THE RELATION BETWEEN PEDAGOGIC TEXT AND PEDAGOGIC PRACTICE: A STUDY OF TWO GRADE SEVEN SCIENCE CLASSES

by

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Declaration

I declare that *The relation between pedagogic text and pedagogic practice: A study of two grade seven science classes* is my own work and that it has not been previously submitted, in whole or in part, for any degree or examination at any university. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signed:

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Abstract

Despite the vast research on school science textbooks and science pedagogy, the relation between these two aspects of science curriculum has not been given much attention. In this thesis the science texts and pedagogic practices of two grade seven South African science classes are analysed in order to explore the potential connections between text and pedagogic practice. Underlying the research is a concern regarding the implications of the nature of pedagogic text for the specialization of student consciousness. The thesis utilizes a theoretical approach that is grounded on Bernstein’s notions of classification, specialization and knowledge structures. The analysis of the pedagogic texts leads to the description of two contrasting textual modalities: independent and dependent texts. These texts types differ in explanatory depth and detail and present differing classification strengths with respect of everyday and scientific knowledge. The texts are shown to be constructed according to differing recontextualization rules. Furthermore, two differing pedagogic practices emerge: localized and generalized practices. The key differences between these modalities are the strength of the classification of teacher voice and text voice and everyday and scientific knowledge exhibited in pedagogic practice. The analysis suggests that pedagogic text can be related to both these classificatory dimensions. Furthermore, it is suggested that strong classification of teacher voice and text voice facilitates an orientation to meaning that privileges the authority of written texts over spoken context embedded discourse. This is argued to be a key aspect of a student’s apprenticeship into specialized scientific knowledge, facilitated by independent texts. Moreover, the thesis recognizes the complex relationship between everyday knowledge in the curriculum and the specialization of student consciousness and offers that this is a crucial question requiring further research. Primarily, the thesis develops a model for further investigation into these and other issues regarding the

relation between text pedagogic practice and the specialization of student voice with respect of scientific knowledge.

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Chapter 1: Introduction

1.1 Introduction

In this thesis I explore the relation between pedagogic texts and pedagogic practice. My specific interests are in developing a general model for looking at how school science texts are differently constituted and mediated by teachers and how these two aspects of pedagogy may be related. Furthermore, I seek to describe the recontextualizing rules guiding the construction of the texts and the pedagogic practices analysed. Underlying these interests is a concern regarding the potential consequences of text and its mediation for the specialization of student consciousness.

My interest in pedagogic text and its mediation arose, partly, through my work as a teacher at a primary school in Cape Town from 2003-2007 (a school I call School A in the thesis). School A places a heavy emphasis on the role of text as the primary pedagogic instrument and utilized lengthy, complex, encyclopaedia style books to teach the sciences. These texts and their pedagogic mediation seemed to present something quite different to what I had experienced at other schools. More specifically I was interested in what the consequences, of School A's methodology, might be for the specialization of student consciousness.

Furthermore, at a national level, the question of the nature of pedagogic texts in the school curriculum has become a central concern. The 2009 reform committee recommended a return to disciplinary knowledge and emphasized the need to use content-rich textbooks as a key pedagogic tool. Moreover, the committee recommended that text books should contain detailed disciplinary knowledge (DOE, 2009). My interest in text, pedagogy and the specialization of student consciousness arose from these circumstances.

1.2 Statement of the primary research question and sub-questions

The study is located in two primary schools in Cape Town. Three consecutive grade seven science lessons were video recorded at each school and the textual materials used by the teachers in the lessons were collected. [1] This data was analysed in order to answer the central question: *What is the relationship between text and pedagogic practice in two grade seven science classrooms?* From this central question three sub-questions emerge.

A: *How are the texts in the two classrooms differently constituted?*

B: *In what ways are the texts mediated differently through pedagogic practice?*

C: *What are the dominant recontextualizing principles underlying these texts?*

Since the concern underlying this research is the consequences of texts and their mediation for the specialization of student consciousness, one final question remains: *what are the consequences of the differences between the two pedagogic approaches for the specialization of student consciousness?* However, the research does not include any data relating directly to student consciousness and thus the answer to this final question remains tentative. However, this does open up interesting directions for further research. The primary outcome of this research is the development of a model, drawn from the analysis of the science lessons of two grade seven teachers, that allows for the exploration of the relation between text and pedagogy focused on aspects potentially relevant to the specialization of student consciousness.

1.3 Overview of how the research questions will be approached

In order to answer sub-question A, the two sets of texts are analysed. The analysis looks at both the form of expression and the type of knowledge content embodied in the texts. More

[1] Grade seven science is constituted by a selection of topics from the following general categories: Physics, Earth Science (Geography), Environmental Science, Life Science (Biology), and Chemistry. In this thesis I have extracted lessons that focus on the categories of Environmental Science and Physics. The topics covered are: "Uses and conservation of natural resources", "Changes in environments", "Energy types, sources and conversion" and "Forces and motion".

specifically, the analysis seeks to gauge the extent to which the texts are congruent with specialized scientific texts such as those found in scientific journals. The orientating theoretical idea utilized is Basil Bernstein's notion of classification. Thus the way the two texts are differently constituted is elucidated in terms of specific classificatory strengths. Sub-question B is answered by a close analysis of the video footage recording of three lessons at each school. This analysis explores the differences between the two teaching practices and begins to relate these differences to the features of the texts elucidated in the analysis of texts section. In this section, teacher explanations, questions, reading and set activities are analysed via theoretical instruments related to those used in the analysis of text. Sub-question C is answered through a consideration of what emerges from the analysis of the texts. The recontextualizing principles underlying the texts form part of the concluding comments analysis in chapter 4. I utilize Douglas Robert's (2007) "curriculum emphasis" categories as a way of talking about the recontextualizing principles.

Finally, the question regarding the implications of the texts and pedagogic practices for the specialization of student consciousness is dealt with briefly throughout the analysis and a more substantial discussion of it is reserved for the final chapter. The question is approached by drawing strongly on the concepts developed in Claire Painter's (1999) paper: *Preparing for school: developing a semantic style for educational knowledge.* In answering this question I look at the ways in which the nature of the texts and their mediation in the classroom (underlined by the recontextualizing rules) may potentially have bearing on the specializing potential of the practice.

1.4 An overview of the thesis

Chapter 2 outlines the theoretical and methodological approach of the thesis. This chapter explains some of the primary theoretical tools that have informed the thesis and outlines the research design. Furthermore, the chapter ends with a discussion of the general methodological approach. Chapter 3 presents a survey of some of the empirical antecedents of the study, locating the study in the context of current and past research. Chapter 4 presents the analysis of the texts utilized by two schools from which two textual modalities are constructed. Chapter 5 presents the analysis of the pedagogic practices of the two schools from which two pedagogic types are defined. The final chapter, Chapter 6, summarizes the thesis and presents a discussion of the findings and implications of the analysis. The chapter ends with a summary of the relations between text and pedagogy suggested by the analysis.

Chapter 2: Theoretical and methodology approach

2.1 Introduction

This chapter consists of two major sections: the first section involves a discussion of the primary theoretical concepts informing the study and the second section sets out the methodological approach of the thesis. The first section begins with a brief overview of Bernstein's theoretical work, as his notion of classification underpins my theoretical approach. I discuss Bernstein's concepts of classification, framing, recontextualization and include a discussion of his later work on knowledge structures. I then move on to a discussion of Paul Dowling's concepts of domains and procedural/principled discourse: applications of Bernstein's classification which I adopt in my analysis. After which I discuss Painter's (1999) work on the development of semantic orientations, which draws on both Bernsteinian and SFL theory. I then introduce the linguistic concepts of nominalization and technicality presented by J. R. Martin, who works within a SFL framework. The theoretical section ends with a brief discussion of specialized and everyday knowledge in which I integrate the concepts of Painter, Bernstein and others. In the second section I develop the analytic framework of the study, building on the previous section's theoretical discussion. Firstly, I briefly describe the study's sample: the schools, and classrooms that were selected. I then discuss the production of the data: data sources and collection strategies. The third part of this section deals with the analytical methods used in the research. Here I outline the general methodological approach involving the development of an external language of description as described by Bernstein (2000). Furthermore, an outline of the specific methodological approach is sketched in this section.

2.2 Theoretical approach

2.2.1 Bernstein: codes, class, classification and framing

In *Class, codes and control, Vol. 2: Applied studies toward a sociology of language* (1973), Bernstein attempts to explain why educational success is so firmly linked to socio-economic class. Bernstein recognized that an answer to this question must give a central place to the role of language in shaping a child's semantic orientation. He proposed the operation of two semiotic codes that he termed *restricted* and *elaborated* (Bernstein, 1975). Restricted code refers to meanings that are localized and tied to particular contexts in time and space, whereas, elaborated code involves meanings that are generalized and removed from specific contexts (Hoadley, 2005: 50). Furthermore, an elaborated orientation to meaning refers to consciousness that has internalized elaborated code and is able to draw on elaborated meaning forms. Alternatively, a restricted orientation to meaning refers to a consciousness that is able draw upon restricted code meaning forms. Bernstein proposed that these coding orientations were class-related and thus linked to the social division of labour. Bernstein argued that:

> The simpler the social division of labour and the more specific and local the relation between an agent and its material base, the more direct the relation between meanings and the specific material base, and the greater the probability of restricted coding orientation. The more complex the social division of labour, the less specific and local the relation between an agent and its material base, the more indirect the relation between meanings and a specific material base, and the greater the probability of an elaborated coding orientation (1990: 20).

Therefore, Bernstein suggested that elaborated orientations to meaning were more likely to be distributed through early middle class family socialization than through working class home environments. Janet Holland (1981) conducted a study, which confirmed Bernstein’s theoretical position, showing that while middle class students are socialized into both elaborated and restricted coding orientations and tend to privilege the former in school contexts, working class students generally receive only a restricted coding orientation from their home environment. Therefore, considering that the school context privileges and rewards an elaborated orientation, middle class and working class students are differentially prepared for success at school.

As his work progressed, Bernstein became interested in how elaborated code was differentially distributed via various modalities of pedagogic practice. This resulted in a focus on pedagogic discourse and its various forms. Bernstein developed the concepts of classification and framing as an algebra for describing various forms of pedagogic discourse. These concepts, which operate at a high level of abstraction, allowed for detailed descriptions of pedagogic practice, when brought into conversation with empirical data (as I will discuss later in regards to languages of description).

Classification has to do with the distribution of power which is manifested in the strength of the boundaries between discourses, spaces, agents or contents. Power relations divide the world into categories: they determine what can and what cannot be brought together. Therefore, classification refers to the degree of insulation between contents: "Where classification is strong, contents are well insulated from each other with strong boundaries. Where classification is weak, there is reduced insulation between contents, for the boundaries between contents are weak or blurred" (Bernstein, 1975: 88). At the micro level of the school, classification renders visible the power grid of the organizational and structural aspects of the school's pedagogic practice. For example, where the classification between school subjects is strong there will be little relationship or connection between subjects. Each subject will have its own specialized discourse and space and will be clearly demarcated in time by specific periods dedicated to each subject. Subjects will be taught by specialist teachers and knowledge from one subject will not be introduced or integrated into another. In short, classification has to do with the *relations between* categories revealing the way in which power relations have divided the world.

Framing has to do with the social *relations within* the bounded categories set up by classification. Framing speaks to the control relations within the various existing categories "of the power grid" (Hasan, 2002: 539). In this way, framing maintains or supports classification, but it also opens up the possibility of contestation and adjustment of power relations (Bernstein, 1996: 5). At the level of pedagogic practice, framing is about the location of control over the hierarchical and discursive rules in the classroom[1]. More specifically, "Framing refers to the degree of control teacher and pupil possess over the selection, organization, pacing and timing of the knowledge transmitted and received in the pedagogic relationship" (Bernstein, 1975: 88). Although Bernstein does not mention the hierarchical rules in the previous quote, framing can also be used in relation to the locus of control of this set of rules: the degree of control teacher and students have over the rules governing social order, character and manner in the pedagogic relationship.

The analysis in this paper does not utilize the concept of framing as my interest is not in offering a description of the relay (pedagogic modalities) and their relation to issues of social class and its reproduction. Therefore, my study does not analyse the control relations between students and teacher. Rather, I endeavour to elucidate the nature of the knowledge relayed by different pedagogic practices: that is the semantic content of what is classified. For this purpose, the concept of classification, as it refers to the strength of the boundary

[1] It is unclear in Bernstein's writing whether or not weak framing actually entails a real control on the part of the students of the rules governing the pedagogic relationship, or whether weak framing merely refers to the disguising of teacher control creating the illusion of student control. What does seem to be clear is that the teacher at some point will evaluate a student's performance. For Bernstein this means that in any pedagogy, control might be abdicated to students in various contexts and ways, but at the crucial point of evaluation the teacher, and not the student, controls the evaluative rules. In this sense weak framing of other aspects of pedagogic discourse may be viewed as merely masking this crucial locus of control that always resides with the teacher.

between everyday knowledge and specialized science knowledge, is fruitfully utilized in the analysis.[2]

2.2.2 Basil Bernstein: vertical and horizontal discourse

In order to elucidate the strength of the boundary between everyday knowledge and specialized, educational knowledge there needs to be an explicit theory of the nature of these forms of knowledge. Bernstein's later work on knowledge structures has specific relevance here.

In the late nineties Bernstein began to explore knowledge structures realizing that his theory up till that point "took for granted, and left unexamined, the form of the discourse" (Bernstein, 1999a: 23). In an essay written that same year, Bernstein describes two forms of discourse: horizontal and vertical discourse. Horizontal discourse refers to everyday knowledge, which, according to Bernstein, "is likely to be oral, local, context dependent, and specific, tacit, multi-layered, and contradictory across but not within contexts" (1999b: 159). Bernstein goes on to sharpen his definition of horizontal discourse, suggesting that it "entails a set of strategies which are local, segmentally organized, context specific and dependent, for maximizing encounters with persons and habitats" (ibid). Pieces of knowledge comprising horizontal discourse 'are related not by some coordinating principle, but through the functional relations of segments or contexts to the everyday life" (Bernstein, 1999b: 160). Conversely, vertical discourse takes the form of a "coherent, explicit and systematically principled structure, hierarchically organized" (Bernstein, 1999b:159). Knowledge in vertical discourse transcends any specific time space context and is thus able to be built upon systematically over time. In this thesis formalized vertical discourse is taken as characteristic

[2] Interestingly, Bernstein (1975) speaks of the "…the degree of insulation, between the everyday community knowledge of teacher and taught and educational knowledge" (89), as an aspect of framing. He justifies this on the basis that it is an issue of control regarding what may be taught and what may not be taught. However, in this thesis the strength of the insulation between everyday knowledge and educational knowledge will be considered from the point of view of classification and thus as a feature of the given power relations in which teacher and pupils operate.

of educational knowledge, while everyday knowledge is described in terms of the features of horizontal discourse.

Thus, Bernstein's descriptions of vertical and horizontal discourse provide the basis for recognizing everyday knowledge and specialized knowledge in the data. Furthermore, the ability to recognize these forms of knowledge in the data allows for meaningful classificatory coding with respect to everyday and specialized knowledge.

2.2.3 Bernstein and Roberts: recontextualization

According to Bernstein, recontextualization can be understood as the process whereby knowledge, produced at universities and other knowledge producing institutions, is transformed into pedagogic discourse. Bernstein argues that a recontextualized discourse such as school physics is a fundamentally different discourse to physics in the field of production. The recontextualizing agents (such as textbook writers), often not physicists, select content from the field of the production of physics, but arrange this content in a manner that bears no relation to the logic of this discourse. Bernstein suggests that the discourse of school science is fundamentally reordered according to the principles of another discourse which he calls the regulative discourse. In the case of pedagogic discourse, Bernstein argues that it "is constructed by a recontextualizing principle which selectively appropriates, relocates, refocuses and relates other discourses to constitute its own order. In this sense pedagogic discourse can never be identified with any of the discourses it has recontextualized" (1996: 33). Thus, in production of the discourse of school science, the discourse of science, as it exists in tertiary institutions such as universities, is relocated and, in the process, it is reordered and focused according to a philosophy regarding the purpose of school science as well as a particular theory of learning (regulative discourse) and reconstituted as school science.

In this thesis I utilize Douglas Roberts' (1982) "curriculum emphases" as a means of defining and recognizing the recontextualizing principles of the pedagogic texts used by the two schools. In a paper titled, *Developing the Concept of "Curriculum Emphasis" in Science Education*, Roberts theorizes the principles underlying the formation of science curriculums. According to Roberts, "A Curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself—objectives which provide answers to the student question: "Why am I learning this?" (1982: 245) Roberts goes on to outline seven curriculum emphases in science education: everyday coping, structure of science, science technology and decisions, scientific skill development, correct explanation, self as explainer and solid foundation. Roberts suggests that each of these emphases is legitimate and address important concerns. Roberts' seven curriculum emphases were a helpful tool for identifying the recontextualizing principles of the pedagogic practices of my study.

2.2.4 Dowling: domains and strategies

This thesis recruits specific aspects of Dowling's "social activity theory". Firstly, my work draws strongly on Dowling's theoretical division between expression and content, which leads to the emergence of four domains of practice. As a result, my analysis of texts considers both the specialization of expression and the specialization of content and frames this specialization in terms of classification strength. This will be explained further in the methodology section of this chapter. Furthermore, I utilize Dowling's distinction between procedural discourse and principled discourse which is operationalized as the concept of connective complexity.

2.2.4.1 Domains

Dowling's concepts (1998), discussed in this section, are developed within what he terms social activity theory. His theoretical framework is summarized by Ensor (1999) as follows:

> According to Dowling, the social can be understood as the articulation of social activities, where an *activity* is 'an analytic space' which enables the description of 'the empirical as constituted by the social division of labour in general' (Dowling, 1998, pg. 88). An activity thus produces and reproduces, (re)produces, the division of labour in society, specializing both social positions and social practices, regulating what subjects may say, do, or mean (p. 45).

Dowling argues that the practices of an activity are only empirically accessible at the textual level in which an instantiation of a practice is referred to as message and a position is referred to as a voice: "pedagogic texts distribute message over a range of voices and so (re)produce the practices and positions of an activity" (1998: 132).

According to Dowling, the recontextualizing gaze of an activity constitutes practices that can fall within four domains setup by the strength of the classification of both the content and expression of the message. Practices displaying strong classification of both expression and content fall in the esoteric domain. Practices displaying weak classification of expression and content fall in the public domain. The expressive domain contains practices weakly classified in terms of expression but strongly classified in respect of content. Finally, the descriptive domain constitutes practices strongly classified in expression but weakly classified in content.

Furthermore, Dowling argues that the regulative principles of an activity can only be fully realized in the esoteric domain. Dowling argues that "Because ambiguity is minimized in the esoteric domain, specialized denotations and connotations are always prioritized. It is, therefore, only within this domain that the principles which regulate the practices of the activity can attain their full expression" (1998: 135). Thus Dowling considers the esoteric domain as the regulating domain of an activity in relation to its practices.

However, Dowling acknowledges the essential role of the public domain for pedagogic purposes. Dowling suggests that "…all activities must look beyond themselves for pedagogic if for no other reasons…If an activity were to make no references outside of itself, then it would be unable to create apprentices" (1998: 136). Dowling suggests that the esoteric domain must cast a recontextualizing gaze upon practices external to it, subordinating, to various degrees, the forms of expression and content to its regulating principles. Dowling considers the public domain as the domain through which apprentices enter the activity. However, in order to fully realize the regulating principles of a practice an apprentice must be exposed to practices beyond this domain. Thus Dowling suggests that public domain practices have an indispensible role in apprenticing students into an activity while acknowledging the limitations of this domain's ability to express the regulating principles of an activity.

