Theme in relation to teacher and student talk illustrated a potentially valuable device for documenting what happens in the classroom from the
perspective of the Textual level of language, and helps take the focus off the purely
word level way of thinking about language and begin an exploration of clause to clause
exegesis.

There are two things to point out in using this particular focus on Theme. The
first is that a strong Thematic Progression, which follows the links from clause to clause
of Theme and Rheme (in different ways as described above) allow for an insight into
the success of a particular form of dialogue in the classroom. This insight allows for
more than is offered in looking solely at exchange or lexis (which are important—but
not on their own). Using the various levels that Systemic Functional theory provides
allows for such an analysis.

In addition, learning more about how teachers (and students) talk within
classrooms begins a dialogue on a wider basis about improving teaching and learning in
school. It is only with extensive research, carried out by different individuals, or groups,
using all available theoretical frameworks, that more can be known.

This ends the analysis of the data. In the next chapter, there will be a discussion
on the results of these chapters, and how they compare to the material covered in the
literature review in chapter three.
The grammar is the central processing unit of a language, where meanings are accepted from different metafunctional input and spliced together to form integrated outputs, or wordings. Without a grammar in the system, it would be impossible to mean more than one thing at once. In order to understand how language works, therefore, we have to engage with the grammar. (Halliday, 1994, p. xxxiv)

10 Discussion

10.1 Introduction

This chapter discusses the analyses of chapters six to nine in line with the literature review of chapter three. Taking into account that results were derived from samples of the transcript after a detailed linguistic analysis, and focussing on patterns of language in use in this classroom (over two sessions) the goal here is to suggest links between what was detailed here and what was suggested in other settings from various theoretical perspectives.

This chapter has three distinct sections, relating to the three sections of chapter three. The first section will focus on the level of exchange and seek resonance between the findings here and those of Sinclair and Couthard, and others from the generic classroom discourse area. The notion of the IRE/F has been so strong within research into the language of the classroom, that ignoring it would be almost foolish. What will be explored here relates not only to the analysis at the exchange level (chapter six) but also to the Theme analysis of chapter nine. It will show a different focus between most of the other research into classroom discourse and this research, and it is hoped that bridging the gap both internationally and within Ireland will help inform Irish schooling in future.
The second section focuses on the specific nature of the science language used in the classroom and looks to contrast itself with the educational literature in section 2 of chapter three. This focuses on two specific areas: the educational perspectives of the language of science (as detailed, being almost totally word-orientated), and the linguistic perspectives offered by the Systemic Functional view of language. There was not clear and explicit focus on words (the lexical level) in this thesis. Rather, the focus was on the three layers of language in use that Systemic Functional theory offers and for this reason, this discussion will focus on language beyond words.

This means taking meaning between individuals, between concepts and between clauses into account. In doing this, the discussion will offer glimpses of how the findings here challenge educationalists to use a wider lens in looking at classroom discourse.

The final section of this chapter will return to Lemke, Scott and Mortimer and other work on the language of the science classroom. Lemke’s work has become somewhat of a bellwether of research in the area of school science, and that will be the starting point for this discussion. Looking at Scott and Mortimer, Christie and Wells, will show that research in the use of language in school science is gaining ground (not just language, but other modes as was documented in chapter three). It is now hoped that such research can be kick-started in Irish schools and within Irish academia.

As detailed in the Introduction to this research, there is a public call for better science teaching and for better science learning. As language is such a key area in the teaching of science, a research focus in Ireland into the language of science is imperative. This research should be the start of that.

Before staring the discussion, there will be a brief review of the suggested findings of this thesis. This should allow for a smooth transition from the current work to what came before.
10.2 Reviewing Findings of the Current Research

This research looked at four specific areas of the language of school science. These were: the exchange level; the Interpersonal level; the Ideational level; and Textual level. Each offered some notion of what happens in the classroom (even based as it is on one classroom over two class sessions). Specific findings were made at each layer of analysis.

At the level of exchange, it was noted that the back-and-forth of common sense and scientific language were at the core of teaching and learning. In fact, it appears that what the teacher is doing combines the exchange with a particular focus on the content being exchanged, the science. However, the back-and-forth is not just language; it also includes views of reality. The views that students bring into the classroom with them need to be balanced against science in the curriculum, and how the teacher mediates between these views. This showed not only a linguistic challenge, but also the teacher demonstrably cognitively challenged students to broker between what they know now and what needs to learnt.