2.2.4.2 Strategies

In Dowling's theory texts incorporate strategies that effect the distribution of message across a spectrum of voices. Furthermore, strategy may distribute principling or proceduralizing discourse. Dowling differentiates between these two discourses:

> The general quality which distinguishes principled from procedural discourse is that the former exhibits connective complexity, whereas the former tends to impoverish complexity, minimizing rather than maximizing connections and exchanging instructions for definitions…principling must involve esoteric domain message. Where exemplars are used their abstractive properties will be made explicitly available (Dowling, 1998:146).

Dowling places principling discourse under the more general category of abstracting discourses while placing proceduralizing discourse in the general category of particularizing discourse. This notion of principling and proceduralizing discourse gave impetus to the concept of connective complexity and will be explained further as it is specifically applied in the analysis chapters.

2.2.5 Painter and the development of semantic orientation

In a chapter titled, *Ongoing dialogue: functional linguistic and Bernsteinian sociological perspectives on education,* Francis Christie (2007) traces the history of the close relationship that existed between the work of the functional linguists M.A.K. Halliday and Basil Bernstein. This relationship, which began in the sixties, has matured into very fruitful dialogue between functional linguists and Bernsteinian researchers on issues regarding the nature of knowledge and its implications for education. An exemplary instance of this dialogue is Painter's (1999) research presented in a paper titled, *Preparing for school: developing a semantic style for educational knowledge.* In this paper Painter attempts to explain how parent-child linguistic interaction in middle class homes will, "from the earliest years, sensitize the child to kinds of meaning relevant for later school learning" (1999: 66).

In Bernstein's terms, Painter's study illuminates how middle class children receive a particular orientation to meaning compatible with the code required for success at school. Painter begins by distinguishing between what she calls common sense knowledge and educational knowledge. She goes on to argue that while the linguistic interactions between a middle class parent and a child, below the age of five, deal with common sense knowledge, these interactions relay semantic habits compatible with the successful acquisition of educational knowledge. This semantic orientation includes: An orientation to learning from definitions, attending to principles underlying categories, construing contexts beyond personal experience, privileging of textual information and inference, and construing information exchange as a means of learning. Furthermore, Painter lists a set of experiences and orientations that she regards as linguistic preparation for accessing educational knowledge. Her understanding of what counts as linguistic preparation for educational knowledge is derived from the theory of the nature and structure of vertical discourse. Painter's theory provides a means of identifying the potential of pedagogic interactions to transmit an orientation to meaning that will allow for the successful acquisition of increasingly specialized knowledge.

2.2.6 SFL and pedagogic texts

2.2.6.1 Nominalization

Functional linguists, in the Michael Halliday tradition, have identified the notion of grammatical metaphor as a key linguistic feature of specialized texts. Here specialization takes on a grammatical embodiment. J. R. Martin (2007), in his paper *Construing Knowledge,* shows how grammatical metaphor, from a linguistic perspective, acts as the key to understanding the difference between vertical and horizontal discourse. Martin argues that grammatical metaphor is the key linguistic resource that "enables uncommon sense classification, composition and explanation right across the humanities, social science and science" (2007: 60). Furthermore, Martin argues that control of grammatical metaphor is indispensable to accessing vertical discourse.

Grammatical metaphor involves a misalignment of semantics and grammar. Francis Christie describes it as "a resource which 'unties' texts from situations and allows writers to reconstrue activities as things and thus break the iconic connections between linguistic and material activity...this resource enables writers to interpret experience from a 'meta' point of view to abstract away from material activity through linguistic activity" (Christie, 2007: 173). According to Martin, a key aspect of grammatical metaphor involves nominalization: "a process of 'thingification' whereby activity is reconstrued as abstract things" (2007: 44). Martin goes on to add "in abstract discourse we find processes, qualities and logical relations realized as nouns and logical relations realized as verbs" (2007: 52). Thus specialized texts tend to transform actions and processes, which would normally be realized as part of the verbal group of a clause, into things or objects found in the nominal group component of a clause. The density of a text's use of nominalization can be used as an indicator of its specialization.

2.2.6.2 Technicality

Martin (1993) argues that scientific discourse functionally utilizes a high density of technical terms. Some of these technical terms are used exclusively in the scientific field and can be described as indexical of the field: "…once we hear the term we know what field we are in" (Martin, 1993: 171). An example of this would be the word colloid as it is used almost exclusively in chemistry. Other technical terms are words that are common in other fields but are given a specific and special meaning within the field of science. For example the word mixture might be bandied around in a domestic context such as cooking but is giving a special meaning in the field of science: a substance that can be easily separated into its component parts without a chemical reaction.

Martin (2007) argues that technicality has a condensing function in scientific discourse. Complex meanings are condensed into single terms. He suggests that "without this condensation scientific texts would become very long, and probably unreadable, even for professionals" (Martin, 2007: 172). As a result Martin proposes that the use of technical terms is indispensable to the forms of meaning needing to be expressed in scientific discourse. Thus, a key aspect of specialized text is its use of technical language and one would expect a greater density of technicality in texts that display a high degree of specialization.

Furthermore, Martin (2007) argues that an understanding of the meanings of technical terms is a logical prerequisite to one's ability to access scientific discourse. This has very interesting implications for science pedagogy texts. These texts will need to systematically build up a student's specialized vocabulary. This can be done visibly via definitions of technical terms that utilize ordinary language already understood by the child or invisibly via frequent use of the term in which the meaning of the term is implicit in its context of use. Furthermore, terms can be explained in the pedagogic text or the teacher can explain them verbally. Both nominalization and technicality are recruited in the analyses as indicators of the specialization of the text and related to the strength of the classification of the texts with respect to educational and everyday knowledge.

2.2.7 Specialized knowledge and everyday knowledge

Much of the theory discussed in this chapter privileges the idea that knowledge can be classified into two distinct categories: that which involves meanings that are context-independent, abstract and codified, and that which involves context- dependent, localized and common sense meanings. Emile Durkheim (1915) distinguished between these types of knowledge terming them sacred and profane respectively. Since Durkheim, theorists have fleshed out the differences between these categories from a number of perspectives. Bernstein's work on elaborated/restricted code was based on this distinction and his later work on knowledges (vertical/horizontal) attempted to explore the ways in which these different knowledge types were structured, expanded and validated. Furthermore, the work of functional linguists, such as Halliday and Martin, explores the linguistic differences between the language used to express specialized knowledge as opposed the language forms typical of common sense everyday knowledge. Finally, Dowling's notion of the esoteric and the public domain is strongly related to specialized and everyday knowledge respectively (Hoadley, 2005: 64).

Painter offers a succinct explanation of the characteristics of everyday common sense knowledge and specialized educational knowledge. Common sense knowledge is characterized by Painter as "knowledge that appertains to the visible material world that is functional for the routine living of daily life, that is non-specialized, shared by all members of the culture/community" (1999: 68). Furthermore, common sense knowledge is built upon concrete non-technical meanings that are context dependent and based on shared and personal experience. Everyday knowledge is negotiated in informal spoken language, built up unconsciously in a piecemeal fragmented way. Meanings are not highly interconnected and a high percentage of meaning remains discursively implicit and situational. In contrast, specialized knowledge, "is necessarily concerned with the transmission and development of universalistic orders of meaning which go beyond local space time and context…embodied in written monologic discourse abstracted from any situational context shared with the interlocutor" (Painter, 1999: 70). Furthermore, specialized knowledge is built up consciously and constituted predominantly in written language involving grammatical metaphor. Meanings are highly connected and systematized and a high proportion of meaning can be made available in language, particularly in written form.

The interplay of specialized and everyday knowledge in pedagogy is a key concern of this thesis. Both Bernstein and Dowling recognize the role of everyday knowledge in school curriculums as an essential apprenticing tool that forms the bridge between the unspecialized consciousness of a student and the specialized discourse of educational knowledge.

2.3 Research methodology

In this section I develop the analytic framework of this study. Firstly, I briefly describe the study's sample: the schools, and classrooms that were selected. I then go on to discuss the production of the data: data sources and collection strategies. The third part of this section deals with the analytical methods used in the research. Here I outline the general methodological approach involving the development of an external language of description as described by Bernstein (2000).

2.3.1 The study sample

This project is concerned with the development of a theoretical model for analysing school science texts and the influence textual features may have on science pedagogy and its specializing potential. Since the concern of the project is theoretical, a small sample explored in detail was identified as the approach most conducive to my research purposes. Thus, only two schools were included in the sample and, more specifically, only three consecutive grade seven science lessons from the same class at each school were analysed.

The schools were selected so as to maximise difference with respect to the specific interests of the research, while holding other unrelated factors as constant as possible. In short, the schools were selected because of the perceived contrast between the type of science texts utilized in the classroom as well as their contrasting pedagogic approaches. Crucially, however, pedagogic text played a central role in both classrooms and the teachers at both schools used text substantially. Furthermore, in other influential aspects, unrelated to the interest of the research, such as location, social class ratios of students, and teacher's social class, the two schools were remarkably similar. Furthermore, both schools are located in the same suburb of Cape Town.

2.3.2 Introduction to the two schools

School A is a small private school that was founded by a church over twenty years ago. The school runs from preschool through to grade nine and has roughly 130 students with an average class size of thirteen students. The school has adequate but fairly humble resources. The building is prefabricated and classrooms are typically equipped with a table and desk for each student and a large chalk board on the front wall. The school has a small computer room and a poorly resourced library. The majority of the students are from wealthy upper middle class backgrounds. However, the school offers a substantial number of bursaries for disadvantaged students and thus roughly twenty percent of the students come from the suburb's township.

The school utilizes an adaption of the education philosophy of Charlotte Mason, a British educator who wrote extensively on education in the first quarter of the twentieth century. Mason emphasised the need for strict training in good habits of both the mind and the body. She called for a generous, liberal curriculum that offered students a wide variety of subjects. Furthermore, Mason discouraged the use of textbooks and rather encouraged the use of 'living books' which she describes as books written by experts in the subject, using excellent literary style and containing many interesting and connected ideas (1925: 162). Mason's pedagogic ideal sought to place as little between the student and the text as possible and thus excluded copious explanation and summarization on the part of the teacher.

School B is an ex-model C junior school located roughly 4km from School A. Being a former model C school, the medium of instruction is English and the school's facilities are extensive and well resourced. The class sizes are comparatively small; usually under 30 students. Furthermore, the school draws students from the surrounding suburb and thus includes both working and middle class students. Teachers at the school are typically middle class and well trained. Classroom resources are adequate and included a desk and chair for each student and large white board on the front wall. The school follows the national curriculum. In summary, School B is a typical well run and resourced government school with a majority middle class and a substantial working class student population.

2.3.3 The two classrooms

Class A (the classroom studied at School A) consisted of fourteen students: four girls and ten boys. Of the fourteen students three came from working class homes. The teacher was a well-educated (English Honours) male teacher in his mid-twenties. Furthermore, this teacher was recommended by the academic head of the school as a teacher that had a firm grasp of the school's methodology. Desks were arranged in a U shape, facing the front, with two desks placed in the middle. Class B (the classroom studied at School B) consisted of twenty one students: twelve girls and nine boys. Of the twenty one students six came from working class homes. The teacher was a well-educated (university undergraduate degree) middle aged women with substantial teaching experience. The old fashioned wooden desks were arranged in four rows, facing the front.

Information about the students' primary caregivers was collected at school B by using a survey form that included questions about parents' level of education and current occupation. This allowed for an estimation of the social class demographic of the class. At School A, I was given access to information regarding how many of the students in the class were on substantial need-based bursary programmes. This allowed for a rough estimate of the social class demographic of Class A.

2.3.4 The production of the data

The research utilized three data collection strategies: direct observation of the classroom, the collection of textual materials and a questionnaire. The data was collected from April 2010 to May 2010.

Three consecutive grade seven science lessons were observed at both schools. The middle of the second term was selected for the observation so that there would be an established familiarity between the teacher and the students. Furthermore, the lessons were recorded in the middle of the term to ensure that a pedagogic rhythm had been established and that preparation for exams would not yet have begun. The three lessons at School A totaled 128 minutes, while the three lessons at School B totaled 106 minutes. The video recordings were transcribed in full, including oral and visual details. Therefore, the transcription included notes regarding details such as the teacher's bodily movements, position in the classroom and work on the board. Furthermore, the students' positions, and actions were noted. Moreover, all the written materials used by the teachers in the course of the three lessons were collected and photocopied. This included worksheets, summary notes and pages from textbooks.

2.3.5 Developing an external language of description

The analysis of the data was approached through the development of an external language of description which arises out of a simultaneous interplay between an orientating abstract set of theoretical concepts (internal language of description) and empirical data. Bernstein describes this process:

> Briefly, a language of description is a translation device whereby one language is transformed into another. We can distinguish between internal and external languages of description... A language of description constructs what is to count as an empirical referent, how such referents relate to each other to produce a specific text and translate these referential relations into theoretical objects or potential theoretical objects. In other words, the external language of description (L^2) is the means by which the internal language (L^1) is activated as a reading device or vice versa (2000: 132-133).

The internal language of description was detailed in the first section of this chapter and includes orientating concepts such as classification, grammatical metaphor and domains of practice. The external language of description brings these high level abstract concepts closer to the data allowing the theory to 'read' the data. Hoadley suggests that the external language of description "...develops on the basis of deductive and inductive analysis, moving iteratively between the internal language and engagement with empirical data" (2005: 87). Therefore, the external language of description allows for an establishment of what is to count as data and provides for its principled reading (Ensor & Hoadley, 2004: 92).

2.4 Conclusion

This chapter has introduced the concerns of this research project and outlined the primary theoretical antecedents to the study. Furthermore, a basic research methodology has been outlined. The chapter concluded with a description of Bernstein's idea of languages of description as the analysis makes use of this general methodological approach. However, a discussion of how the data was specifically analysed is delayed till the analysis chapters in which a thorough description of the analytical framework is laid out.

Chapter 3: Literature Review

3.1 Introduction

In this chapter I locate my study in the context of previous research relevant to the interests of this thesis. In chapter one I defined my research project as an exploration of the relationships between text and science pedagogy, with an underlying interest in the specialization of student voice. This chapter begins with a brief review of examples of South African studies concerned with science pedagogy. The second section looks at research relating to understanding the way in which pedagogic text is constituted. This section includes reference to the SFL literature and describes some empirical studies focused particularly on the constitution of pedagogic texts. The third section of this chapter turns to pedagogic practice and outlines some studies focused on describing pedagogic practice and the specialization of student voice conducted in the Bernsteinian tradition (within which my study is theoretically and methodologically located). Here I seek to outline the similarities and differences between my study and the concerns of this body of research. Finally, this chapter reviews some of the research concerned with questions regarding recontextualization and its implications for pedagogic practice. Most of this research is not explicitly framed in terms of recontextualization rules, but rather explores possible approaches or orientations to curriculum construction and pedagogy.

3.2 South African research related to science pedagogy

Much research into science education has been done in South Africa. This includes studies focused on official science curriculum policy. Green and Naidoo (2006) describe the changes in policy approach from the pre to post-apartheid era. Lubben and Bennet (2008) address issues of textbook and policy alignment. Furthermore, Edwards (2010) examines the alignment of science curriculum documents with official examinations. Laughksch (2000) looks at the concept of scientific literacy and Naidoo and Lewin (1998) critique the South

African education department's approach to the perceived crisis in science education in South Africa. Moreover, Stoffels (2007) examines the development of commercial reform based textbooks in South Africa, focusing on the factors that determine the format, style and content of the texts. Finally, Lemmer *et al*, (2008) looks at the textbook selection criteria of a sample of South African science teachers. These are a few examples of the wide range of research on science education already conducted in South Africa. In what follows I look at research, both South African and international, specifically related to my research concerns.

3.3 The constitution of pedagogic texts

3.3.1 Systematic Functional Linguistics and pedagogic texts.

There is a large body of research within Systematic Functional Linguistics (SFL) that attempts to describe the nature of specialized discourse and, more particularly, scientific writing. Examples of this research include Halliday (1993), Martin (2007), (1993a), (1993b), (1993c), Wignell *et al* (1993), Lemke (1998), Fang (2004) and Unsworth (2001). In this section I review four studies from this body of research that are relevant to the present study and show how these studies informed my analysis of texts.

Martin (2007) utilizes SFL to describe, in terms of linguistics, the characteristics of Bernstein's (1999) notions of vertical and horizontal discourse, arguing that grammatical metaphor is an essential characteristic of both discourses. Martin analyses samples of school, geography and biology texts (examples of hierarchical knowledge structures) and compares them with a variety of history texts (examples of a horizontal knowledge structure). Martin concludes that while there are marked differences (from a linguist's perspective) between and within vertical and horizontal knowledge structures, both draw heavily on grammatical metaphor that "enables uncommon sense classification, composition and explanation right across humanities, social science and science" (2007: 61). It is this feature of specialized scientific text that informed my development of the indicator nominalization used to gauge the degree to which a text's expressive form exhibits high or low specialization.

In another paper titled *Literacy in science: learning to handle text as technology* (1993a), Martin specifically analyses the language of science by looking closely at the way scientists talk and write. Martin shows how scientific discourse utilizes linguistic features and ways of making meaning that differ from common sense everyday ways of utilizing language. He offers that the use of technical terms is an essential aspect of scientific language. He argues that a crucial aspect of science pedagogy is inducting students into the language of science. Martin concludes:

> What seems to have gone wrong in the development of science textbooks is that an attempt has been made to make science more accessible by downplaying science literacy. But diluting scientific discourse necessarily involves diluting the science that is taught. As we have seen, science is unthinkable without the technical language science has developed to construct its alternative worldview (1993: 202).

Martin calls for science teachers to be well-versed in understanding the ways scientists make meaning and teach in such a way as to explicitly induct students into the language of science. This paper gave impetus to the concern regarding the density of technical terms in the analysis of texts.

Fang (2004) makes a very similar argument to Martin (1993a). Fang identifies four features of scientific writing: informational density, abstraction, technicality, and authoritativeness. Fang discusses the challenges these features present to comprehension and composition of science in schools. However, Fang suggests that "To become scientifically literate, students must ultimately learn to cope with the specialized language of science" (2004: 345). The paper ends with a call for science teachers to understand and explicitly teach the specialized language of science. The paper suggests that SFL theory will be helpful in this endeavor, but it does not suggest what this might look like in practical terms.

Unsworth (2001) argues that written school science texts and the talk generated from them play an important role in the apprenticeship of students into the characteristic language structures of scientific English. The study focuses on the quality of various junior high school explanatory texts. The intention is to “show how a comparison of the language features of these explanations can indicate their relative quality as ‘apprenticing’ texts to the language of scientific English” (Unsworth, 2001: 586). The study utilizes the following three concepts from SFL: ‘genre’ theory, conjunctive relations and the use of noun forms derived from verbs to ‘nominalize’ events and relations.

The analysis shows that the explanations analyzed differ in their effectiveness in textual bridging between common sense language toward scientific English. Unsworth concludes that “effective writing of explanations in school science books is identifiable and amenable to specification” (Unsworth, 2001: 607). This study is related to my interests in that it explores the link between the specialization of a pedagogic text and the text’s potential to specialize students’ voice, i.e. apprentice the student into the specialized language of science.

The SFL research informed my thinking regarding the linguistic features of specialized scientific discourse and gave impetus to the idea that the use of specialized scientific texts may play a crucial role in the specialization of student consciousness with regard to science. Although the specialization of consciousness is not explicitly mentioned in the research, the similar notion of the development of scientific literacy features strongly.

3.3.2 Scientific discourse in the academy and school science texts

There is a body of research that explores issues regarding the differences between the discourse of science textbooks and the discourse of science research communities at tertiary institutions. Much of this research explores linguistic and semantic differences between the two and the implications of this for the aims of science pedagogy. In this sense it is closely aligned with the body of research mentioned in the previous section.

Myers (1992) offers an analysis of university science textbooks with an interest in what makes them different from other academic texts. He suggests that textbooks are "…seen as the end of the development of a fact…" (Myers, 1992: 6). Myers explains this idea by looking at the differences between journal articles and textbooks. Myers argues that journals are arenas for conflicting views, and the presentation of a claim not a fact. In contrast a science textbook offers a "complete survey of knowledge" and is "part of the initiation of new members of the discipline" (Myers, 1992: 7*)*. The claims found in textbooks are the claims positioned near the end of a process in which they become facts. This process begins with, "journal articles and articles citing them and review articles and finally to textbooks, encyclopedias, and undergraduate lectures" (ibid).

Myers goes on to suggest that "if we, as analysts, consider the different genres in terms of their place in the process of accreditation, we can look at the linguistic features that are foregrounded in comparisons" (Myers, 1992: 9). Myers compares a passage from a journal with a portion of a textbook; the comparison involves the texts differing use of personal and impersonal subjects, tense, modalities, cohesion, references to other texts, illustrations.

Myers' study is of interest to my research in that it offers an example of the use of linguistic tools as a means of comparing texts. Furthermore, the analysis can be viewed as showing the linguistic implications of the recontextualization of science discourse from the arena of research into a form suitable for pedagogic purposes. As Bernstein's theory predicts, the discourse is altered. Myers suggests that there may be pedagogic significance around the differences between the discourses; however this is not developed in the paper.

Sharma and Anderson (2009) acknowledge that 'scientists' science' differs remarkably from 'school science'. Furthermore, the paper recognizes that teaching of science demands that 'scientists' science' is recontexualized into 'school science'. The paper seeks to "understand this transformative process in the context of schools' efforts to help students acquire science literacy…" (Sharma & Anderson, 2009: 1253). My interest lies in the papers' attempts to describe the differences between science discourse in journals and the discourse of school science texts.

The paper offers that science text, as it appears in research journals, is characterized by: the concealment of rhetoric, use of grammatical metaphors, use of empirical evidence as a tool of persuasion and double-edged addressivity. The authors suggest that this results in a text that is largely inaccessible to the lay-person or school student. Therefore, it is argued that, "in order to make itself accessible to non-specialists like school students, it has to reinvent itself in a form very different from the ones scientists use and produce. Textbooks play a central role in this transformation process, that makes a school subject out of a research discipline" (Sharma & Anderson, 2009: 1261).

The authors argue that in the recontextualization process some features of academic scientific discourse transform while others do not. They conclude that:

> The concealment of rhetoric and the use of grammatical metaphor persist with adverse consequences for the accessibility and thus inter-textuality of the school science discourse. However, there is a diminution of the role of empirical evidence as a tool of persuasion and the addressivity of science texts also loses its inclusivity, openness to differences in meaning and dialogic interaction. Consequently, science discourse loses much of its internal persuasiveness and becomes an authoritative discourse in a science classroom" (Sharma & Anderson, 2009: 1271).

Various suggestions are made with regard to how to address these problems. These include teaching students to understand the 'rhetoric' of science and how scientific knowledge is constructed as to be able to control and critique the dominant discourse of scientific knowledge. The paper ends with a call to find ways of making science discourse internally persuasive for students.

Sharma and Anderson's paper begins to address the role of everyday knowledge in pedagogic texts as a necessary means of apprenticing students into the specialized field of science. However, the paper does not consider the potential differences between the language of various pedagogic science texts. Rather, the paper considers science textbooks in general. Therefore, the analysis assumes there exists a general uniformity in the way in which science is recontextualized in pedagogic texts. The study ignores the possibility of a recontextualization principle that might, for example, do away with grammatical metaphor. My study differs in that it considers specific educational science texts and the differences that emerge in terms of the manner in which they have differently recontextualized science knowledge.

Mulkey (1987) offers an analysis of 187 science textbooks of varying grade levels taken from middle and working class districts in New York. The study sought to explore whether the content of science textbooks used in middle class schools and higher grades were "more facilitative of the intellectual and emotional characteristics of scientists than for working class schools and lower grades" (Mulkey, 1987: 512). The results did not show significant difference between textbooks used in middle class and working class schools. The lack of any significant differences between the textbooks used at middle and working class schools is explained by the universality of science knowledge. This universality is proposed to result in textbook writers embodying a uniform approach to the presentation of science knowledge that neutralizes social class effects.

While my analysis is not concerned with social class effects, Mulkey's study makes claims regarding the intellectual characteristics of school science textbooks. A uniformity of approach to the presentation of science knowledge is suggested. My analysis of science texts offers a far closer reading of school science texts and potentially challenges this claim of uniformity.

Abd-El-Khalick *et al.* (2008) research the representations of nature of science (NOS) in fourteen chemistry textbooks spanning four decades. The textbooks were rated on a six point scale regarding the accuracy and completeness of their representation of ten central aspects of NOS (NOS is a particular theory that attempts to describe scientific knowledge in the academy). The results indicated that recent textbooks generally fared poorly in their representations of NOS in comparison to older textbooks. This research was of interest as it suggests that pedagogic texts may differ in the way in which they present science knowledge: potentially more or less congruent with science as it is presented by scientists. This possibility is what is explored in the analysis of texts in the fourth chapter.

3.3.3 Further studies on school texts

The following three studies: Dimopoulos *et al* (2003), Dimopoulos *et al* (2005), and Hatzinikita *et al* (2008), present a framework for analyzing the degree of specialization of school science texts. Dimopoulos *et al* (2003) specifically develops a grid for analyzing visual images. The analysis tool considers the visual's "content specialization (classification) and the social-pedagogic relationships (framing) promoted by the images as well as the elaboration and abstraction of the corresponding visual code (formality)…" (Dimopoulos *et al*, 2003: 189). The grid was used to compare scientific images in the press with scientific images in school text books. Dimopoulos *et al* (2005) adapts the former grid used for analyzing visual images and applies it to the language of school science textbooks. The study analyzed texts from various school science subjects (physics, chemistry, biology) and from varying grade levels. The analysis showed that the specialization of the message increased with grade level, but remained fairly constant across the three disciplines within the same grade. Finally, Hatzinikita *et al* (2008) brings together the grids developed in the previous two studies mentioned above and presents a framework for analyzing the linguistic and visual modes of school science texts. The study sets out to compare the nature of the textual construction of the Program for International Student Assessment (PISA) science test items and science texts used in Greek schools. The analysis showed that PISA items tended to display low specialization in the linguistic mode and high specialization in the visual mode. In contrast, the Greek textbooks displayed high specialization in the linguistic mode and weak specialization in the visual mode. The study concludes that this disparity could potentially account for the weak performance of Greek students in the PISA testing.

These three studies present a similar approach to textual analysis adopted in this thesis. The grids draw on SFL as a means of recognizing code specialization and utilize the Bernsteinian concept of classification as a way of understanding content specialization. Moreover, my analysis of the iconic mode draws on some of the indicators developed in these studies (more details are provided in Chapter 4). However, these three studies do not go on to consider the relation between textual specialization and pedagogic practice. Furthermore, the implications of textual specialization for the specialization of student voice is not considered.

I conclude this section by outlining Dowling's (1998) research on mathematics textbooks. I consider this study in detail since I draw on its theoretical ideas in my own analysis. Dowling's study analyses two sets of school mathematics textbooks put together by The School Mathematics Project. These textbooks are called the G and Y series and are designed for lower and higher ability students respectively. Dowling shows that the G series texts contain a far higher percentage of public domain content (weak classification of expression and content) in comparison to the Y series which contains a high percentage of esoteric domain content (strong classification of expression and content). Furthermore, Dowling shows that the texts use contrasting strategies: while the Y series utilizes abstracting strategies that distribute abstract and interconnected meanings, the G series predominantly utilized particularizing strategies that distribute context dependent and fragmented meanings. Dowling argues that the Y series constructs the apprentice position (positions relate to the opportunity provided by the text for the reader to access the regulative principles of mathematics), increasingly allowing access to the esoteric domain, while the G series constructs dependent positions, offering minimal access to the regulative principles of mathematics.

Dowling's analysis of mathematics texts displays similarities to my research in its focus on showing how pedagogic texts distribute different messages about mathematic knowledge. His concepts of the esoteric and public domain inform my analysis as does his notions of abstracting and particularizing strategies. However, in this thesis the analysis of texts is followed by an analysis of how the text is mediated in pedagogic practice in order to consider the relationship between text and practice. Therefore, while Dowling's study is interested in the relation between pedagogic text, social class and the distribution of mathematics knowledge, his work does not relate these aspects to pedagogic practice.

3.4 Research relating to pedagogic practice: The Bernsteinian tradition

In this section I review research on pedagogic practice adopting a Bernsteinian approach. This approach privileges pedagogy as specialization of consciousness with respect of school knowledge: a notion that is central to the argument of this thesis. Much of this research is concerned with the social class implications of various pedagogic practices and specifically considers pedagogic forms (classification and framing strengths) optimal for working class students. Rose (2004), Lubienski (2004), Bourne (2004), Nyambe & Wilmot (2008), Singh (2002) Morais *et al* (2004) and Christie (1999) are examples of this body of research. The primary focus of this research is on the 'how' of pedagogic practice, that is, the framing strengths of various aspects of pedagogy such as sequencing, pacing, evaluation and the classification strengths of pedagogic spaces.

However, some of this research is concerned with the 'what' of pedagogic practice considering the nature of the knowledge indicative of various practices. This research considers factors such as conceptual demand, abstraction and conceptualization of the knowledge presented and its implications for the specialization of learners' consciousness. It is these aspects that bear most directly on my research interest. Three pieces of research, which raise these concerns, will be reviewed: Morais *et al* (2004), Ensor *et al*, (2009) and Hoadley (2005).

Morais *et al.* (2004) set out to explore which modalities of pedagogic practice are favorable to the acquisition of scientific knowledge and practices for all students. Interestingly, the study not only considers the 'how' of teaching and learning but also the 'what' (scientific knowledge and investigative practices). The study pre-proposed an optimal pedagogic modality drawn from previous research. Four teachers' practices were analyzed in terms of the degree to which their teaching practice was congruent with 'optimal practice'. Furthermore, the achievement of students under these varied practices was quantified. Conclusions were then drawn as to whether congruency with 'optimal practice' correlated with student achievement across social class. The results indicated that differences in achievement were explained mainly by the 'what' of the pedagogic practices. The researchers conclude that "Teachers can also seek to implement pedagogic practices involving high levels of conceptual demand when they promote learning processes based on conceptualizing and applying knowledge…such processes promote the development of complex cognitive competences and access of *all* children to texts more highly valued by the scientific community and society" (Morais *et al.* 2004).

Ensor *et al*, (2009) examine the specialization of pedagogic text in foundation phase numeracy classrooms. The research attempts to characterize some of the key features of the pedagogic practice of foundation phase numeracy classrooms in three schools serving very poor South African communities. The study specifically looks at the shift from concrete to symbolic reasoning with numbers, facilitated by the pedagogy. The notion of semantic density (the level of specialization of text over time) was utilized to analyze the content and strategies utilized by teachers and learners. The research suggested that while there was a discernable trajectory involving a move to greater abstraction, the pedagogy offered far too little opportunity to conceptualize and work with numbers in more abstract ways. The pedagogy was dominated by concrete methods and offered little access to more abstract ways of working with numbers.

In her PhD thesis, Hoadley (2005) looks at the potential for the specializing of learners' voice offered by maths and literacy pedagogy at four Cape Town schools. The data was collected from four schools: two middle class and two working class schools. In chapter six, she looks at the tasks grade three learners were required to do and whether these tasks drew on context-dependent or context-independent meanings. Furthermore, she looked at the relation between everyday knowledge and school knowledge in the pedagogy. Her research showed that in the middle class school context teachers mostly employed strategies that required learners to draw on context-independent meanings. Furthermore, every day and school knowledge were strongly classified. Conversely, in the working class school context, the pedagogy mostly employed strategies that required context-dependent meanings and every day and school knowledge was weakly classified.

The focus in this research on the ‘what’ of optimal pedagogic practice has particular relevance to the concerns of my project, which focuses on this aspect of pedagogy exclusively. The research indicates that what is taught is particularly relevant to a pedagogic practice’s potential to specialize student consciousness with respect of school knowledge.

3.5 Studies related to recontextualization and pedagogy

In this section I survey research that attempts to make explicit various general approaches to curriculum which underlies the constitution of pedagogic texts. Although these studies do not specifically use the terms ‘recontextualization principle’ or ‘regulative discourse’, they attempt to explore the underlying assumption or philosophy driving the formation of school subject curriculums and the implications of this for pedagogic practice. In this sense these studies are, at varying levels of generality, exploring the recontextualizing principles of pedagogic discourses.

Examples of this body of research in subjects other than science include a study of various approaches to English pedagogy by Christie and Macken-Horarik (2007), Bertram's (2007) research on the 'doing history' approach to history pedagogy adopted by official policy in South African schools, and Dempster and Hugo's (2006) discussion of the implications of a biology curriculum in which evolution is not a fundamental ordering principle. However, none of these studies consider the relation between differing recontextualization principles and the constitution of pedagogic text.

Deng and Luke's (2008) paper, *Subject matter: defining and theorizing school subjects*, explores the question of what knowledge should be included in school curriculums and, more particularly, the relationship between disciplinary knowledge and subject matter. They identify four major curriculum orientations at the institutional level which form the ideological base for the selection and formulation of knowledge in the curriculum: "academic rationalism, social efficiency, humanism, and social reconstructionism" (Deng & Luke, 2008: 70). Academic rationalism approaches subject matter as primarily transmitting "disciplinary knowledge for the development of the intellectual capacity of students and for the maintenance and reproduction of culture. Academic disciplines or organized fields of study are viewed as the authoritative sources from which curriculum knowledge is derived" (ibid). Social efficiency emphasizes the need to prepare future citizens with the necessary skills, and knowledge for economic and social success. Knowledge in the curriculum is justified by reference to "occupation, profession and vocation" (Deng & Luke, 2008: 71). Humanism emphasizes the fostering of individual "development, self-actualization, innovation, and creativity" (ibid). It is argued that the humanist orientation justifies the choice of knowledge in subject matter via reference to its ability to facilitate individually empowering experiences. Finally, social re-constructionism views education as a means for social reform. Therefore, subject matter is chosen "with the purpose of providing meaningful learning experiences that might generate social agency" (ibid).

Deng and Luke argue that the matter of knowledge and school subject matter needs to be approached with concern for three interrelated factors: specialized knowledge, learners and society. They criticize "academic rationalism" for not taking into account the factors of learners and society. What is of relevance in this paper is the attempt to make explicit general ideologies driving the formation of school subjects and how these ideologies differently position disciplinary knowledge in the curriculum.

A further study that involves discussion of general approaches to curriculum is Lubben and Bennett (2008). This research focuses specifically on chemistry teaching and contextualization: the inclusion of everyday experiences in science teaching. The study sets out four models of context-based chemistry courses. Firstly, "*Context as the direct application of concepts.* This involves a one directional and rigid relationship concepts-then-application: 'Applications are tagged on as an afterthought'" (Lubben & Bennet, 2008: 253). In this model context is back grounded. Secondly, 'context as reciprocity between concepts and applications', thirdly, 'context provided by personal mental activity' and finally 'context as social circumstances'. The four models increase in their foregrounding of everyday experience with 'context as social circumstances' described as being "Based on a genuine, sustained enquiry into a topic important in the lives of the community" (ibid). The study sought to find the extent to which the *ideal* curriculum (the underlying socio-political vision), the *formal* curriculum (curriculum documents' learning objectives, outcomes, recommended teaching strategies) and the *perceived* curriculum (curriculum as perceived by textbook writers and teachers) incorporated context.

The findings of the study suggested that from 1995- 2006 the South African Curriculum incorporated mostly non-contextualized curricula with only a weak model one apparent in textbooks. However, from 2006 onwards, non-contextualized chemistry curricula disappeared. Instead, model one characterized the *ideal* and *formal* curriculum while the *perceived* curriculum incorporated model one, two and three.

While this study deals with approaches to science curricula and the use of everyday knowledge, the study does not address the implications of contextualization for the specialization of student consciousness. However, the study does suggest that everyday knowledge and its incorporation in curriculum is a defining factor of differing curriculum approaches.

The research outlined in this section shows that there is a body of research that focuses on making explicit various underlying approaches to curriculum construction. However, none of this research specifically addresses the connection between these general approaches and the constitution of pedagogic text and pedagogic practice.

3.6 Conclusion

In this chapter I have outlined some of the empirical antecedents to this study in order to locate the study in terms of prior research. In summary, the SFL literature confirms that there are specifiable linguistic features of scientific discourse such as nominalization and the frequent use of technical terms. These features allow for the construction of condensed, abstract meanings indicative of scientific discourse. This research also suggests that a key aspect of science pedagogy is an induction into scientific discourse that requires exposure to specialized texts.

This chapter also outlined research which compared school science texts with scientific discourse in the academy. The research suggests that there are marked differences between these two discourses that can be specified in various ways. The research confirms that scientific discourse fundamentally changes as it is recontextualized for educational purposes. However, the research does not explore the possibility of differing recontextualization principles resulting in pedagogic texts that vary in their proximity to scientific discourse. However, Abd-El-Khalick *et al.* (2008) showed that school science texts can differ in their presentation of the nature of science. Moreover, Dowling's work on mathematics textbooks offers useful theoretical tools for specifying differences between pedagogic texts.

The chapter then reviewed some of the research on pedagogic practice in the Bernsteinian tradition. Some of this research was shown to be concerned with the nature of the knowledge made available in the classroom in terms of the classification of everyday and educational knowledge, as well as the cognitive demand of pedagogic activities. These aspects were related to the specialization of student consciousness. However, the research reviewed did not attempt to explore the relation of these aspects of pedagogy to the pedagogic nature of the texts used in the classroom.

Finally, the chapter ended with a brief review of studies concerned with general approaches to curriculum. Here it was indicated that a key aspect of a curriculum approach has to do with the manner in which everyday knowledge is utilized.

Chapter 4: An Analysis of the Written Instructional Texts

4.1 Introduction

In this chapter I investigate the nature of the written texts utilized in the two grade seven science classrooms. The analysis focuses on both the visual images (iconic mode) and the written language (symbolic mode). This exploration seeks to answer sub question A: How are the texts differently constituted? Furthermore, the analysis focuses specifically on factors relating the classification of everyday/specialized knowledge. The chapter produces a model for analysing the extent to which instructional texts are congruent, in both expression and content, with specialized scientific discourse. Moreover, I briefly comment on the potential implications of differing textual specialization for the way in which the students are apprenticed into thinking about science knowledge. The chapter ends with a brief discussion regarding the recontextualization principles underlying the respective texts.

4.2 A Preliminary description of the written texts

The written instructional texts that form the data for this chapter were strictly limited to texts utilized by the teachers in the course of the three successive lessons video-recorded for this research. The teacher at School A utilized three pages from a children's science encyclopaedia called *The New Book of Popular Science*. I have called this Text A. Each student was handed one of these encyclopaedias at the beginning of the lesson. The book is over 4cm thick and has a hard cover. The teacher at School B utilized 5 A4 pages photocopied from three different sources; these are termed Text B. Two pages were taken from a book called, *Key Stage Three Science: The Revision Guide,* edited by Richard Parsons and written for levels 3-6 KS3 of the British schooling system. This text is labelled B1. Another two pages are from a science poster and worksheet resource on energy and energy transfers published by McGraw Hill. This text is referred to as B2. Unfortunately, information regarding the third original resource was not available but it seems as if the teacher may have compiled this page from two different sources. This text is called B3.