However, one problem noted within the exchange structure was that students often did not have or get the chance to use the language of science, outside of curricular concerns. Therefore, students were able to answer teacher questions, but often with single words or small nominal groups. As well, there were exchanges focusing on what students should be writing into their copybooks. This did include exchanges between teacher and students, but, again, with simple answers rather than meaningful (and full) clauses.

At the Interpersonal level, the language of the classroom first looked at questions and Speech Function. The first was a look at questions as part of the Speech Function. The question types of WH- interrogatives and those of Y/N- interrogatives
were explored and the different use of each by teacher and students was discussed. Two key points were the form of questions by the teacher, as well as how. The teacher tended to cluster questions together, or group them iteratively. Students on the other hand asked far fewer questions (which would be expected) and it appeared the bulk of those were non-science questions (relating to protocol of what to do at a particular time in the classroom).

In addition, this section also looked at both Subject and Complement, and how teacher and students use them differently. The teacher did use both parts of the grammar in most of her speech, but students frequently truncated their utterances and this could be seen when looking at the presence of Subject and Complement, and when they were missing. Much of the student language was brief (again, single words or groups) and meaning had to be inferred. Likewise, in looking at the use of Mood Adjuncts, the findings showed that the teacher used the vast majority of these and they appeared to have specific functions within the classroom. These were illustrated by reference to the transcript.

In looking at the Ideational aspect of language, the focus was on Processes and Circumstances. This explored how the teacher and students (again) use language differently in making meaning in science. It was noted that the teacher often used Verbal and Mental Process types (verbs of speaking and thinking) while the students used very, very few. However, in their use of Material Processes (doing verbs), it appears, based on an analysis of the transcript, that students use them for specific purposes. These were again illustrated using the transcripts and their functions seemed unrelated to science. In addition, in looking at Behavioural Processes, the students did use them, but almost solely in relation to one specific area of science (respiration and Carbon Dioxide). That would be fine, but it would be worth further investigation to see if other science topics are likewise Process-dependent.
Circumstances were also looked at here. Circumstances allow for meaning to be added to clauses, and Circumstances of Manner and Quality were analysed to see how teacher and students used them in the class. While the teacher used the majority of each type of Circumstance (which would make sense as she would be an educated adult), students used them for different reasons relating to making meaning in science. Each of these was explored.

Finally, the Textual layer of language was analysed, as this offers a view of meaning beyond the individual word (or, indeed, clause). This showed the exchange of teacher and students by following Theme through selections from the transcript. This illustrated how the teacher controlled the discourse by maintaining the focus of the Theme. Illustrations were again taken from the transcript, but this time it looked at sequences of talk from the classroom with a focus on meaning being carried from clause to clause.

In the next three sections, a discussion relating these findings to the separate sections of the literature review will commence. It is important to note that different research focus results in different conclusions. This research used a specific linguistic lens to explore classroom discourse. The focal areas of each of the following sections will be highlighted to link the perspectives together.

**10.3 Discussing the Findings in Line with Previous Research**

This chapter discusses the analyses of chapters six to nine in line with the literature review of chapter three. Taking into account that results were derived from samples of the transcript after a detailed linguistic analysis, and focussing on patterns of language in use in this classroom (over two sessions) the goal here is to suggest links between what was detailed here and what was suggested in other settings from various theoretical perspectives.
10.3.1 Classroom Discourse: Generic

The research into generic classroom discourse has evolved over the past four decades. The most significant piece of research would appear to have started in the mid-1970s with Sinclair and Coulthard’s landmark work (1975), which looked at layers of exchange and function. From this work comes the ubiquitous Initiation/Response/Feedback(Evaluation) sequence, the Triadic Dialogue sequence continues to be a focus of education discourse. Meehan (1979) took this analysis further and looked more specifically at the functional underlying the exchange. It was also Mehan who introduced the distinction between knowledge and action in this work.

Margaret Berry (1981a, b, c; 1987) further extended this analytical framework by introducing the notion of Knower and establishing Primary (teacher) and Secondary (student) Knowers. This is valuable to educational research and takes into account the different pedagogical roles within the classroom. Berry also looked at Actors and considered both Primary and Secondary Actors into her framework. Berry’s work was then taken ahead by Ventola (1987) and next Martin (1992) and solidifying it from within a Systemic Functional perspective. Ventola’s contribution, based on work looking at the broader category of exchange labelled ‘service encounters’ further nuanced the moves within exchanges and the roles taking on those moves. Martin then introduced terms such as ‘backchannel’, ‘clarifying’, ‘replaying, ‘probing’, and ‘confirming’. All of these are useful in an educational context.

Edwards and Mercer (1979) continued the evolution of the analysis of classroom discourse. They suggested more iterative modes of exchange within the classroom and this has since been developed by Wells (2001b) in his framework from research over the previous decade. In addition to providing an alternative framework to Sinclair and Coulthard, Wells has been particularly trenchant in commenting on the Triadic
Dialogue sequence (2000a). The purpose of this critique has not been to negate the sequence, but to challenge and move it to a more pedagogically sound set of moves.

Each of these perspectives has provided value in looking classroom discourse, but the findings here suggest that Berry (and later Ventola and Martin), along with a solid grammatical framework (underpinning the exchange moves) offer more value in the longer term.

In looking at the points in chapter six here, the exchange has to be factored in with the content. Otherwise, the subject specificity of science (or any other subject) is ignored. Education tends to be subject specific, specifically at second level. Not including some reference to content (as Wells does in his framework) would seem to neglect reality.

In addition, the exchange would seem to devalue the structure of each stage of the exchange. If students are using minimal language in the exchange (say, in the Response/Reply slot), while the teacher is using complete clauses and full meaning most of the time, then certainly the contents shift the value of the stage.

In addition, it might be worth suggesting that the stages can be accrued over several clauses. In the analysis of the transcripts here, the teacher used several clauses to utter questions, and these were not exceptions. Extending the research beyond the utterance and looking at how the clauses interact at a linguistic (rather than a purely exchange, or pedagogical) level could contribute to better understanding this point.

10.3. 2 Language of School Science

The literature into the language of school science was split into two parts: the educationally orientated, and the linguistic perspectives.

The focus in the first section was what the specific features of the technical nature of the words in school science. Key points here looked at distinctions between
'technical and non-technical' language as clarified by Slater (1978). O’Rafferty (1987) highlighted the fact that science often uses mathematical symbols and these should be added to the research agenda.

O’Rafferty listed a set of features of the language of school science, including, ‘...long and complex noun-phrases, a high proportion of passive constructions; frequent use of logico-grammatical items such as ‘unless’, ‘whatever’, [and] a high use of items of specialised vocabulary.’ (1987, 40-50) This list is something to take seriously, but only if they are introduced to students as part of the teaching and learning process.

In the discussion on technical and non-technical terms (which was part of the analysis and detailed in chapter eight), it was noted that the use of technical and scientific terms did not seem to pose the students in the classroom problems. However, those same students had little chance to develop those terms, and that language, in the context of the classroom. This is a key point that has to be addressed if science teaching is to be taken more seriously in future.

Wellington and Osborne (2001) categorise problems with the language of school science into separate categories: ‘Naming words; Process words; Concept words; and Mathematical ‘words’ and Symbols.’ In the classroom researched here, the words and concepts again seemed to pose no problem. It was having, or getting, the opportunity in class to use them that was the problem.

The point that Osborne makes that, ‘...without this case for the importance of language in science education being acknowledged, all else is in vain’ (Osborne, 2002, 213) is relevant here. In Ireland, with virtually no research into the English used in Irish classrooms (as documented in chapter two), there is little understanding of the way teachers and students talk in classroom, never mind how they talk science. This is something that does suggest efforts to improve science teaching may be ‘in vain’ as Osborne suggests.
Also in chapter three, Harrison (1980) has done valuable work in the area of 'readability', and how it matters across all subject areas, including school science. But reading science must be combined with speaking science.

However, as was noted, the bulk of the educationally orientated research into the language of school science has tended to focus on words alone (O’Rafferty’s work, mentioned above, not withstanding). There must be a wider focus than words, and this is where Halliday’s work contributes to our understanding of the classroom discourse of science.