Using the TIMMS science knowledge classification, the content of the texts was analysed to determine what aspect of science knowledge the texts presented.[1] Text A covers content that falls under the content domain 'environmental science'. More specifically it deals with the topics of 'use and conservation of natural resources' (75% of the content) and 'changes in environments' (25% of the content). Text B falls exclusively in the content domain of 'physics' and deals mostly with the topic 'energy types, sources and conversion' (90% of the content), but includes a small section on 'forces and motion' (10%). The texts are reproduced in Appendix A.

4.3 An overview of the theoretical approach

This analysis of texts considers two theoretically separable dimensions: the specialization of expression and the specialization of content. Expression considers the choice of the vehicle through which meaning is communicated, while the analysis of content explores the nature of the scientific knowledge embodied in the text. A separate analysis is presented, along these two dimensions, for the iconic and symbolic modes. This division of the data into two separable signifying modes follows the theoretical distinctions presented by Dowling (1998).[2]

The diagram below summarizes this approach:

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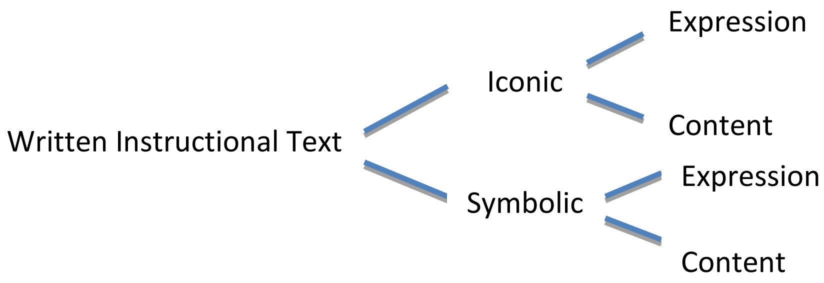
[1] The TIMMS coding scheme is reproduced in Appendix B

[2] Dowling introduces three signifying modes: indexical, iconic and symbolic. According to Dowling, the indexical mode includes tables, graphs equations and other specialized representative forms. For the purposes of my research, I have collapsed the indexical mode into the iconic, treating elements of the former, in the data, as specializing characteristics of the iconic mode. This decision was made due to the minimal use of the indexical mode in the data and the tendency toward the combination of the iconic and indexical in the few places in which the indexical mode can be recognized.

Figure 4.1 A summary of the theoretical structure of the textual analysis

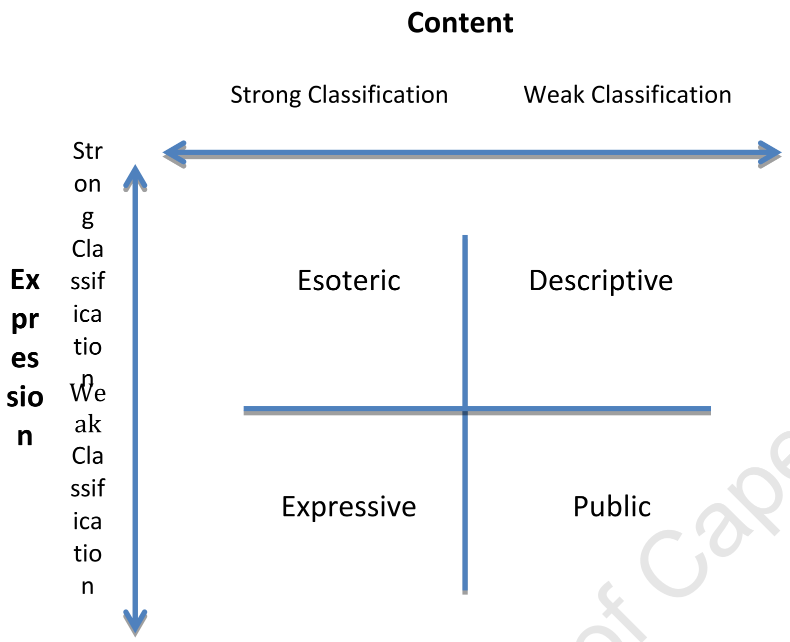


Furthermore, the approach to the coding of the iconic mode draws on an analysis grid developed by Dimopoulos et al. (2003). However, this grid has been adapted to suit the purposes of my study.

The expression and content of both the iconic and symbolic modes are analysed using the Bernstinian notion of classification. Classification of content relates to the extent to which the content of the pedagogic text embodies content belonging to the specialized field of science. Strong classification corresponds to the existence of mostly specialized scientific content while weak classification relates to the inclusion of ‘everyday common-sense’ content such as popular culture, domestic knowledge, local culture and practical know-how. Furthermore, classification of expression relates to the specialization of the codes used by the texts to convey meaning. Weak classification corresponds to the prevalent use of codes that resemble informal, everyday forms of expressing meaning used in non-specialized contexts. Conversely, strong classification of expression equates to expressive codes that embody the characteristics specialized scientific communication.

Following the theoretical work of Dowling (1998), four potential textual modalities can be generated: esoteric, descriptive, expressive and public. The esoteric corresponds to texts embodying strong classification of expression and content. The descriptive modality describes texts strongly classified in expression, but weakly classified in content. The expressive domain corresponds to weak classification of expression and strong classification of content. Finally, the public modality embodies weak classification of both expression and content.

Figure 4.2 Dowling's 4 Modalities



(Dowling, 1998: 135)

4.4 Analysis of the Iconic Mode.

This section details the approach taken to the analysis of the iconic mode. Firstly, the classification of content for the iconic mode is assessed using the concepts of: a) function and b) representation (Dimopoulos et al, 2003). Secondly, the classification of expression for the iconic mode is assessed using: a) elements of techno scientific code and b) shade modulation (Dimopoulos *et al*, 2003). These are explained further below.

4.4.1 Unit of Analysis

The unit of analysis for the iconic mode was taken as any clearly bounded unit within the text recruited to illustrate a single idea. Therefore, various separable images are counted as a part of a single icon unit if they are all recruited to illustrate the same idea and are grouped together in a manner which indicates this unity. Headings and linear borders were taken as designating single units.

4.4.2 Analysing the content of the iconic mode

I begin with a brief explanation of the approach adopted for analysing the content of the iconic mode. Here two dimensions are considered: function and representation. With regard to function, four image functions of the iconic mode, adapted from Dimopoulos et al (2003), are considered:

- analytical (C^{++})
- classificational (C^{++})
- narrative (C^{+})
- illustrative (C^{-}) (Dimopoulos et al, 2003: 194)

Narrative icons convey processes and unfolding action or events. Analytical images present relationships between objects in terms of part-whole structure. Classificational images present taxonomies. Lastly, illustrative images provide concrete examples of a general concept or pictorial representation of a particular scenario. Images functioning in classificational or analytical manner are considered strongly classified in terms of function, while narrative images are coded as moderate and illustrative as weak classification. These classification values were assigned due to the idea that images in scientific texts usually have an analytic or classificatory function and occasionally used to present processes, but are very rarely purely illustrative (Dimopoulos et al, 2003: 196). The coding device is given in the figure below:

Figure 4.3 Coding device for iconic mode content: *function*

Classification: Iconic Mode: **Content** *function* (Between Specialized scientific knowledge and everyday knowledge) (C^{+-})

	C^{++}	C^{+}	C^{-}
1.	Strongly bounded	Moderately bounded	Weakly bounded
In the function of the iconic unit	The image unit either functions analytically, that is it portrays part whole relationships, or it functions as a classification device portraying taxonomic relationships.	The image unit has a narrative function portraying the unfolding of a process or action.	The image unit has an illustrative function providing concrete examples of a general concept or pictorial representation of a particular scenario.

The content of the iconic mode is analysed in terms of representation. Here the visual images are coded according to the nature of the activities, objects and participants represented. Image units containing mostly representations recognizable only within the context of the specialized scientific field, such as experimental apparatus or molecule structures, are coded as strongly classified. Text images containing a fairly even mix of both specialized and everyday representations are considered moderately classified. Finally, image units involving mostly representations of unspecialized everyday objects or actions are coded as weakly bounded. The coding device is given in Figure 4.4 below:

Figure 4.4 Coding device for iconic mode content: *representation*

Classification: Iconic Mode: **Content** *representation* (Between Specialized scientific knowledge and everyday knowledge) (C^{+-})

	C^{++}	C^{+}	C^{-}
2.	Strongly bounded	Moderately bounded	Weakly bounded
In what is represent ed	Mostly specialized scientific objects, actors or processes are represented in the text image. These objects, actors or processes are only recognizable in a specialized scientific context or by the scientific gaze (such as a microscope).	The text image contains a fairly even mix of both specialized and everyday representations. Thus containing representations that fall within the C^{+} and C^{-} categories.	The objects, actors and processes represented are mostly mundane and unspecialized. They are recognizable outside of the scientific context.

4.4.3 Analysing the expression of the iconic mode

Classification of the expression of the iconic mode attempts to link strong classification with expression forms facilitating high abstraction and weak classification with expression forms that increase the context specificity of the image. Two elements of visual expression are considered: a) elements of techno-scientific code and b) shade modulation.

Firstly, I consider elements of the techno-scientific code (geometrical shapes, scientific symbols, alphanumeric strings). High classification corresponds to extensive use of techno scientific code covering more than 50% of the image space. Moderate classification corresponds to any image that utilizes elements of techno-scientific code. Finally, images are coded as weakly classified with respect of techno-scientific code if there is an absence of this code in the image. The coding device can be viewed in Figure 4.5 below:

Figure 4.5 Coding device for iconic mode expression: *techno scientific code*

Classification: Iconic Mode: **Expression** *techno scientific code* (Between Specialized scientific knowledge and everyday knowledge) (C^{+-})

3.	C^{++}	C^{+}	C^{-}
	Strongly bounded	Moderately bounded	Weakly bounded
In the use of techno-scientific code	Extensive use of techno-scientific code (geometric shapes, scientific symbols, alphanumeric strings) encompassing more than 50% of the image unit.	Some use of techno-scientific code but less than 50% of image unit space is taken up by it.	Techno-scientific code is not used in the image unit.

The second aspect of iconic expression considered is shade modulation. Since the images in the data are all greyscale, shade modulation refers to the variations of grey shades in the image. Strong classification corresponds to the use of a single shade of grey. Moderate classification refers to images utilizing two-four shades of grey. While weak classification of shade modulation refers to images that use more than four shades of grey.[3] The coding device can be viewed in the Figure 4.6 below:

Figure 4.6 Coding device iconic mode expression: *shade modulation*

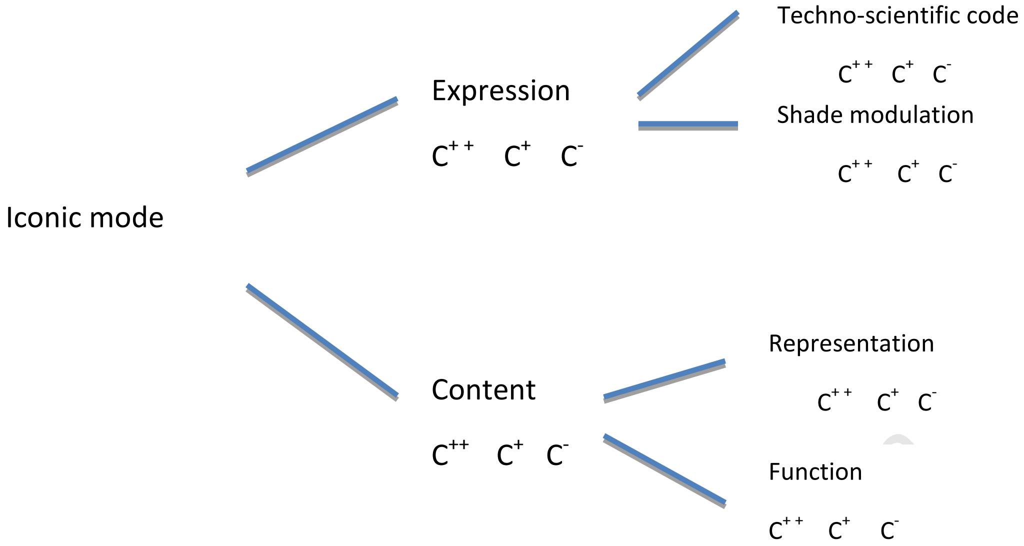
Classification: Iconic Mode: **Expression** *shade modulation* (Between Specialized scientific knowledge and everyday knowledge) (C^{+-})

4.	C^{++}	C^{+}	C^{-}
	Strongly bounded	Moderately bounded	Weakly bounded
In the use of shades	A single shade of grey utilized in the image unit.	2-4 shades of grey used in the construction of the image unit.	More than 4 shades of grey used in the image unit.

[3] Increase in shade modulation generally results in an increase in the context specificity of the image which is why specialized scientific images, needing to represent abstract concepts, generally utilize low shade modulation (Dimopoulos et al, 2003: 196).

The diagram below summarizes the analysis framework for the iconic mode:

Figure 4.7 Summary of the analysis framework for the iconic mode



4.4.4 Coding Results and Examples for the Iconic Mode

A total of 20 iconic mode visual units were identified in the data. Text A contained three units, while Text B contained seventeen visual units. Although Text A contained far fewer visual units in comparison to Text B, the percentage page space allocation to the iconic mode in both texts is fairly similar at approximately 40%.

I begin by presenting the results of the iconic mode analysis for Text A. Two of the three icon units are presented below:

Figure 4.8 Text A: Image of a polluted river

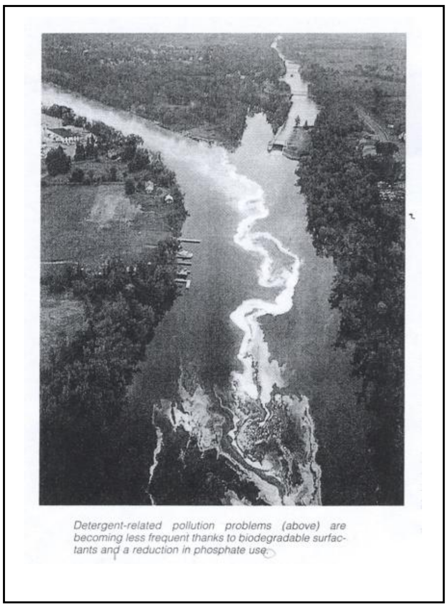
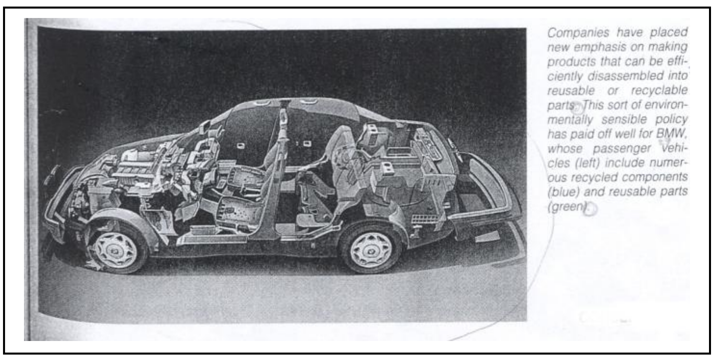


Figure 4.9 Text A: Image showing the recyclable parts of a car



The image in figure 4.8 was coded as illustrative in function, as the image functions as a concrete example of water pollution and is thus weakly classified in terms of function. Furthermore, it is weakly classified in terms of representation, since a polluted river was considered mundane and recognizable outside of a specialized scientific context. Therefore the overall classification of content for this image unit was weak. Moreover, the analysis of this image for the two expression indicators also indicated weak classification: no techno-scientific code is contained in the unit and the image displays complex shade modulation. Therefore, Figure 4.8 was coded as weakly classified for both content and expression. Thus it is an example of a textual unit belonging in the public textual modality.

Figure 4.9 was coded similarly to figure 4.8, except that it was considered strongly classified in terms of content function. The image was coded as functioning analytically: showing a part-whole relationship. The image allows for a display of the various parts of the car that are recyclable or reusable. Therefore, this image was coded as moderately classified in terms of content and weakly classified for expression. Thus this image unit represents a slight movement toward the expressive domain due to its slightly stronger classification of content in comparison to the previous image.

The following summarizes the overall coding of the iconic mode for Text A:

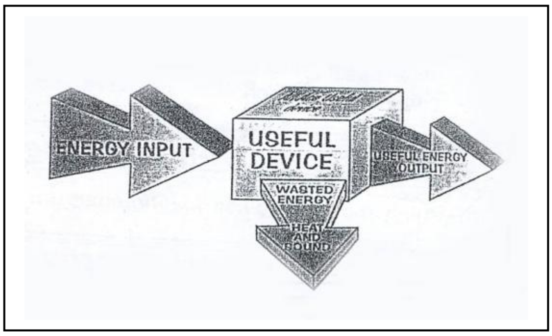
Figure 4.10 Coding of the iconic mode for Text A

Iconic Mode Text A (3 iconic units)		C^{++}	C^{+}	C^{-}
Content	Function	1	0	2
	Representation	0	0	3
Expression	Techno-scientific code	0	0	3
	Shade modulation	0	0	3

The analysis of Text A's iconic mode shows that this mode consists of images that belong in the public domain. The images depict non-specialized content in non-specialized ways and thus require very little specialization to read. Furthermore, Text A's iconic mode, with its weak classification, blurs the boundary between specialized science knowledge and everyday knowledge.

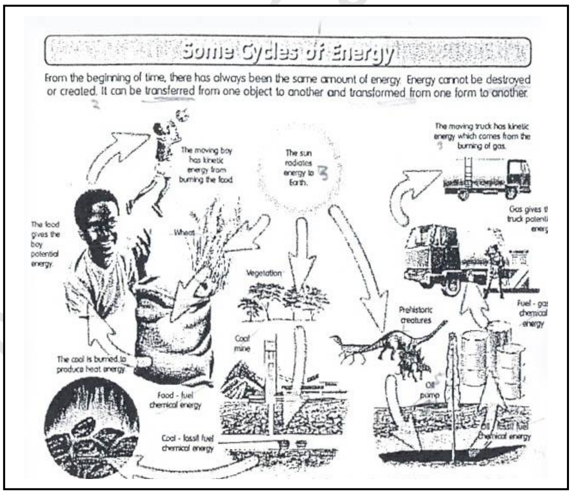
Seventeen iconic units were identified in Text B. Three examples of the coding of these units are given below:

Figure 4.11 Text B1: Image showing energy transfers



The image in Figure 4.11 functions narratively as it depicts the unfolding of an energy transformation process. Furthermore, the content was coded as strongly classified for representation as it depicts a generalizable energy transformation process only recognizable in the specialized field of science. The image is also characterized by strong classification of expression in terms of techno scientific code as it utilizes geometric shapes such as boxes and scientific symbols such as arrows to represent generalized concepts. However, the image utilizes extensive shade modulation which weakens the classification of expression. The image would belong to the expressive domain as it exhibits fairly strong classification of content and moderate classification of expression. This icon unit was one of the most specialized of the seventeen units coded from Text B.

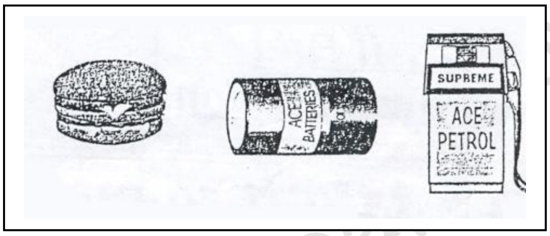
Figure 4.12 Text B2: Image depicting various energy cycles



The image in Figure 4.12 is coded as narrative in function as it depicts unfolding energy cycles. This icon unit depicts both mundane objects and activities such as a boy kicking a ball, as well as specialized representations such as the sedimentary layers in the earth's crust which are only visible in terms of a scientific gaze. Therefore, this icon unit was coded as moderately classified for representation. Therefore, a moderate classification of content is embodied by this unit. Furthermore, representation in this image is weakly classified. The image contains very little techno- scientific code and extensive shading modulation. Thus this iconic unit belongs in the public domain, while tending toward the expressive domain due to its moderate classification of content.

The final example of the coding of Text B's iconic mode is typical of the majority (eleven out of seventeen) of texts B's iconic units. The image is coded as weakly classified in both content and expression.

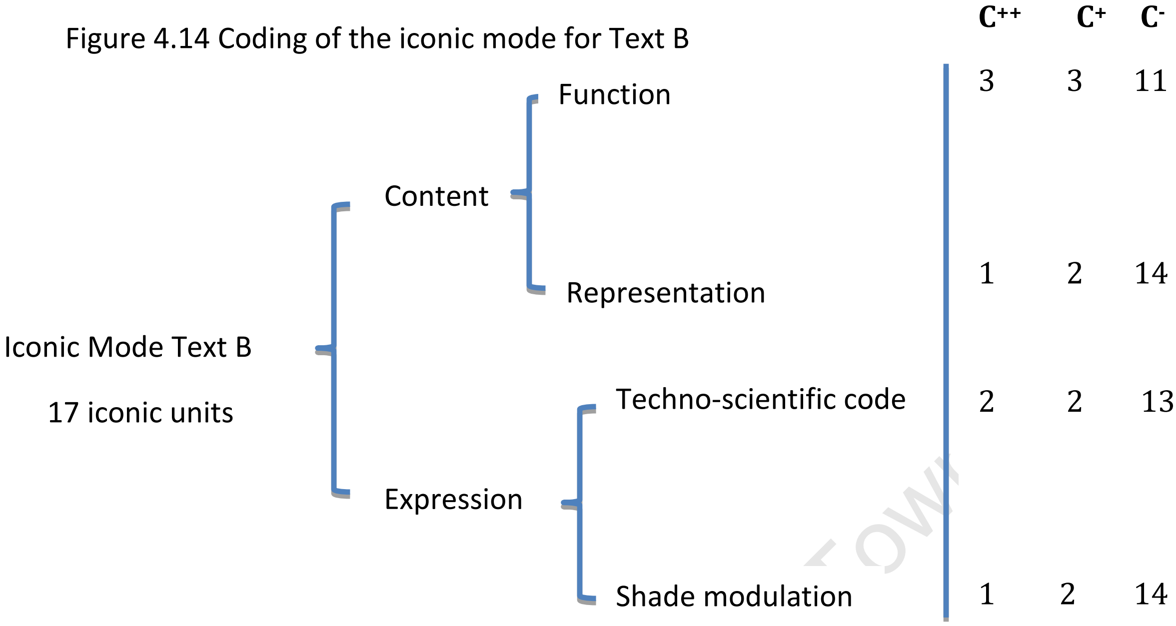
Figure 4.13 Text B1: Image depicting examples of chemical energy



The images in the icon unit above function in the text as examples of chemical energy. Therefore, they are coded as illustrative in function. Furthermore, they are quite clearly representations of unspecialized mundane objects recognizable in the context of everyday life. Therefore, the icon unit is coded as weakly classified in terms of representation. The icon unit also contains no techno-scientific code and displays extensive shading variation. This icon unit is thus weakly classified in terms of content and expression and thus belongs in the public domain.

The overall results of the coding of the iconic mode of Text B are presented in the figure below:

Figure 4.14 Coding of the iconic mode for Text B



The majority of icon units in Text B involved mundane objects and activities functioning as illustrations of a scientific concept. These images also involved unspecialized expression more akin to the sort of images one would find in comic books than in scientific journals. Thus the iconic mode of Text B is characterized by unspecialized unscientific images belonging in the public textual modality.

In summary, both Text A and Text B utilize iconic modes that are, for the most part, unspecialized in both content and expression, recruiting images for illustrative purposes and depicting objects and activities that are mundane rather than specifically scientific. Therefore, the iconic mode of Text A and B feature a predominant public domain textual modality.

4.5 Analysis of the symbolic mode

The structuring of the analysis of the symbolic mode also considers separately the expression and content of this mode. The analysis of expression considers the following three theoretical categories:

- Nominalization
- Technicality
- Elaboration

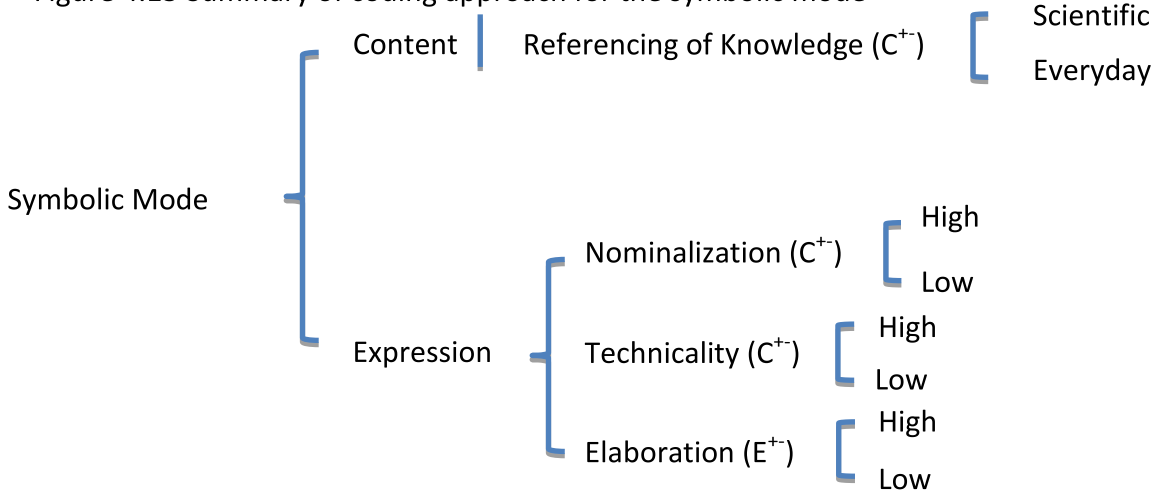
The first two indicators are drawn from the field of SFL and will be explained further in the following sections. The third indicator, elaboration, is gauged by looking at the nature of the symbolic modes in relation to textual space and average sentence length. Furthermore, high and low nominalization density and technical density are coded as indicative of strong and weak classification of symbolic expression respectively. However, the indicator elaboration has no bearing on classification, but rather offers further insight into the fundamental differences between Text A and Text B.

Secondly, the coding of the content of the written texts is approached by considering the following aspect:

- Referencing of knowledge

Once again this indicator is linked to the concept of classification. Texts that present mostly specialized scientific knowledge, with very little reference to every day mundane objects, agents and activities are considered strongly classified with respect to referencing of knowledge while the introduction of everyday knowledge is considered to weaken the classification of content in terms of this indicator. The table below summarizes the coding approach for the symbolic mode:

Figure 4.15 Summary of coding approach for the symbolic mode



4.5.1 Results of the analysis of the symbolic mode for expression

The aim of this section is to compare the specialization of the symbolic signifying mode of Text A and Text B through the three indicators: elaboration, nominalization and technicality. This will give an indication of the comparative strength of the classification of expression of these two texts: the degree to which the symbolic mode takes on the characteristics of specialized scientific texts.

4.5.1.1 Elaboration

The extent to which the symbolic mode of a pedagogic text is considered elaborated or restricted is gauged via three considerations: character density, average sentence length and the percentage of characters in full sentences. These indicators seek to capture whether the symbolic mode of the text is likely to facilitate in-depth explicit meanings. The following table shows how these three indicators provide a coding for textual elaboration:

Fig 4.16 Device used for coding Elaboration

	Elaborated (E^{++})	Moderately elaborated (E^{+})	Restricted (E^{-})
Character Density (Characters/cm^2)	10 or more	5-10	Less than 5
Average sentence length in characters.	100 or more	70-100	Less than 70
% Characters in full sentences.	95-100	75-95	Less than 75

The results of this analysis are summarized in the table below.

Figure 4.17 Summary of analysis of elaboration

Analysis unit (Text)	A		B		B1		B2		B3	
Character density (characters/cm^2)	11.8	E^{++}	5.58	E^{+}	3.91	E^{-}	7.78	E^{+}	4.03	E^{-}
Average sentence length in characters.	112	E^{++}	65	E^{-}	71	E^{+}	63	E^{-}	61	E^{-}
Percentage of characters in full sentences.	98	E^{++}	79	E^{+}	83	E^{+}	85	E^{+}	25	E^{-}
Overall elaboration coding	Strongly elaborated		Moderate to weakly elaborated		Moderate to weakly elaborated		Moderate to weakly elaborated		Restricted	

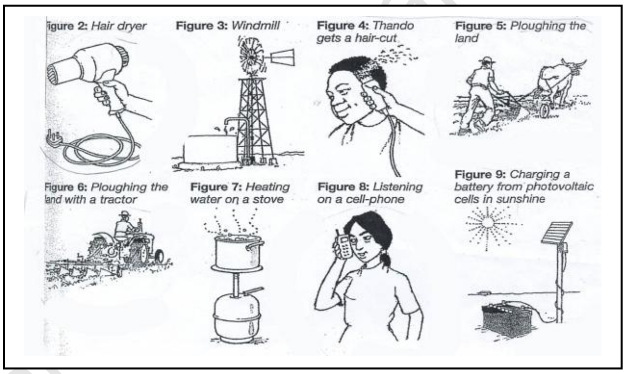
Character density was calculated by dividing the total number of characters in the text's symbolic space by the number of square centimetres comprising this space. Therefore, character density is an indicator of the size and layout of the texts' characters. Text A has a character density of 11.8, which is more than double the character density of Text B (5.58). Furthermore, within the three texts that make up Text B, Text B2 has a substantially higher symbolic density than texts B1 and B3. However, Text B2 still remains significantly less dense than Text A.

The results of the analysis of sentence length show that, on average, a Text A sentence will contain more than twice as many characters as a Text B sentence.

Furthermore, there is not much variation in sentence length between the three texts that make up Text B.

Finally, the texts were analysed for the percentage of characters found in full sentences. 98% of characters in Text A were found in full sentences. The few characters that were not in sentences made up section headings such a “Conservation of Phosphates” or “Nonrenewable Resources”. 79% of characters in Text B were in full sentences. 21% of characters comprised various sentence fragments. This had a lot to do with the basic format of the three B texts. Firstly, the fragmented iconic space of Text B, results in the proliferation of iconic captions, which are often sentence fragments. Fig 4.17 provides an example from Text B3.

Figure 4.18 Text B3: Images of examples of systems

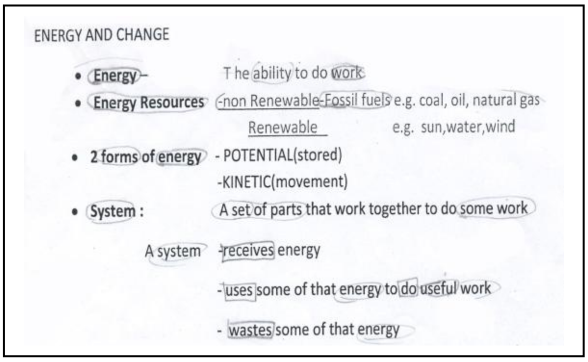


Each of the images in the extract in Figure 4.18 above has a caption. Most of these captions are sentence fragments.

Secondly, and most particularly in Text B1, the text does not take on a discursive format, but is rather divided into short sections of meaning often divided up or punctuated by various forms of underlining, blocking, shading or font variations. These short sections are given titles that are often sentence fragments.

Finally, the high percentage of characters in Text B not found in full sentences is due to the use of point summary format. Text B3, which only has 25% of its characters in full sentences, utilized this format almost exclusively. The extract from B3, below, illustrates this:

Figure 4.19 Text B3: Extract on energy and change


ENERGY AND CHANGE

- Energy – The ability to do work
- Energy Resources -non Renewable-Fossil fuels e.g. coal, oil, natural gas
  Renewable e.g. sun,water,wind
- 2 forms of energy - POTENTIAL(stored)
  -KINETIC(movement)
- System : A set of parts that work together to do some work

A system -receives energy
-uses some of that energy to do useful work
- wastes some of that energy

This text takes on the form of a summary. Verbal groups are left out; for example in the first line of the text above the relational verb "is" is left out, leaving two sentence fragments: "Energy" and "The ability to do work". In other places the nominal group is left out: "-uses some of the energy to do useful work". The result is a highly fragmented, summary type text that contains a substantial amount of sentence fragments.

The analysis shows that Text A has a far greater character density then Text B and consists of much longer sentences. Furthermore, Text A has far higher percentage of its characters in full sentences in comparison to Text B. Therefore, in terms of my definition of restricted and elaborated texts, Text A embodies a symbolic mode characterized as strongly elaborated, while Text B is coded as moderately to weakly elaborated.

4.5.1.2 Nominalization density

Systematic Functional Linguists, such as Halliday, Rose and Christie, have studied the language of specialized scientific texts and shown that a key aspect of these discourses is a high density of nominalization coupled with large clumpy nominal groups. Martin describes nominalization as "a process of 'thingification' whereby activity is reconstrued as abstract things" (2007: 44). In linguistic terms, nominalization involves discourse in which processes, qualities and logical relations are realized as nouns. In a sense scientific discourse arrests the universe and makes it a noun. This language feature is utilized because it "enables writers to interpret the world from a 'meta' point of view to abstract away from material activity with linguistic activity" (Christie & Macken-Horarik, 2007: 173). Nominalization is thus the language of specialized scientific texts.

The text was coded with respect to nominalization by firstly identifying all the nominal groups in the written texts. Once the nominal groups had been identified, they were examined for the occurrence of nominalization. The number of nominal groups containing nominalization was then counted and a nominalization density indicator was then produced. Nominalization density is calculated by the number of nominalised nominal groups divided by the total number of nominal groups. Often specialized texts will have fewer nominal groups than a similar amount of unspecialized text. This is because specialized texts often have very long complex densely nominalised nominal groups, whereas less specialized texts have shorter simpler nominal groups. Thus, merely counting the number of nominalised nominal groups in similar length portions of text may not present an accurate picture of the degree of nominalization occurring in the text. The idea of nominalization density adequately overcomes this problem. The following table indicates the nominalization density taken to indicate strong, moderate and weak classification.

Figure 4.20 Coding table: nominalization density

	Strong classification of expression. C^{++}	Moderate classification of expression C^{+}	Weak classification of expression C^{-}
Nominalization Density	0.4 or greater	0.2 - 0.4	Less than 0.2

The following is an extract from Text A that shows how the text was coded for nominalization. The nominal groups have been placed in square brackets. Nominalised nominal groups are highlighted and the head of the group has been underlined. The post head qualifiers are in italics.

> [Widespread use *of electricity*] also increased [the demand *for new and better oil - and gas - powered generating plants*]. By about 1960, [natural gas] had joined [oil and coal] as [an important source *of energy*] to provide [heat and power production]. As [the use *of fossil fuels*] has increased, so have [environmental, economic and political problems]. [Oil and natural gas exploration] opens up [vast regions *of essentially untouched land*] to easy access, threatening [wilderness areas] with [environmental damage]and disrupting [the varied wildlife *in sensitive ecosystems*] (Text A).

Nominalization can be identified by particular reference to the head of the nominal group. If the head of the nominal group contains a verb or adjective that has been recruited to play the role of a participant in the clause then it has been nominalised. The following table gives a summary of the results:

Figure 4.21 Summary of nominalization coding

Text	A	B2	B	B3	B1
# Nominal groups	141	289	458	54	115
# Nominalisation	64	41	53	6	6
Nominalisation density	0.45	0.14	0.12	0.11	0.05
Percentage nominalization	45	14	12	11	5
Classification	C^{++}	C^{-}	C^{-}	C^{-}	C^{-}

The results of the coding for nominalization show that Text A has a far higher nominalisation density then Text B. The total number of nominal groups counted in Text A was 141, of which 64 were judged to contain nominalization. This gives a nominalization density of 0.45, which means that 45% of nominal groups in the text were nominalised. Text B contained a total of 458 nominal groups, of which 53 were nominalised. Thus the nominalisation density of Text B is 0.12, with only 12% of the nominal groups displaying nominalization.[4]

There are a substantially greater number of nominal groups in Text B than in Text A, despite the fact that the texts are very similar in length in terms of word count. Text A, which contains 1511 words, only 172 less then Text B, contains less than a third of the quantity of nominal groups contained in Text B. Therefore, the analysis also revealed that Text A is made up of fewer, but more complex, nominal groups. What is apparent is that complex, lengthy nominal groups are often constructed around nominalization. The following example from Text A illustrates this point:

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[4] The nominalization density of the three texts comprising Text B also showed significant differences. Text B1 contained a total of 115 nominal groups six of which contained nominalization. Thus the nominalization density for Text B1 is 0.05, indicating that only 5% of the nominal groups were nominalised. This is significantly lower than the average of 12% calculated for Text B. Text B2 contained 289 nominal groups, 41 of these were nominalised. The nominalization density is thus 0.14, with 14% of the nominal groups containing nominalization. Finally, T3, with 54 nominal groups and only six nominalizations, has a nominalization density of 0.11 and a percentage nominalisation of 11%.

> The introduction *of internal-combustion engines*, however, created a tremendous demand *for petroleum derived from oil*. (Text A)

In the example above the two nominal groups have been highlighted and the nominalised noun, acting as the head of the nominal group, has been underlined. Furthermore, the nominal group is significantly lengthened by the use of complex post-qualifiers, which have been italicized. In contrast, the following example from Text B1 shows the use of many short non-nominalised nominal groups in a single sentence:

> There you are then, eight types *of energy* to learn, remember that temperature is not a form *of energy*, it just measures how hot something is. (Text B1)

The sentence above contains six nominal groups. Four of these are a single word. Furthermore, none of the heads are examples of nominalization.

Therefore, Text A is characterised by dense nominalization with few but often lengthy and complex nominal groups. In contrast, Text B contains a much lower density of nominalization coupled with a proliferation of simple, short nominal groups with some, but limited, variation across the three texts.

The analysis of the linguistic features of the language shows that Text B takes on a form closer to non-specialized everyday conversation, while Text A, with its dense nominalization and clumpy nominal groups is more congruent with the language of specialized written scientific texts. Thus, in terms of nominalization, Text A is strongly classified (C^{++}), while Text B is weakly classified (C^{-}).

The predominance of everyday familiar forms of language in Text B potentially limits apprenticeship into understanding and working with the language forms of specialized scientific knowledge. Students are potentially excluded from developing a consciousness that will allow them access to scientific discourse and knowledge. In contrast, Text A, with its comparatively dense nominalized form, offers greater potential for induction into academic discourse.

4.5.1.3 Technicality

Technicality, as a measure of specialization, is indicated by the frequency of the introduction of technical terms in the written texts. The coding of the texts for technicality involved a fair measure of subjective judgment. Often only the context of the word can determine if it is been recruited in a technical sense; this is particularly true of 'common' technical terms. These terms are used in everyday contexts but are given a specialized meaning in a particular field. For example the word "work" is a common everyday word but it is given a specialized meaning in the field of science in which it becomes a technical term referring to a relationship between force and its distance of application. A term is coded as technical if it is unlikely to be recruited in everyday discourse and embodies a condensing of meaning.

In the coding of the data a technical term is counted only the first time it is introduced. If it is used again in the text it is not counted again. 'Indexical' technical terms (terms used exclusively in a particular field) are tallied separately to 'common' technical terms. An overall tally of technical terms introduced in the two written texts will be divided by the total number of words comprising these written instructional texts to give an indication of the technical density of the two texts. The following table shows what technical densities will count as strong, moderate and weak classification.