The second section of chapter three detailed Halliday’s extensive look at the language of school science. His extensive list proposing a list of difficulties in learning scientific English, include:

- interlocking definitions
- technical taxonomies
- special expressions
- lexical density
- syntactic ambiguity
- grammatical metaphor
- semantic discontinuity. (2004, 162)

Drawing on Halliday’s Systemic Functional theory, this research identified three of these categories in the analysis. The notion of interlocking definitions was touched on when it was noted that students speak in very brief segments, as in answering with single words or small groups. Definitions require extensive use of Relational Process types, and the fact that this research highlighted other Process types (Material, Mental, Verbal and Behavioural) comments on the lack of definitions in the classroom.

As well, the fact students are limited in the amount of time to talk in class (combined with their truncated utterances) leads to issues relating in lexical density. Students speak in a spoken pattern at virtually all times, and the science that Halliday is
referring to here requires a form of language geared around the written word, which equates with speaking as if the language were written. With this opportunity in class, the science students are learning may be limited.

Grammatical metaphor was not discussed as part of this research. And very few instances of such grammatical metaphor were noted in the transcript (this was not part of the explicit research). Of particular interest to Halliday is the idea of nominalisation, and this formed a small focus of the classroom analysed. It should however be part of any future work on science in the Irish classroom.

10.3.3 Language of Science Classroom

This final section reviews the research into the specifics of the science classroom, with a focus on language. Lemke’s work in particular, but also Scott and Mortimer, as well as that by Christie and Wells was discussed.

Lemke’s key work is to the language of the science classroom what Sinclair and Coulthard was to classroom discourse more generally. Published in 1990, Lemke’s research took notion of ‘talking science’ to new levels and exposed a generation of educational researchers to new methods of understanding language in the science classroom.

In particular, Lemke established two guiding principles in researching classroom discourse, the first is that, ‘two aspects—the dynamics of social interaction and the development of the thematic content of the subject being taught.’ (1990, 17) He refers to these as being, ‘...simply two aspects of the same flow of behaviour,’ and that, ‘we separate [them] in the analysis only so that we can then look at their relation to one another.’ (17)
Lemke’s second principle is to, ‘...look for the reflections of the larger social system in the moment. Of course, we really need to look at many such moments to go beyond a few hypotheses about larger social implications.’ (17)

The present research, begun with the same theoretical framework as Lemke’s, sought to establish the first principle in its analyses. By taking account of the Exchange, the Interpersonal and the Ideational modes of meaning within language in use within the classroom, it is hoped these were achieved. What is missing from the current research is looking at the classroom into the wider social realm. Future research should take this into account.

Lemke’s look at ‘thematic patterns’ in the science classroom are directly related to the findings here in Theme and Thematic Progression. Lemke’s thematic patterns are somewhat differently defined than Themes in Systemic Functional theory, but come down to the same thing: how patterns of language around science work together to make meaning. This is not a quotation from Lemke, but a formulation of the links between that work and the current research. By looking at the Textual layer of language in use, and following their path through discourse, it is possible to identify such patterns as Lemke does in his own work. It offers two paths, with the same goal and destination.

In Scott and Mortimer’s work, the stated goal is a focus, ‘...on the form of student and teacher utterances and is framed in terms of three categories: description, explanation, and generalisation.’ (2000, 130) While the present research did not look at grouping sequences of the classroom discourse into distinct ‘genres’ as is done in their work, this seems almost like a natural progression (and takes the analysis in the direction of Christie) for such analyses to take. By looking at the linguistic features of interrelated clauses, the next step would be document stages to see if/how those stages are replicated.
Scott and Mortimer also highlight the iterative nature of the IRE/F sequence. That is certainly the case in this research. The teacher takes frequent opportunity to extend the content by posing questions, after question, and challenge after challenge. This pedagogy may appear aggressive (as suggested in chapter nine). This questioning is meaningful if what takes priority in the sequence is the progression through meaning, rather than personal rancour. At no time in the present research was any rancour suggested on the teacher’s behalf.

Christie’s work, detailing the specific Genres and Macro-Genres of the classroom, and the science classroom, has contributed greatly to what happens in the classroom from beginning to end. She has detailed a sequence ‘Initiation/Elaboration/Closure’ (1997, 157) that seems much more meaning than the Triadic Dialogue. She was looking beyond the immediate clause or utterance using a wider lens and that provides a much more satisfying result. This research did not look at the generic features of the science classroom, but taking into account the combination of exchange, the Interpersonal and the Textual modes of meaning, it is (as mentioned above) a next logical step.

10.4 Recommended Pedagogical Changes Based on the Analyses

The previous chapters analysing the language of the classroom under review provided sections detailing the advantage of using Systemic Functional theory in such research. Those sections illustrated how the theory, and its associated grammar, explicated features of language used by the teacher and students in the classroom, and sought to identify issues for future development. This section will clarify three of those issues, and explore how they might be applied in future educational work.

The first will introduce possible course work for teacher training in the area of pre-service education. The second will look at possible approaches to in-service
education in the context of continuing professional development for Irish teachers. The third section looks at additions to the science curriculum that might contribute to improved learning for all students.

10.4.1 Proposed Course Work for Pre-service Education

While being educated to become teachers at post-primary/secondary schooling, it would be beneficial for pre-service teachers to learn more about specific features of language in schools. The research covered in the literature review (but including more specific Irish research) should be part of coursework for all teachers to be and structured around specific pedagogy methods classes.

This would mean that along with subject-specific lectures across the curriculum, but focussing on Maths and Science (as a start), subject pedagogy courses would include learning about the research into language in the subject area and looking at pedagogical approaches that include both educational as well as linguistic perspectives. This would mean learning about functional grammar at a level appropriate for teachers and not for those intending to pursue linguistic study.

Such work as being done by Lexis Education (http://www.lexised.com/courses/), an educational company in Australia, providing courses in the language of maths and science (based on Systemic Functional research) could be developed in Ireland based on research such as this thesis, and adapted for pre-service teachers.

This course work in teacher education in Ireland could also be drawn from Douglas Barnes' work in England in the mid-1970s. As documented in Barnes (1971 and 1977), this work entailed student teachers recording themselves in their classrooms, and analysing their own language for assessment in their course. In doing this, teachers could gain a heightened awareness of how they teach via language (as well as many
other valuable elements of their teaching practice), specifically in relation to subject content.

It must be stressed that neither of the above efforts (introducing language in the curriculum into pedagogy courses for pre-service teachers, and having pre-service teachers research their own classroom language) is intended to produce linguists of students. The goal would be for increasing awareness and understanding of the use of language in schools and in specific areas.

10.4.2 Proposed Course Work for In-service Education

Similar work could be done as part of in-service education for existing Irish teachers. Here, experience would be particularly valuable, as teachers with varying levels of practical experience in specific subject content (including how subject curricula change over time) could begin to learn about features of the language of those subjects.

Research has been conducted in subject specific language from several perspectives, but no theoretical framework has done this to the extent that Systemic Functionalists have over the past several decades. Educational and linguistic researchers such as Jay Lemke, Frances Christie, Jim Martin, Kay O’Halloran, Christine Coffin and Robert Veel have been documenting various features of the language of Science (Lemke, 1983, 1985, 1990), maths (O’Halloran, 2002, 2004) as well as classroom discourse (Christie, 2002; Lemke, 1984). This thesis would like to sit along with those research studies and be as relevant to practicing teachers as many of those works are.

But Ireland has to overcome a particular issue in relation to the use of English in the classroom. For historical and ideological reasons, English has been little studied, as shown in the literature review when considering classroom discourse. While beyond the scope of this thesis, others have documented reasons why. This has become more
meaningful in Irish schools today, as more and more students are entering (various levels of Irish schools) without a native grounding in English. (See Ó Croidheáin, 2006)

Building from work proposed in pre-service education above, in-service education could include exposure to the same academic literature, but be more aggressive in approaching the reading of the theory as well as its application. The effort here could be focused on participants attending in-service summer courses entailing reading suitable research and beginning to apply the thinking to their specific subject areas. As experienced teachers within the subject areas, this self-reflective approach to research (or researching one-self) could be extremely helpful.

One important aspect of this in-service education could be looking at the language research detailed in this thesis, and combining it with the dialogic approach now being theorised and developed. This research (see Alexander, 2004 and Wells, 2009 for specific details) seeks to achieve a more even balance of talk between teachers and students towards real dialogue in the classroom. The goal of such dialogue would be increased engagement to improved learning.