Figure 4.22 Summary of coding for technical density

	Strong classification of expression C^{++}	Moderate classification of expression C^{+}	Weak classification of expression C^{-}
Technical density	0.06 and above	0.3- 0.6	0.3 and below

A small extract from Text A is coded below as an example. ‘Indexical’ terms are highlighted in yellow, ‘common’ terms are highlighted in pink. Technical terms are only highlighted when they are first introduced.

> As demand for fossil fuels has increased exploration and exploitation have increased as well, reaching even into the oceans. The continental shelves - those portions of the continents extending from the shore outward beneath the surrounding oceans – have proven to be abundant sources of oil in some areas...The introduction of internal combustion engines, however, created a tremendous demand for new and better oil – and gas – powered generating plants. By about 1960, natural gas had joined oil and coal as an important source of energy to provide heat and power production (Text A).[5]

The following table gives a summary of the results of the coding of the texts with regard to technicality:

[5] The coding of this section highlights some of the difficulties involved. Firstly, it raises the questions as to why exploitation is included as a technical term while exploration is excluded? Secondly, while heat is given a specialized meaning in scientific discourse it is not clear that this specialized meaning is in operation when heat is used in this extract. Might not the everyday meaning of heat be intended instead of the specialized version? There are no definite answers to these questions and a fair amount of subjective judgement is conceded. Thus, the coding of technicality can only be regarded as an approximation, rather than an exact, indication of the texts’ technical saturation.

Fig 4.23 Overall results for technical density

	B3	B2	B	A	B1
Indexical	8	32	44	50	11
Common	4	18	21	5	4
Total	12	50	65	55	15
Technical density	0.083	0.048	0.039	0.036	0.030

Text A was coded as containing 55 technical terms (A list of these technical terms is located in Appendix C). Of these 55 technical terms, 50 were considered ‘indexical’ and 5 were ‘common’. Dividing the number of technical terms by the total word count generates a technical saturation value of 0.036. This means that, on average, every 100 words of text will introduce between three and four technical terms.

A technical term count for the combined Text B yielded a total of 65 technical terms: 44 indexical and 21 common. Therefore, the technical density of Text B was calculated at 0.039. Therefore, on average, close to four technical terms are introduced in every hundred words of Text B. The results show that there is a large variation in the technical density of the three texts comprising Text B: compare text B3, with a technical density of 0.083 (utilizes eight technical terms per a hundred words of text), to Text B1, with a technical density of 0.03 (utilizes three technical terms per a hundred words of text). Furthermore, Text B was coded as having a slightly higher technical density then Text A (Lists of the technical words counted in the three texts comprising Text B can be found in Appendix C).

The analysis suggests that Text B is slightly more specialized than Text A with regard to technicality. However, the difference between the texts is minimal. Both texts utilize a fairly high density of technical terms. Both Text A and Text B were coded as moderately classified in term of technicality. Part of accessing scientific knowledge is a familiarity with scientific technical terms, which I have argued are a necessary aspect of specialized texts. The use of technical terms in both Text B and A potentially allows for an expansion of the student's technical vocabulary.

4.5.2 Analysis of the symbolic mode for content.

I now move on to the concepts dealing with the specialization of the content of the symbolic mode. In this section I explore the specialization of the text's symbolic content via the following concept: referencing of knowledge. The unit of analysis in the coding of symbolic content is the paragraph or, in the absence of paragraphing, a section of text marked by a subheading or a text box.

4.5.2.1 Referencing of knowledge

This indicator refers to the nature of the knowledge referenced in the symbolic mode and specifically the extent to which everyday knowledge is recruited. Strong classification for this indicator corresponds to the minimal use of everyday knowledge, while weak classification corresponds to the expansive use of unspecialized knowledge in the text. The coding device for this indicator can be found in Figure 4.24 below:

Figure 4.24 Coding device symbolic mode content: *referencing of knowledge*

Classification: Symbolic mode: **Content** *referencing of knowledge* (Between Specialized scientific knowledge and everyday knowledge) (C^{+-})

	C^{++}	C^{+}	C^{-}
In the referencing of knowledge in the text.	Everyday knowledge is never/seldom referenced.	Everyday knowledge is sometimes referenced.	Everyday knowledge is often referenced.
	Only subject specific content, operations and procedures are introduced. Examples are strictly scientific and no attempt is made to incorporate everyday knowledge into the content.	Everyday knowledge is occasionally introduced as part of the text unit but it is dealt with swiftly and incorporated into the text so that it is the scientific concept, operation or principle that is made explicit. Science is portrayed as been able to successfully re-describe the everyday.	Everyday knowledge is often introduced as part of the text unit. Everyday concepts are widely utilized to explain scientific concepts. Most of the examples are familiar everyday objects or processes.

The results for this section will be presented and explained taking one text at a time and offering textual justification for the manner in which it has been coded. The analysis will end with a discussion of how Text B is coded, taking into account its multi-textual nature.

The symbolic signifying mode of Text A makes little reference to everyday knowledge, and avoids recruiting everyday objects as examples of scientific concepts. All fifteen units comprising the symbolic mode of Text A were coded C^{++}. The following extract was judged as the closest the text came to recruiting everyday knowledge:

> For decades, phosphates were a common ingredient of detergents because they acted as emulsifiers to break down oil and dirt particles (Text A).

In this sentence the word detergent is chosen rather then something like soap or cleaning material; as a result, despite the fact that soaps and household cleaning materials are contained within the category of detergents, the text remains strongly classified since the word detergent is a specialized scientific term.

Although the symbolic text recruits very little everyday knowledge, it does contain a fair amount of content that speaks about values and attitudes related to one's relationship to the environment and society. The following is an example of this from the text:

> Based on the belief that the world is worth protecting, conservation teaches that human beings are integrated in a complex relationship with Earth. Work done today will make the world a better place tomorrow, when it is inherited by future generations (Text A).

The knowledge presented in the text above is not strictly scientific. Rather it contains a more regulative or value driven message. However, this regulative message is not drawing on everyday knowledge, but rather seems to represent the presence of what might be termed a specialized conservation-science discourse. However, the existence of this more regulative discourse in Text A was not taken as a weakening of the classification since the discourse remains outside of the realm of everyday, or context specific knowledge.

The symbolic content of Text B1 substantially recruits everyday knowledge. Of the 12 units of analysis comprising Text B, nine were coded as C^- and three as C^+. Text B often recruits everyday non-specialized phrases that act as explanations of scientific concepts. Furthermore, everyday objects exemplify the concepts. Three examples of this are listed below. The everyday knowledge is highlighted:

> Anything noisy gives off sound energy—things like vocal chords, speakers and instruments (Text B1).
>
> Anything that is above the ground has potential energy, --i.e. anything that can fall, like ski jumpers, aeroplanes and climbers (Text B1).
>
> Anything stretched has elastic energy, -- things like rubber bands, springs, knicker elastic, etc (Text B1).

The four general classes, mentioned in the text above, (anything noisy, anything that is above the ground, anything that can fall and anything stretched) are common sense, unspecialized categories. These are considered to be examples of everyday explanations of scientific concepts. Moreover, the exemplars (speakers, instruments, ski jumpers, aeroplanes, climbers, rubber bands, springs and knicker elastic) are all common, everyday objects. In this way the text draws heavily on everyday knowledge: Everyday knowledge is foregrounded in the text.

Furthermore, an informal everyday discourse that includes humour, instructions and colloquial language pervades Text B1. Two sentences from the text serve as examples of this everyday discourse.

> Scientists have only been studying energy for about two or three hundred years and so far, they've come up with two "Pretty Important Principles" relating to energy. Learn them really well (Text B1).
>
> I've said it so many times now—it's making me horse… (Text B1).

The content of the extracts above serve as examples of the prolific use of unspecialized, informal language that punctuates the scientific content in various place in the text. The frequency of this informal discourse is considered to weaken the classification of the subject and everyday knowledge. Overall, Text B was coded as C^- in terms of representation of knowledge.

Of the six units analysed in Text B2, four were coded C^+, one was coded C^- and one was coded C^{++}. Text B2 has one unit that draws strongly on everyday occurrences as examples of a scientific concept. For example, it recruits five everyday processes to illustrate the idea that "in nature things are always changing". Two of these processes are given below:

> We put a fire under a pot of water; the water boils (Text B2).
>
> We switch on an electric heater; it heats the room (Text B2).

The unit from which sentences have been taken was coded as C^-. On other occasions Text B2 focuses on re-describing everyday events in term of scientific concepts. For example the winding of a clock is given a scientific re-description in the following:

> Once work has been done on body A, it is possible that work can be done by body A on another body. For example: when we wind a clock, we do work on the clock spring. The spring does work on the other mechanisms (cog-wheels, clock hands, etc.) (Text B2).

In this example, the everyday action of winding a clock is given a scientific explanation. The science is fore-grounded and the everyday is back-grounded. The paragraph containing this sort of re-description of the everyday was coded as C^+. Since the majority of units in B2 received a C^+ coding, Text B2 was given an overall coding of C^+.

The symbolic content of Text B3 was minimal and comprised only one unit of analysis which was coded C^{++}. The unit is full of technical terms and very little everyday knowledge is apparent. The table below gives a summary of the results.

Figure 4.25 Summary of coding for classification of knowledge everyday/educational

	C^{++} units	C^{+} units	C^{-} units	Overall Coding
A	15			C^{++}
B1	0	3	9	C^{-}
B2	1	4	1	C^{+}
B3	1			C^{++}
B	2	7	10	C^{-}

The overall classification of Text B sits somewhere between a C^{+} and C^{-} coding since a fairly even number of units comprising most of Text B are evenly distributed in these two categories. However, the overall classification in the table was described as C^{-} since more units were coded C^{-} than C^{+}. What is clear from the analysis is that Text B recruits far more everyday knowledge in its content then Text A and thus displays substantially weaker classification in terms of the indicator representation of knowledge.

In summary, the coding of the Texts in terms of the symbolic mode shows that Text A exemplifies an esoteric domain message with strong classification of both expression and content, while Text B recruits moderate to weak classification of expression and content which results in the construction of a predominantly public domain message. Furthermore, Text A is an elaborated symbolic text, while Text B is restricted.

4.6 The recontextualizing principles

In this section I argue that the pedagogic practices of the two schools are grounded in very different perspectives regarding what school science is about and how it should be taught. I draw on Bernstein's theory of recontextualization and Robert's notion of curriculum emphasis to explain and make explicit these apparent differences. I then argue that these underlying philosophies potentially account for the way in which science knowledge is differently presented and distributed in the lessons constituting the data for the analysis.

The science discourse presented in Text B would seem to predominantly embody a curriculum emphasis most congruent with what Roberts terms the 'everyday coping' emphasis (1983). The overall aims of this recontextualization strategy is to give students a functional understanding of scientific principles, including the ability to apply the principle in practical situations. Although all three texts comprising Text B include canonical science knowledge (e.g., science facts, ideas, concepts or theories), this knowledge is invariably connected to everyday knowledge; the scientific is consistently being explained via reference to everyday concepts and exemplified by mundane objects and activities. The recontextualizing principles of Text B view school science as a discourse needing to relate science to the students' real life. This results in, amongst other things, the choice of informal unspecialized linguistic forms in which to express meaning. The language style is chosen in order to present science as a discourse that is relevant and connected to the student's everyday experience. Therefore, it would seem that an underlying pedagogic approach, with emphasis on relevance and proximity to the student's actual everyday experience, drives the formation of science pedagogy in Text B. In short, the 'everyday coping' emphasis, underlying Text B, attempts to reconstitute science in accordance with the structuring of common-sense knowledge.

In contrast, the recontextualizing principles of Text A are derived from broad social, political, environmental and economic concerns. Science concepts are introduced as helpful ways of understanding and dealing with large scale societal issues. The text is, in a sense, introducing the student to the concerns and science knowledge that together make up the field of conservation. Thus scientific knowledge is explained and exemplified, not via the everyday, but rather through reference to broad macro relationships relating to ecology and its particular concerns and values. Thus, the discourse remains specialized throughout in the sense that it links science, not to the mundane, but to other specialized discourses such as ecology and history. This curriculum emphasis is closest to what Robert calls the ‘science and society’ emphasis. In contrast to the ‘everyday coping’ emphasis, the ‘science and society’ emphasis does not directly attempt to reconstitute science knowledge in accordance with the characteristics of common sense knowledge.

4.7 Discussion and conclusion

This chapter has laid out the results of the analysis of the Grade seven science texts used in the two classrooms. The analysis showed that the two texts were similarly constituted in terms of the iconic signifying mode but differed greatly in terms of the symbolic mode. Furthermore, it was argued that the two different curriculum emphases underlie the formation of the two texts.

Both texts utilized images that fall within the public domain and were therefore weakly classified in both content and expression. The icons in both texts were predominantly illustrative in function, depicting everyday objects, actions and agents. Furthermore, the icons used little specialized techno-scientific code and were generally realistic and context dependent. Therefore, the icons in both Text A and Text B were weakly classified in terms of everyday/educational knowledge. These images do not have great potential for inducting a student into reading the specialized and highly abstract iconic messages of scientific texts.

However, although the two texts were similarly constituted in the iconic mode, the analysis highlighted marked differences between the texts in terms of the symbolic mode. It was argued that these differences are related to the differing recontextualizing principles underlying the formation of the texts: Text A was identified with the 'science and society' emphasis, while Text B was related to the 'everyday coping' emphasis. Two textual modalities can be derived from the analysis: dependent and independent pedagogic texts. These text types are characterized by considering the three dimensions addressed in the analysis: classification of content, classification of expression and elaboration of expression.

Dependent texts are constituted as follows: Firstly, these pedagogic texts are weakly classified in content in terms of everyday and educational knowledge. Everyday objects, actions and agents are substantially recruited in the text. Secondly, the language used to express meaning contains little nominalization and introduces few technical terms. The language mimics informal, everyday speech. Finally, the text is constituted by a low character density, short sentences and many individual phrases that do not form full sentences. The text is thus unelaborated and presupposes a supplementary pedagogic voice. In summary, a dependent text is less specialized with respect to disciplinary knowledge and is characterized by a high number of messages that fall within the public domain.

In contrast, independent texts are strongly classified in content in terms of everyday and educational knowledge. Everyday objects, actions and agents are minimally recruited. Furthermore, the language used is densely nominalized and utilizes a plethora of technical terms. The language thus mimics the specialized language of scientific texts. Finally, independent texts are constituted by high character density, long sentences and very few sentence fragments: the text does not assume the operation of a supplementary pedagogic voice to full out the scientific knowledge. Independent texts consist of predominantly elaborated, esoteric domain messages.

Texts A and B can be categorized, with respect to the symbolic mode, as independent and dependent texts respectively. The table below provides a summary of the features of the two text types identified:

Figure 4.26 Summary: dependent and independent texts

		Content	**Expression**		**Elaboration**		
Text type	Domain message	Referencing of knowledge	Nominalization density	Technicality	Character density	Sentence length	% Characters in full sentences
Dependent	Public	C^-	Low C^-	Low C^-	Low	Short	Low
Independent	Esoteric	C^{++}	High C^{++}	High C^{++}	High	Long	High

Chapter 5: An Analysis of Pedagogic Practice

5.1 Introduction

This chapter is concerned with the nature of the transmission strategies evident in the three science lessons recorded at the two respective schools. The chapter addresses sub question B: In what ways are the texts mediated differently through pedagogic practice? In the previous chapter it was argued that the two teachers utilized very differently specialized pedagogic texts with respect to the symbolic mode. In this chapter I aim to describe the transmission strategies with special interest in the ways in which the nature of pedagogic text is related to pedagogic practice. Furthermore, this chapter aims to provide a detailed description of the pedagogy in order to make explicit the type of science knowledge that it makes available to students. Since the data set is very limited, I do not intend to make any empirical claims about the general practices of the two respective schools (these lessons may or may not be typical of the schools' general pedagogic approach). Instead, my analysis is aimed at exploring the relationship between text and pedagogy in order to produce a general theoretical framework with which to look at text and pedagogic practice in relation to the specialization of student's consciousness in school science teaching.

5.2 How the data was coded.

The coding of the data began with a basic time analysis which sought to describe in broad brushstrokes, how classroom time was divided among various possible activity categories. Firstly, time was divided into two basic sections: 1) time in which students have opportunity to learn science and 2) time in which there is no opportunity to learn science[1]. Time offering no opportunity to learn science was divided into the following three sections:

- Discipline

[1] The term "opportunity to learn science" was adopted from the TIMMS study in which it meant... In this study the term merely refers to classroom activity involving the transmission or assimilation of science knowledge.

- Preparation for science learning
- Non-science related discourse/activity.

Time providing opportunity to learn science was divided into four sections:

- Reading
- Teacher explanations
- Teacher questioning students
- Student activities (individual and group)

This framework is summarized in the figure below:

Figure 5.1 Framework for analysing use of pedagogic time

<table>
<tr><td rowspan="7">Pedagogic Time:</td><td rowspan="4">Opportunity to learn science.</td><td>Reading</td></tr>
<tr><td>Teacher explanations</td></tr>
<tr><td>Teacher questioning students.</td></tr>
<tr><td>Student activity</td></tr>
<tr><td rowspan="3">No opportunity to learn science.</td><td>Discipline</td></tr>
<tr><td>Preparation for science learning</td></tr>
<tr><td>Non-science related discourse/activity.</td></tr>
</table>

The analysis focuses on the activities offering opportunity to learn science. These activities are coded by looking at:

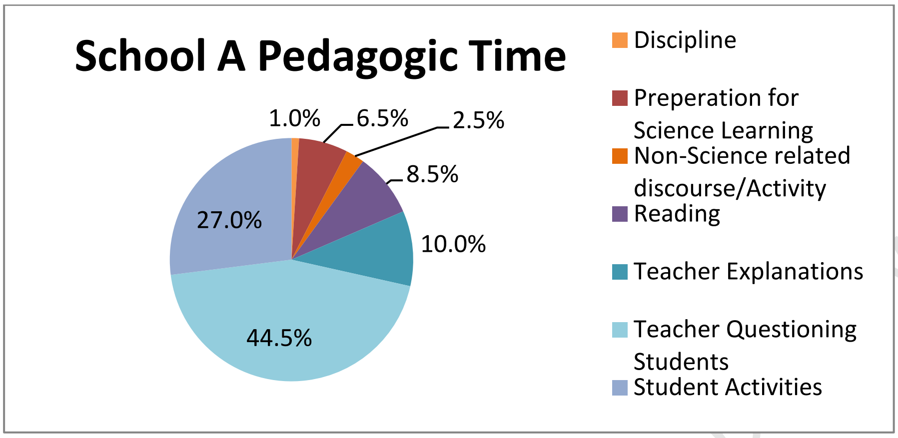
- The classification of science knowledge from everyday knowledge.
- The classification of the teacher's voice from the text.
- The extent to which meanings are elaborated/restricted.
- Connective complexity

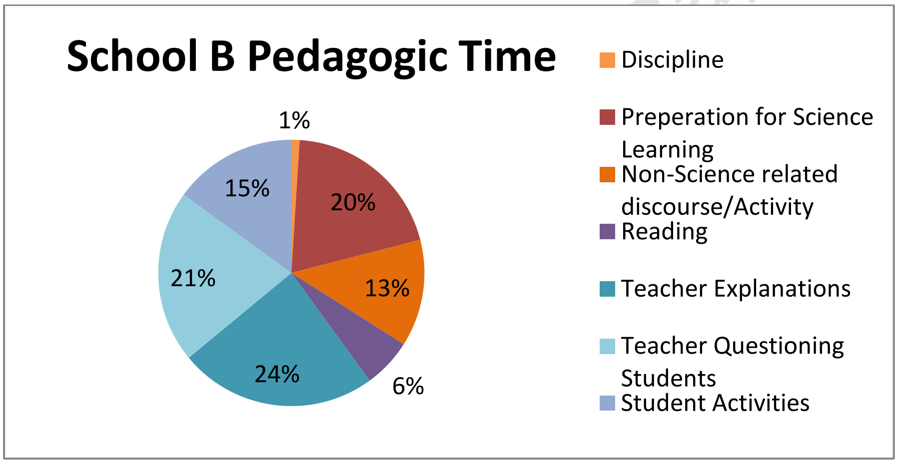
Further explanation of these concepts will be given in the following analysis section.

5.3 Analysis of Time Usage

The total amount of time analysed was 127 min at School A and 107 min at School B. Fig 5.2 below provides a summary of how pedagogic time was apportioned to various activities at School A and B respectively.

Figure 5.2 Apportioning of pedagogic time at School A and School B





The warm colours represent time spent on activities that do not offer opportunity to learn science and the cool colours represent time spent on activities offering opportunity to learn science.

5.3.1 Time offering no opportunity to learn science

The results of the coding of pedagogic time revealed that School B apportioned a substantially greater amount of time to activities and discourse judged to provide no opportunity to learn science in comparison to School A: 34% of lesson time at School B in comparison to 10% of lesson time at School A. However, both teachers only utilized 1% of pedagogic time to addressing discipline issues. Other than the occasional instruction to keep quiet, neither teacher spent much class time enforcing rules or maintaining order. Therefore, the major differences between the two classrooms emerged in the categories of “preparation for science learning” and “non-science related discourse/activity”.

A large portion of class time, 21% at School B, was utilized in administrative activity aimed at preparing the class for various modes of science learning. This would include the time taken to hand out notes, discussion as to where the lesson finished the day before, information around homework and various other administration issues linked to science pedagogy. In contrast, only 6.5% of lesson time was taken up for these sorts of activities at School A. Part of the reason for this difference is potentially linked to the differing class sizes at the schools. The larger class size at School B inevitably leads to a greater amount of time spent on classroom administration, as administrative activities, such as handing out books, take longer in larger classes. However, class size alone cannot explain the magnitude of the difference. Another potential factor contributing to the disparity between the two schools in terms of time spent on preparation to learn science is that School A utilized science books while School B used photocopied pages. A considerable amount of classroom time at School B was used for distributing pages of text to students at the beginning of each lesson, dealing with students who had lost or misplaced pages and allowing students to find the relevant pages. In contrast, the time taken to hand out books and find the correct page at School A was minimal. In summary, School B practices an administratively time consuming approach in comparison to School A.

Finally, there is also a noticeable difference in the amount of time spent on non-science related discourse in the two classrooms: School A, with only 2.5% in this category, and School B utilizing 13% of pedagogic time on non-science related discourse. This discourse included jokes, personal anecdotes, discussion of topics unrelated to science, intercom interruptions and discussion of extra-mural school activities and administration. It will be shown that some of the reasons for this large amount of non-science related discourse can be linked with the nature of the written texts used in School B. This is taken up in more detail in the sections on reading and teacher explanations.

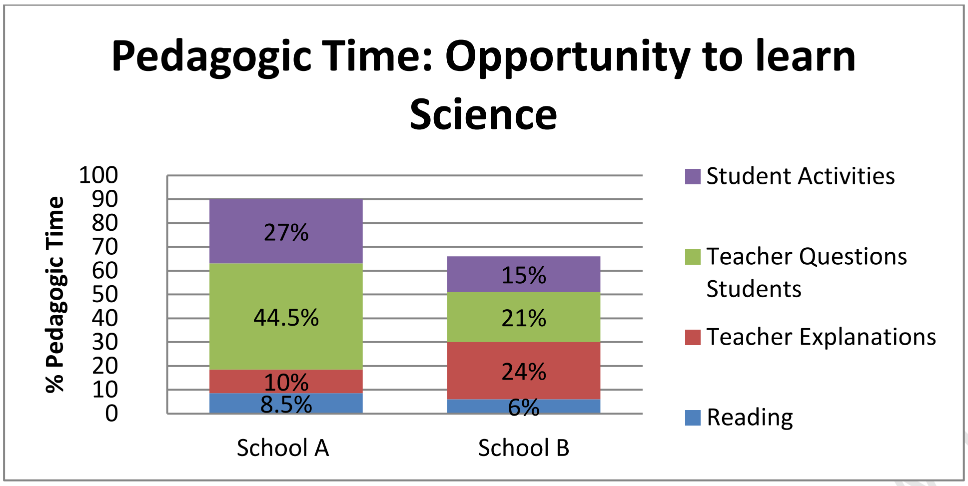
The three categories comprising “No opportunity to learn science” represent the allocation of pedagogic time to activity that involves no potential to specialize student consciousness with respect to science knowledge. The large portion of pedagogic time at School B allocated to activities offering no opportunity to learn science (24% more than School A) potentially weakens the semantic density of School B’s pedagogic practice. Semantic density refers to the amount of scientific meaning made available in the classroom in relation to pedagogic time.[2] School B’s allocation of substantial portions of time to activities involving no opportunity to learn (unspecialized content), weakens the semantic density of the pedagogy and the potential of the pedagogy to specialize student consciousness with respect to science knowledge.

5.4 Close analysis of time offering opportunity to learn science

The following graph presents a summary of the analysis of pedagogic time offering opportunity to learn science:

[2] Ensor and Hoadley (2009) define semantic density as the distribution of pedagogic text over time. A semantically dense pedagogy utilizes large portions of pedagogic time to highly specialized text/content. Conversely, the allocation of large portions of classroom time to unspecialized content, results in a weakening of the semantic density.

Figure 5.3 Time offering opportunity to learn science at School A and School B



In the table above substantial differences emerge between the two schools with respect to the apportioning of pedagogic time to the four categories of activities offering opportunity to learn science. School A allocated far more time to student activities (27%) and teacher questioning students (44.5%) in comparison to School B (15% and 21%). However, School B utilized far more time to teacher explanations (24%) than School A (10%). Furthermore, School B used only slightly more time for reading (8.5%) than School A (6%). In this section I will closely analyse the following four categories: reading, teacher explanations, teacher questions and student activities.

5.4.1 Reading

I begin the discussion of the results of the coding of pedagogic time offering "opportunity to learn science" by looking at the time spent on reading in the two classrooms. School A utilized 8.5% of time for reading, while School B used 6%. In both classrooms the teacher read the text out to the whole class. A detailed discussion of the nature of the texts utilized in the classrooms was given in the previous chapter and thus this will not be repeated here. It was shown there that the texts utilized in School A were substantially more specialized in both expression and content than the texts used at School B in terms of the symbolic mode.[3] This means that students at School A listened to and interacted with substantially more specialized texts. Therefore, the time spent on reading at School A offered students access to a far more specialized discourse in comparison to School B. Thus reading time at School A represents a semantically dense pedagogic activity while reading at School B is, in comparison, semantically sparse.

5.4.1.1 Reading: classification of teacher voice/written text

Furthermore, there were noticeable differences in the ways in which the texts were mediated by the two teachers. There emerged a clear difference in the classification of the two pedagogies with respect to the boundary between the teacher's voice and the text's voice. The external language of description for the coding of the data in relation to this classificatory category is given below:

[3] It should be noted that the reading time at both schools offered little opportunity for students to interact with specialized iconic representative forms as both texts utilized images that, for the most part, represented public domain messages.

Figure 5.4 Coding table: Classification Teacher's voice/ Written text

Strength of the boundary between **Teachers Voice and Written Text** (C^{+-})

Classification	C^{++}	C^{+}	C^{-}	C^{--}
	Very bounded	Quite bounded	Quite unbounded	Very unbounded
Teacher's Voice and Written Text	Large portions of text are read out without interruptions or teacher commentary. Text is written in formal style. The teacher continually refers to the text as the authoritative information source. The teacher explicitly, verbally distinguishes herself from the text	Fairly large portions of text are read out punctuated with occasional teacher explanation. Text is written in fairly formal style that is mostly distinguishable from spoken discourse. The teacher sometimes refers directly to the text.	Short sections of text are read out punctuated by teacher commentary that is usually distinguishable from the text. Text is mostly informal in style. The teacher seldom refers specifically to the text and mostly sets herself up as an equal information provider/authority.	The teacher reads out short sections of text punctuated by continual commentary which is often seamlessly added to the text. The text is written in a style that mimics spoken discourse. The teacher almost never refers to the text specifically and rather sets her own voice up as authoritative. The teacher refers to herself as the source of science knowledge

The teacher, at School A, read out lengthy sections of text, often reading without interruption for around a minute at a time. In contrast, Teacher B continually inserted commentary and explanation as she read. The following extract illustrates this commentary. The teacher's commentary has been highlighted.

> **Teacher B:** The law of the conservation of energy then tells us that the initial potential energy equals the sum that means added all up, of the final kinetic energy, sound energy, vibrational energy, and so on and so forth. And also the example here of an apple on a string. As the apple is raised its position is changed, as we lift the apple higher and higher and higher off the ground it is getting further and further away. Ok um work has to be done on the earth's gravitational field. You actually have to do work against the earth's gravitational field. This gives the apple gravitational potential energy. The

higher the apple is raised the greater is its potential energy. And then we cut the string it's gonna fall it's gonna turn into kinetic energy…

The interruption of the reading by teacher commentary weakens the authority of the text and places the voice of the teacher at the same level as the text. It was often difficult to determine when the teacher was reading and when she was explaining. The teacher and the text merge into a single pedagogic voice. Therefore, the text and the teacher's voice are weakly classified. This is facilitated by the weak specialization of the expression of the written text which, as mentioned in the previous chapter, mimics spoken communication. Furthermore, the unelaborated nature of the written text invites and often necessitates the interpellation of the teacher's voice. Here we see one implication of the use of unelaborated written texts for the allocation of classroom time: The use of unelaborated text tends to increase the amount of time used for teacher explanations.

Interestingly, when Teacher B is summarizing the work from the previous lesson, she often asks the students to remember what "we gave you" or "what I said to you" while also mentioning the text, "we will whizz through the front page to just make sure we are all in the right spot". Therefore, the teacher offers her voice and, more weakly, the text as the authoritative knowledge provider.

In contrast, the teacher's voice and the text are strongly classified in School A's pedagogy. Technical terms and difficult words are defined before the reading of the text so that the teacher's voice does not need to be inserted in the reading of the text.

Teacher A: So that is what we are going to look at today, that's ah non-renewable resources, but before we do that there are a few words on the board that you need to be familiar with before we get to the text.

Furthermore, the teacher often refers directly to the text and continually points the student back to the text as the source of authority, for example:

Teacher A: And what did we learn about phosphates from the passage?

In the quote above the teacher distinguishes himself from the text by referring to what has to be learnt in the passage. Furthermore, the teacher subordinates himself to the pedagogic oversight of the text by including himself as a learner under the text. Moreover, the dense nominalization of Text A, which is not typical of spoken speech, allows for a clear distinction between the text and the voice of the teacher.

The strength of the classification of teacher voice and written text will have potential implications for the specialization of student consciousness. In most cases the teacher's voice will present a discourse of lower specialization than what is presented in written texts. In this sense the teacher's voice will tend to weaken the specialization of the written discourse via punctuating the written text with teacher talk. For example, although some parts of the written text utilized by Teacher B represented fairly specialized discourse (particularly Text B2), when it is presented in class, it is punctuated by teacher explanations and thus the students are not exposed to the pure specialized text, but rather to a hybrid discourse comprising of the teacher's voice and the written text. This hybrid is a less specialized version of the pure written text. Thus the teacher's voice lowers the sematic density of the reading activity.

In School A the implication of strong classification of teacher voice and written text is a facilitation of an orientation to meaning that privileges textual information and inference over information or inference from observation or informal spoken discourse. Painter (1999) argues that this is an important aspect of a semantic approach that is compatible with the acquisition of specialized knowledge (this will be taken further in the next chapter).

5.4.1.2 Reading: classification of science/everyday knowledge in the written text in relation to time spent on discourse unrelated to Science

One further implication of the nature of the texts' read in the two classrooms is worth exploring. Text's B's substantial use of everyday examples and activities often acts as a catalyst for discourse that is unrelated to science. This might partly explain the weaker classification of everyday knowledge and specialized knowledge evident in School B's pedagogy, which is apparent in the far larger percentage of pedagogic time spent on non-scientific discourse at School B. The following extracts serve as examples of this trend.

> **Teacher B**: Alright um (reading from text) "once work has been done on a body it is possible that work can be done on another body". Now the example that they give is a clock a wind up clock. I guess you guys don't even remember wind up clocks.
> **Student**: No
> **Teacher B**: I'm so old that I do remember that…

The lesson continues for another half minute on a discussion about wind up clocks that does not link in with science knowledge. This discussion is initiated by the textual example of a wind up clock which serves as a catalyst for a teacher driven non-science conversation. On other occasions the everyday knowledge in the text would act as a catalyst for a student initiated discussion of something unrelated to science knowledge. The following extract is an example of this.

> **Teacher B**: Yes, ok this one didn't print out so well. (Reading) "Electrical energy is a very useful form of energy because it is easily converted into other forms. Whenever there is current flowing there is electrical energy. You get light energy. Anything that's luminous gives light energy". (Teacher looking at pictures in the text) So it's a globe it's the sun its candles and even glow worms.
> **Student 1**: But what about luminous tops?
> **Class**: Chatter
> **Student 2**: Lumo tops lumo
> **Student 3**: You need to have light shining on them.
> **Student 1**: No that would be glow in the dark.

The discussion continues for over a minute around non-science related everyday notions of light ranging from 21st birthday lights to fireworks. The student's question that leads to this unspecialized conversation was initiated by an idea related to the list of unspecialized objects serving as examples of light in the text. Therefore, the weak classification of everyday and science knowledge in the text contributed to the weak classification of everyday and science knowledge in the classroom discussion.

The weakly specialized text utilized in School B is related to the time utilized for reading having low specializing potential and contributes to the weakening of the semantic density of the pedagogy. It would also seem that an unelaborated written text leads to the allocation of a greater portion of pedagogic time to teacher explanations which, in this case, weakens the specialization of the discourse. Furthermore, the weak specialization has implications for the weakening of the classification of text and a teacher voice and provides impetus for classroom discussion of topics unrelated to science learning. The result is an orientation to science learning that does not privilege textual information and inference and a weakening of the classification of classroom discourse with respect to science knowledge and everyday knowledge.

5.4.2 Teacher explanations

The next section of pedagogic time to be analysed is the time used by the teacher to offer explanations. Teacher explanations include the teacher elaborating on aspects of the text considered to be difficult or in need of further explanation, as well as the teacher responding to student's questions or responses. The time analysis showed that the teacher at School B utilized a total of 24% of classroom time offering explanations, while Teacher A only used 10% of pedagogic time on explanations. The reason for this substantial difference in amounts of time spent on explanation relates strongly to some of the factors discussed in the section on reading. There it was noted that Teacher B offered continual commentary as the text was being read, while Teacher A did not. This commentary, supplementing the written text, takes up a substantial portion of class time. Because, such a substantial portion of pedagogic time at School B is utilized for teacher explanation, the degree to which the teacher's explanations are considered to be specialized will substantially affect the overall semantic density of

Teacher B's pedagogic practice. In what follows I consider the nature and specialization of the explanations offered by the teacher by looking at the following aspects:

- The classification of knowledge
- Connective complexity

A single explanation unit was considered to consist of teacher talk that addressed a single question, concept, definition, or idea. Therefore, an unbroken section of teacher talk may consist of multiple explanation units. Moreover, an explanation unit may consist of teacher talk punctuated by student questions or comments. The three lessons at School A contained a total of 29 explanation units, while the lessons at school B contained 62 explanation units.

5.4.2.1 Explanations: classification science/everyday knowledge

The coding of teacher explanations for classification of science and everyday knowledge utilized a coding rubric given below:

Figure 5.5 Coding table for explanations: classification everyday/science knowledge

Strength of the boundary between **Everyday/Science Knowledge** (C^{+-})

Classification	C^{++}	C^{+}	C^{-}	C^{--}
	Very Strong Classification	Strong Classification	Moderate Classification	Weak Classification
Referencing of knowledge in teacher explanations	Science is explained purely in reference to Science. The explanation does not reference anything recognizable outside of the specialized field of science. Objects terms, processes and agents used in explanation are specialized and scientific.	The explanation utilizes mostly scientific language with only small implicit traces of terms, objects, processes and agents outside of the specialized field of science.	The explanation utilizes some non-scientific concepts, objects, processes or agents. Mundane or domestic examples are mentioned as examples of scientific concepts.	The explanation centres around the use of everyday objects, actions, concepts or agents. The explanation utilizes non-scientific terms and might involve the physical presence of everyday objects or actual experiences of the teacher or students.

Furthermore, only explanation units consisting of two or more sentences of teacher explanation were coded for classification.[4] A total of eighteen explanatory units from Teacher A and 32 from Teacher B were counted. The results of the coding are shown in the figure below:

Figure: 5.6 Results of coding of explanations for classification everyday/science knowledge

	Teacher B (32 units)	Teacher A (18 units)
Number of explanatory units coded C^{++}	0%	0%
Number of explanatory units coded C^{+}	13%	44.5%
Number of explanatory units coded C^{-}	43.5%	44.5%
Number of explanatory units coded C^{--}	43.5%	11%

The explanations offered by Teacher A often contained only small traces of everyday knowledge with only brief mention of domestic activities or objects. The teacher gives a scientific explanation of everyday objects. The following explanation of emulsifiers is typical of Teacher A's practice:

> **Teacher A**: And then we have this word emulsified. I don't think it is very important to the text but I looked it up in the dictionary and an emulsifier is a substance that stabilizes processed food. So foods that are kinna man made and are processed, you usually put a chemical in it to make sure it remains stable. I suppose so that the chemicals in that food remain bonded and remain one substance. So if you look at, I think at things like Marmite, if you look at the ingredients you will see it says emulsifiers, which means a chemical has been placed in there to hold the food together. But we will see these terms as they come up.

[4] Restricting the coding of classification of knowledge to the more lengthy explanation units was deemed necessary as short explanations did not lend themselves to accurate assessment.

In the explanation above scientific language and concepts are dominant; however, the teacher does recruit the household spread Marmite as part of the explanation. This is an example of a C^- explanatory unit. Eight out of the eighteen explanatory units were coded as moderately classified.

A further eight of the explanatory units of Teacher A were coded as displaying strong classification. In these units the teacher makes no obvious use of everyday objects, agents or concepts. The explanation does not substantially refer outside of the scientific. The following explanation of phosphates is a typical example:

> **Teacher A**: So you see so we have spoken about nuclear power as an alternative to our dependence, as we put it, on technology which is fuelled by fossil fuels, because fossil fuels cause problems. But nuclear power can also cause problems. Then it (the text)speaks about using other resources, you can put your hands down for a while, other resources such as the sun and the wind and unfortunately we do not have the ability to harness that power to feed our desire for power that will meet our needs as they currently are.

In this explanation the teacher keeps the discourse at a level of generality that excludes the mention of everyday context specific activity. Domestic uses of power are summed up in the abstract category of "our needs" and rather than specifically mentioning household technology the teacher speaks about "our dependence on technology." This is typical of the explanations given by Teacher A over the course of the three lessons. The explanatory discourse generally avoids context dependent examples of a familiar, everyday, domestic nature or recourse to the students' experiences.

Only two of Teacher A's explanations were coded as weakly classified. Both of these explanations formed part of a discussion involving values related to the environment. In the example below, the teacher is attempting to call into question the huge demands modern society places on the environment.