This suggests that such work as proposed here need not be a case of reinventing the wheel as research has been done in other countries covering much of the territory. Of particular interest, however, could be subject areas where particular research has not been done. In-service education could be considered truly advanced continuous professional development if new research, and new knowledge, is promoted within the process.

Again, it is hoped that this thesis could contribute both research methodology and a theoretical framework for such in-service coursework. It could be appropriate for practicing teachers, in seeking to extend the knowledge base of those teachers for improving pedagogical practice in the science classroom.
Finally, at the level of curriculum, it is hoped that research such as this thesis can contribute to looking seriously at language as being an inherent part of the curriculum. Issues such as Knowledge About Language (Carter, 1991), the Literacy Curriculum (Webster, et.al, 1996) and other research have been considering the strong role of language across the school curriculum. This has meant looking at language (and linking in literacy) in ways that demands engagement with the literature in chapter three of this thesis.

While that chapter focused on the language of the classroom, specifically the science classroom, it is important to look at theorising the role of language in the curriculum the way it has been done in efforts based on Systemic Functional theory over the decades. This theorising began in the early 1960s in the United Kingdom (Halliday, 2007); continued through the early- and mid-1980s in Australia (Cope and Kalantzis, 1993) and more lately in Australia with the *Scope and Scales* work (see [www.unlockingtheworld.com](http://www.unlockingtheworld.com) for details of this project).

The work of the *Scope and Scales* project is based on a linguistic analysis of the language demands of students from four to 18 years of age. This includes subject specific research for the post-primary/secondary years of schooling. Rather than simply adopting this research in Ireland, it would be important to consider the contents of this thesis, and seek to extend it to other subject content areas (each as part of the curriculum), and how such research can inform both the curriculum and, in an Irish context, the relevant accompanying *Teacher Guidelines*. 
If those guidelines accompanying the syllabus documents included language content relevant to teaching the subject, the link between the curriculum and teaching and learning as proposed above could begin to help all students improve learning, and communication, through the schools.

This set of proposals seeks to link pre-service teachers, in-service teachers, curriculum developers with academics in the Schools of Education and 'teacher training' colleges in a way that progresses all of their levels of awareness of language in schooling. The overall goal is to improve teaching as it happens in Irish classrooms.

10.5 Conclusion

All of the research reviewed in chapter three and restated here for discussion have created insights into the classroom via language and tried to both increase that understanding leading to improved classroom teaching and improved learning.

There are two key points to make at this stage. Research into the language of the classroom in Ireland is urgently needed, and the research reported in chapter three, along with the analyses of chapters six to nine should offer a framework for doing that research. It is hoped that such research will be part of Irish educational work in future. Second, the framework used in this research has been described as being extravagant. It is large, and it is wordy, but it also offers much for making informed analyses and evaluation of language as it currently occurs in the classroom. By using such an extravagant framework, the results of future research will hopefully shed additional light on how schools might improve the teaching of children in Irish schools in future.
11 Conclusion

11.1 Introduction

This conclusion will review the entire thesis by looking at the motive and reason for this research, by looking at the key questions and by walking step-by-step through the chapters briefly to encapsulate their content. The conclusion then reviews the findings from the analysis in a way that relate them (in order) to the exchange level, and then the Interpersonal, Ideational and Textual levels. Next, the conclusion will discuss limitations of this research and what might have been done had resources been more plentiful. Finally, a set of recommendations for future research will be suggested based on this research. It will be noted that ‘classroom’ here refers not solely to the secondary science (or other content areas) specifically, but also includes the university school of education lecture hall, where it is hoped this research will offer the most benefit.

11.2 Synthesis of Thesis

This thesis began with an introduction that suggested there is a public debate about science and how it is taught in Irish schools. With changes in technology and society over the past few decades (which seems to be accruing at an astonishing rate), there is a call for more and better science teachers; for different and more improved forms of assessment; and a yearning for more graduates in science to populate universities and colleges and later the ‘smart economy’. This debate has pushed for changes in Irish schooling, specifically in the way science is taught at Junior and Senior cycles.
The second chapter then provided a short history of science at second level with a focus on junior cycle (at it is presently known). It detailed the level of assessment of science progressing from Intermediate to Junior cycles, and changes to pedagogy as content changes. In fact, as this research was being conducted and this thesis being written, the Junior Certificate Science focus changed to be made more ‘practical.’ The result of this shift in focus is not yet known.

The third chapter looked at three distinct strands of research into the language of the classroom. The first focused on classroom discourse, and had variations based on either educational or linguistic forms. However, in both forms, the focus was non-subject specific. In primary education, this may not matter, but in secondary/post-primary schools, it is essential to not make that conflation. The second strand of this chapter looked at research into the language of school science. This was also in two strands (likewise educational and linguistic) with the focus in the former principally on words, or lexical items. While the linguistic research reviewed did look beyond the word level, both sections tended to conflate issues of spoken with issues of written school science. In addition, while it may be true that students at second level must have scientific literacy, it is speech in the classroom that dominates, and that is as true for as science as any other subject area. The third strand sought to condense the first two and look specifically at classroom discourse in relation to science. There were several theorists and different analytical frameworks offered in this section.

Chapter four then provided the approach to research in this thesis. The key question in this thesis was, ‘what does a micro-linguistic analysis of the science classroom tell us about the teaching and learning potential in that classroom?’ This chapter detailed the collection of data, the transcription and analysis of that data and the approach to answering the research question.
Chapter five then presented samples of the analysis in order to make the reading of the analysis chapters more accessible to non-linguists. Images of screenshots from the software were presented, but this was not intended as a complete tutorial into Systemic Functional grammar or theory. While chapter five did show the screen shots of the analysis, and these were used in several chapters, more use was made of segments of the transcripts, as these were taken from the output of the software. It was hoped by using the transcript to illustrate certain linguistic features, that more meaning was given to the suggested findings.

Chapters six through nine then presented various levels of findings. Chapter six looked at the exchanges in the classroom between teacher and student and provided several insights into how to see those exchanges. Chapter seven proceeded to look at the Interpersonal level of language, from a Systemic Functional perspective and provided a glimpse into different styles of speaking in the classroom between teacher and students.

Chapter eight continued the linguistic analysis, looking at various aspects of the Ideational level of language and included a focus on technical and non-technical language in the classroom. While chapter nine moved to a Textual analysis of the data, and how the links might be made from clause to clause rather than solely within individual clauses. At the core of each of these analysis chapters was a focus beyond the word (or small group) and into the lexicogrammar (combining lexis and grammar) and interclausal relations. Meaning is made via language in all of these ways, not solely through words.

Chapter ten then proceeded to review relevant sections of the literature review and discussed those views along with the current research finding. In addition to exploring the findings, this chapter also contained a set of proposals relevant to pre-service education, in-service education, and curriculum development. It is hoped that
appreciation for research from the past was conveyed and how that research contributed to what is offered in this research.

11.3 Review of Findings

The main findings of this research can be synopsised by looking at the four chapters of analysis.

Within the exchange chapter, it was suggested that better and more brokering between science (and other content areas) and common sense, every day language could help students accessing learning in the subject. This needs to extend beyond language and include cognitive linking. The teacher must be in the situation to help all students express their local realities in ways that allow each student to connect with science in more meaningful ways.

One way to help this is to increase teacher’s awareness of the Triadic Dialogue sequence (IRE/F) in order for them to begin making it more useful educationally within their classroom.

On the Interpersonal level (which is closely related to but not the same as exchange) there should be increased awareness of questions and heightened understanding of Subject/Complement. In the first case, having greater awareness of the roles of WH- and Y/N-interrogatives in the classroom and how they are used could allow for students to have greater comfort and competence in answering those questions fully and begin asking them themselves. The findings were that too many questions are asked by the teacher and that too many students responses are single word or small word group answers.

Related to questions, is the idea of increased awareness in the use of Subject/Complement in completing clauses for fuller meaning. By learning to
communicate (in their responses) in longer clauses with full Subject and Complements could allow for enhanced learning as the pedagogical environment becomes more and more explicit in the subject area through language.

At the Ideational level, the key finding was that students have virtually no engagement with Verbal and/or Mental Processes types. As teaching and learning are all to do with talking and thinking, this was most surprising. Part of resolving this issue means learning how to make mistakes in the classroom and having confidence saying something that may not be correct.

In addition, the lack of Circumstances (of the Means and Quality variety) means that students are adding very little value to their contribution in the classroom. Perhaps linking the notion of Subject/Complement with Process/Circumstance could also address this in future classrooms.

Finally, at the Textual level, it was noted that tracing the Theme through both short and extended sequences of dialogue allow for maintaining meaning in relation to content. The teacher in the transcript showed solid (unconscious) awareness of keeping the flow of meaning (science) in her exchanges. This could be traced by following the Theme (starting point of the clause) through some illustrative examples.

These findings all relate to the grammatical resources that are used and required in the classroom to achieve success. For all students to achieve such success as we want of them, in science and other subject areas, such a focus on language would be beneficial.

11.4 Limitations of this Research

The limitations of this specific research project were not unlike similar projects. One person collecting data, analysing that data, and then writing up a thesis while
working or getting on with other aspects of life are part and parcel of post-graduate and
doctoral-level research. Visiting schools around county Dublin, with two video cameras
in a rucksack, while on a bicycle, in mid-winter is problematic at the best of times.
When the bicycle broke down half way to one school session, the troubles mount.

That however, is the nature of personal research. Support from likely as well
unlikely places partly motivates the post-graduate researcher to completion. This
research was supported both personally and professionally, as well as both socially and
academically.

One specific limit to this research was the inclusion of a single school (two class
sessions) in the analysis. Three schools were initially video-recorded and transcribed
but over time, and partly due to the level of analysis, only one was selected for this
thesis. The selection of this specific school was principally random (actually the longest
of the three transcripts was taken) as that contained 1,633 separate clauses (with
embedded and interrupting adding to that number and analysed), and a total exceeding
40,000 individual labels on those clauses covering the various levels of clause, analysis
and exchange functions.

Additional computing resources may have provided for additional material
(including transcripts) to have been used, but that was beyond the practical scope of this
research.

It is hoped that future research can extend the use of the framework used here
and the software in various ways.

One note on the use of the software. Systemics, published by the University of
Singapore Press, is very, very good software, but does has limitations. As it is not native
to any computer operating systems and runs in a shell on various platforms, one oddity
is that upon a change in daylight savings time (clock change in Spring and Autumn) the
software stopped working and required re-registration. While this was always given speedily, getting in touch with colleagues in Singapore was not always instantaneous. That is based on the vagaries of time and space, not the support staff at the University of Singapore.

11.5 Recommendations for Future Research

This research into the discourse of the science classroom should be seen as only a starting point. There are areas of future research that should be considered, and these are in three key areas.

Within Irish education and schooling, there is a dearth of research within the classroom. This research means looking at language, but not only language. It involves looking at English in the classroom, but also Gaeilge and other modern languages and how they impact on young people’s learning. This research can contribute to understanding how English, Gaeilge and other languages are taught, learnt, extended, and assessed across the primary and post-primary spectrum. In addition, the subject specific languages used in science, maths, and all other subject areas need to be seen in a new light via research, and that research cannot be limited to words (the lexical) level, but must go deeper.

The second area of research is how teachers are taught to be teachers, or are socialised into becoming teachers. Including the sort of research conducted for this thesis (not necessarily using the same theoretical or linguistic framework) could contribute to educating teachers who take language seriously in their own and other subject areas and for multiple purposes. This sort of pedagogy, in the universities and colleges, would be as important as research in the classroom.

Finally, research based on linguistic features that help expose the linguistic demands of learning (through but not limited to English) in Irish schools could
contribute to a heightened awareness and pedagogical development. This would be relevant for both students who struggle at present in schools (specifically in cases on disadvantage, language pathology and special needs) but also in relation to non-Irish nationals and their access to the curriculum via English. By combining the first two points above it might be possible to imagine future schooling for all students where language is taken seriously and meaningful, and based on helping all students learn more.

11.6 Closing Comments

To conclude, it is hoped that seeing how science is talked about in the classroom by teachers and students in one class might promote the use of language research in the classroom in future. It is important to stress that it is not important which specific theoretical framework is used (Systemic Functional theory was used for this research). But what is important is that language in the classroom become as researched in Irish school and academia as it is in other parts of the world.

That said, Systemic Functional theory has contributed to development in school language since the early 1960s in the United Kingdom, has been used to spur research and pedagogical approaches in the U.K. and Australia since then, and has recently been instrumental in English as Second Language Programmes in Asia. It may be the time for such an approach to language (functional linguistics) to come to Ireland in the form of similar research.
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