> **Teacher A:** So what you are saying is that the modern system, which for our purposes is important, within this context, because it relies on fossil fuels to

> give it power and electricity whether it be our planes our banking systems everything you have said. But what is interesting is that we managed without all those things. They have become necessary because we have made them necessary. What do you think about that?

This explanation is only tentatively related to the topic of environmental science and recruits everyday entities such as planes and banking systems. However, explanations such as this one were not the norm and formed a minor percentage of the total explanations coded.

As a result of the very minimal way in which Teacher A recruited everyday knowledge into his explanation, the explanatory discourse at School A was displayed primarily moderate or strong classification of scientific knowledge and everyday knowledge.

In marked contrast, Teacher B's explanations substantially recruited everyday knowledge with the majority of the explanations coded as either moderately or weakly classified in terms of scientific and everyday knowledge. More particularly, the teacher often drew upon the actual experiences of the students. The following example illustrates this weak classification:

> **Teacher B**: So you eat that food, you eat that food and its being transformed into chemical energy in the body. And it's been used in some of those things that you can see when you want to run that race, or you know I was climbing that mountain last Sunday. I was so exhausted.
> **Student**: And you ate wine gums.
> **Teacher B**: and I gave you wine gums. Ok I needed extra energy to get over the hill.

In the extract above the teacher begins with a strictly scientific explanation and then she recruits everyday knowledge as she gives perceptual evidence for the scientific concept she is explaining. A noticeable feature of Teacher B's approach is the emphasis on the perceptual. She consistently attempts to link the scientific to things which the students would have observed or can observe. This often results in the recruitment of everyday knowledge.

Another reason for the substantial use of the everyday in Teacher B's explanations can be related to the use of everyday knowledge in the written texts. For example, the poster stuck to the white board contained a picture of a boy kicking a soccer ball as part of an energy cycle. The following extract is an explanation given by the teacher that is influenced by this poster:

> **Teacher B**: And energy can be transformed from one form to another. So it's when it's transferred from one object to another…if you kick the soccer ball (teacher does a kicking motion) Ok then it's going to go from your muscles it's going to go to the ball it's is going to kick the ball off and the ball is going to get kinetic energy.

In this example the teacher's use of everyday activity is linked to the recruitment of everyday knowledge in the text.

At School B, everyday knowledge is substantially recruited to explain scientific concepts and to draw science into the perceptual world of the student. Although the use of everyday knowledge may be useful in this regard as a pedagogic tool, too much of it can have negative implications for the apprenticeship of students into science knowledge. The overuse of everyday knowledge can mean that scientific knowledge is back grounded to the point that very little science knowledge is made available to the students. Furthermore, everyday knowledge potentially makes the knowledge presented context specific with weak potential for realizing generalizable meanings. In this sense, too much everyday knowledge can result in a pedagogy that does not give students access to the quantity or quality (high abstraction) of science knowledge necessary for successful entry into the specialized field of science.

The teacher at School A does not share this concern to bring science within the realm of the students' perceptual experience. Instead, Teacher A attempts to instil a consciousness that values the text as the source and explainer of science. This again is potentially developing an orientation to meaning, which, according to Painter, is necessary for the successful induction into specialized knowledge. However, the danger of this strongly classified approach is the potential alienation of students. The discourse may be too specialized for students and fail to draw on enough familiar knowledge presenting a discourse that is unable to be understood. Therefore, pedagogies may adopt too much or too little everyday knowledge in terms of optimum specialization of student consciousness.

5.4.2.2 Explanations: connective complexity

I now move on to a coding of the two teachers' explanations in terms of connective complexity. A detailed discussion of connective complexity was given in the previous chapter and the language of description can be viewed in the figure below:

Figure 5.7 Coding apparatus for connective complexity

High connective complexity	• Careful, thorough and accurate. • Present science knowledge in an interconnected way pulling together various ideas. • Provide knowledge of generalized principles that can be broadly applied.
Medium connective complexity.	• Accurate but condensed knowledge. • Definitional rather than interconnected, focused on one idea or concept. • The knowledge would have limited applicability in other contexts.
Low connective complexity	• Very brief, incoherent, inaccurate or overly simplistic knowledge. • Statements of fact devoid of explanation. • Exemplars offered without definition of concept.

The coding of explanations was complicated due to a variety of factors. For example, both teachers offered low connectivity explanations to introduce a question; for example:

> **Teacher B**: Ok what was the thing with wood? I said to you wood it depends on how you actually process the wood as to whether it's renewable or non-renewable. What is the most important thing about wood to make it renewable?

In this example the teacher gives an explanation (highlighted) which would be coded as low connective complexity as it lacks explanatory depth and does not connect how wood is processed with the idea of renewability. However, the explanation opens up the way for a question that focuses on this connection. The resulting student answer and teacher response pull the knowledge in the direction of high connectivity:

> **Student:** If you cut down a tree you have to replant it.
> **Teacher B:** You have to replant it. If it is not replanted then it is not renewable. So that is very important…

Therefore, some explanations, taken in isolation, seem to be exhibit low connective complexity but are actually part of a larger high connective complexity strategy. The analysis takes this larger perspective and codes explanations such as the one in the example above as high connectivity. The figure below summarizes the coding results:

Figure: 5.8 Results of coding explanations for connectivity

	Teacher B (62 units)	Teacher A (29 units)
Number of explanatory units coded High Connectivity	14.5%	69%
Number of explanatory units coded Moderate Connectivity	34%	24%
Number of explanatory units coded Low Connectivity	51.5%	7%

The majority of Teacher A's explanations (69%) exhibited high connective complexity. The following explanation serves as an example:

> **Teacher A**: Electricity doesn't just come from nowhere, you often have to burn something, burn some kind of fuel which turns a turbine and from that, we are going to look at the process next semester so I'm not going to look into it now, but from that we get we get electricity. And so in South Africa much of our electricity comes from the burning of coal. So when you turn on a light that represents coal burning. And of course as it says reserves, reserves of coal, oil and natural gas are dwindling.

Although this explanation does not describe how turbines produce electricity it creates explicit connections between electricity in the home, the burning of coal and the dwindling reserves of fossil fuels. Therefore, the explanation was coded as displaying high connective complexity. In contrast, the following explanation, at School B, was coded as offering weak connective complexity. The explanation arose out of a discussion about what energy transfers are involved when hands are rubbed together. One student suggested that static is released and the teacher corrected him saying that it is friction he is thinking of.

> **Teacher B**: Ok but you have got to overcome, overcoming friction; that is why I can clean my board so beautifully because there is no friction on it. There is little friction on it compared to the old one.

This explanation was coded as exhibiting low connective complexity for several reasons. Firstly, the teacher presents friction in objective terms as something that can be "on" a board. This conception of friction is inaccurate as, strictly speaking, friction is not a substance but a force that resists the relative motion of two surfaces. Therefore, the teacher has sacrificed scientific accuracy in order to concretize a scientific concept. Secondly, the explanation does not attempt to define friction or what it might mean to overcome it. Finally, the connection between friction and the ease of with which one can clean the board is not explained.

Of the 29 explanation units identified for Teacher A, twenty exhibited high connective complexity, seven were medium and two were identified as low. Therefore, Teacher A utilized a predominantly high connective complexity explanatory strategy in the three lessons recorded. Of the 62 explanations coded from Teacher B, nine displayed high connectivity, 21 were medium and 32 were low. More than half (51.5%) of Teacher B's explanations were coded as displaying low connective complexity. Therefore, the dominant explanatory strategy, in the three lessons at School B, was low connectivity.

5.4.3 Questioning of students

I now move onto the analysis of the pedagogic time spent on questioning the students. Teacher A utilized 44.5% of class time engaging students with questions. Thus questioning can be regarded as central to Teacher A's approach to science teaching. Teacher B used 21% of class time questioning students which, although less than Teacher A, still remains a significant portion of class time. 110 question units were identified in the three lessons at School A and 98 at School B. The analysis focuses on two aspects of the questions asked by the teacher. Firstly, I look at the length of the response required by the questions: Do they seek to illicit single words or short phrases or do they require extended responses? Secondly, the questions will be coded for connective complexity. In other words, to what extent do the questions require students to explore connective complexity between ideas?

5.4.3.1 Questions: elaborated/restricted

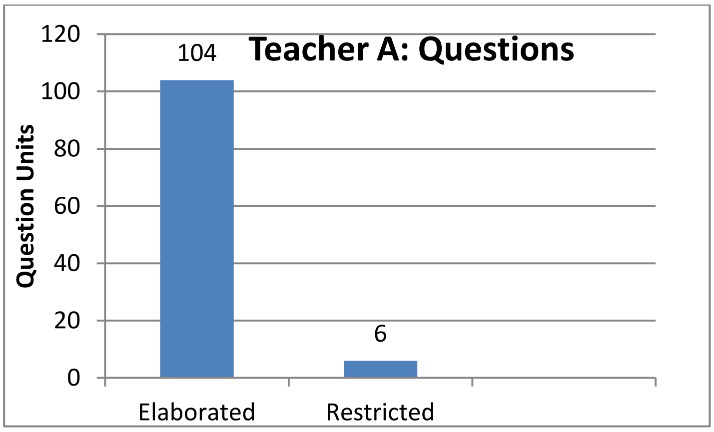
This section sought to determine the length of student response required by the teachers' questions. A coding instrument was developed for categorizing the questions. This instrument can be viewed in the figure below:

Figure 5.9 Coding device for questions: elaborated/restricted

	Question Type	Example from data
Elaborated Question: The question invites a response that goes beyond a single word or short phrase.	**A question requiring a definition**	**Teacher B**: Who can remember the definition of energy that we gave you?
	A question requiring an explanation	**Teacher A**: Why do we call them fossil fuels?
	A question requiring students to tell back what has just been read out	**Teacher A**: Josh can you tell back what we have just read please?
	A question requiring students to add to another student's answer	**Teacher A**: Can anyone add to what he said?
	A question requiring extended factual recall	**Teacher A**: The use of fossil fuels what problems does it create in our societies?
	A questions asking a student to elaborate further on their given answer	**Teacher A**: Why do you say that?
	Any restricted question that leads into an elaborated question	**Teacher A**: Can anyone think of a renewable resource that is not living? **Student**: Water. **Teacher A**: Ok how does water renew itself?
Restricted Question: The question requires a very short response often merely a single word and does not serve as a springboard into an Elaborated question.	**Questions requiring a yes or no answer**	**Teacher B**: Is soil a renewable resource?
	True or false questions	**Teacher B**: Fuel is a source of potential energy?
	Questions requiring the student to choose between two given options	**Teacher A**: According to the passage do you think it is clear or do you think it is blurry as to what is renewable and what is non-renewable.
	Questions requiring students to name an example of a category or concept	**Teacher B**: Who can remember an example of fossil fuels?
	Single word or short phrase factual recall questions	**Teacher B**: What is another name for kinetic energy?

A summary of the coding of Teacher A's questions is given in the figure below:

Figure 5.10 Coding results of Teacher A's questions: elaborated/restricted



The coding of the Teacher A's questions revealed a questioning strategy that prioritized eliciting extended responses from the students. Of the 110 questioning units identified only six were coded as questions requiring restricted or short answers. A few examples of the coding will be discussed in what follows.

The majority of the restricted questions asked by Teacher A were those that required students to name examples of a concept or category. The following is typical:

> **Teacher A**: Can you give me some examples of fossil fuels?

However, the vast majority of Teacher A's questions were coded as requiring elaborated responses. On eight occasions, Teacher A posed a question requiring a restricted response but then followed this question with a related question requiring an elaborated response. The following serves as an example.

> **Teacher A**: Can anyone think of a renewable resource that is not living?
> **Student 1**: Water

In isolation this question would be coded as restricted, but the questioning continues:

> **Teacher A**: Ok, how does water renew itself?
> **Student 1**: I'm not sure
> **Student 2**: Because of rain falling down and evaporation and it goes into rivers…

The teacher's second question requires the students to explain how water connects with the category of "renewable resources". This requires an elaborated response as given by Student 2. Thus, while the teacher initially asks a question requiring a restricted response, this question is followed up by a related question requiring an elaborated response. Therefore, both questions are coded as 'elaborated'. This strategy was utilized eight times by Teacher A.

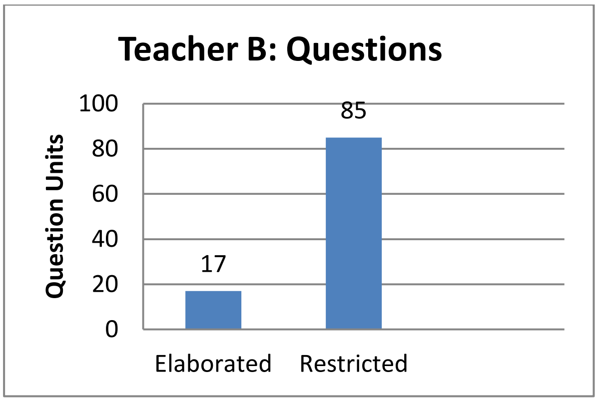
Another common questioning strategy used by Teacher A was to actively invite further elaboration throughout the questioning process. Invariably, once one student had answered a question, the teacher would invite the rest of the class contribute further by saying "can anyone add to what she said". This type of encouragement of elaboration occurred 24 times, thus forming a substantial aspect of the teacher's questioning approach. Furthermore, on ten occasions, Teacher A sought for further elaboration from a student who had just answered a question by asking questions such as, "Can you explain further?" or "Why do you say that?" or "What do you mean?".

A further strategy utilized by Teacher A was to rephrase the same question in order to illicit further response from the students. For example, the teacher first asks "What advantage is there in conserving phosphorous according to this passage?"; a while later, after a student has responded, he asks, "So why is it advantageous to not let it go to waste? How do we benefit from not letting it go to waste?" and then finally, "But what is a positive effect of phosphorous that we need to preserve?" Thus, by asking a similar question in three ways, the teacher facilitates an elaborated engagement of the question from the students.

Therefore, considering only six of the 110 questions asked by Teacher A were coded as restricted, it can be concluded that Teacher A utilized an approach to questioning that attempted to draw out elaborated responses from students regarding science knowledge.

I now move on to the coding of Teacher B's questions. The table below presents a summary of the results.

Figure 5.11 The coding results of Teacher B's questions: elaborated /restricted



The coding of teacher B's questioning revealed a questioning approach that predominantly utilizes questions requiring restricted responses. Of the total of 102 question units counted in the data, 85 were coded as requiring very restricted answers (usually one word). These questions included the restricted forms mentioned in figure 5.9: questions that ask for an example of a particular scientific category and questions requiring students to choose between two given options presented by the teacher. An example of the former, "Who can remember an example of fossil fuels?" and the latter, "Can you make your own food?". Teacher B would also often utilize questions that require the recall of a single scientific word or sometimes a couple of categories. The following are examples of this:

Teacher B: What were the two things I was showing you with the slinky?
Student: Sound movement and light movement.

Teacher B: Carbon dioxide is?
Student: C O 2

Teacher B: what is the earth's main source of energy?
Student: The sun.

Teacher B: Where does electricity come from though? From what?
Student: Coal

One of the reasons for the proliferation of restricted questions in Classroom B had to do with the in-class marking of worksheets. Many of the questions posed by the teacher were questions from the student worksheets. These worksheets required mostly restricted answers including true or false and fill-in-the-blank type questions (more on this in the following section).

> **Teacher B**: And I think there would be heat energy too with radio. Ok B, we had the heater and it's a specific electrical heater so it's going to be electrical energy?
> **Student 1**: to heat energy.
> **Teacher B**: Goes to heat and?
> **Student 2**: Light.

In the above dialogue, the students typically answer the question via inserting words that finish the teacher's sentence. These questions were often answered by a chorus of students giving the answer. True and false questions were also included as examples of restricted questioning strategies:

> **Teacher B**: The remains of dead animals can form oil over long periods of time?
> **Student chorus**: True.

Therefore, Teacher B's questioning was coded as strongly restricted. This has implications for the way in which the students are apprenticed into thinking about science. I suggest that the students at School B are not given opportunity to develop a semantic orientation that enables them to make science concepts verbally explicit, as they are not given much opportunity to engage in scientific discourse.

5.4.3.2 Questions: connective complexity

I now move onto an analysis of the questions that looks at whether the questions asked by the teacher promote connective complexity. A question is regarded as promoting weak connective complexity if it does not require the student to make explicit connections between scientific concepts or offer detailed explanations, but rather requires short factual responses that can be memorized without understanding. These questions will not reveal whether a student has understood the scientific knowledge with any cognitive richness. In contrast, questions promoting strong connective complexity are questions that explore scientific meaning and connections that require the student to make meanings between different aspects of what has been taught or to apply what they have learnt in novel ways. These questions cannot be answered by memorization as they require an understanding of the scientific concepts involved, requiring the student to make connections between ideas and categories. These questions require an interconnected and in-depth understanding of science knowledge. The coding instrument used for this section of the analysis can be viewed in the figure below:

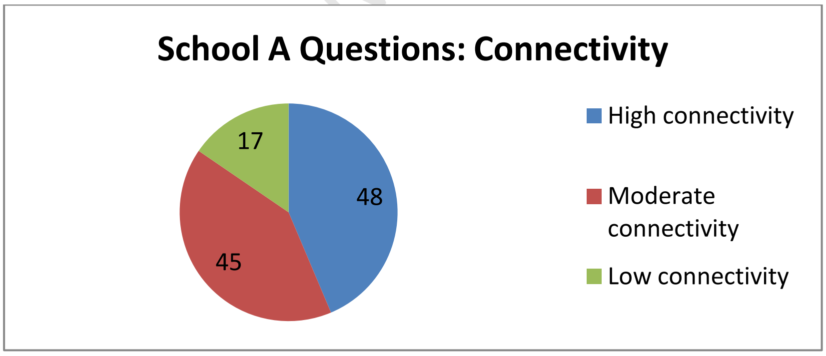
Figure 5.12 Coding device for questions: connective complexity

Strong Connectivity: Questions require the student to make meanings that go beyond what they have been told and to explore connections between ideas. High level abstraction and generality.	**A question requiring the student to make a connection between two or more concepts not linked in the text.**	**Teacher A**: If a resource is renewable why do we need to conserve it?
	A question requiring inference from known information to new information.	**Teacher A**: Gathering what you know about renewable resources what do you think non-renewable resources are?
	A question requiring an original explanation of how a particular exemplar is linked to a scientific concept where this is not given in the text.	**Teacher A**: Ok how is water a renewable resource?
	A question requiring the student to make a judgement or give and opinion.	**Teacher A**: What solutions do you think there could be to this problem?
	A question requiring generalization from given information.	**Teacher A**: What is one of the central lessons conservation teaches us?
Moderate Connectivity Questions that require the student to recall in detail the	**Questions requiring the student to give an explanation of certain phenomenon explained in the text.**	**Teacher A**: Why are we running out of Phosphates?
	A question requiring a definition of a given scientific concept.	**Teacher A**: What is a renewable resource?

concepts learnt or previously presented requiring some conceptual understanding.		
	A question requiring extended general recall of previous work or reading.	**Teacher A**: Can you tell back what we have just read?
	A question that asks for exemplars of a combination of scientific categories.	**Teacher A**: Who can give an example of a renewable resource that is not living?
Weak Connectivity: Questions require little understanding of concepts and mostly test student's ability to remember isolated or unconnected facts.	**A question asking for exemplars of a single scientific category.**	**Teacher B**: Who can remember an example of a fossil fuel?
	A question that moves from a given exemplar to a asking for the relevant scientific concept that matches.	**Teacher B**: Wind has what type of energy?
	Single word or phrase factual recall questions from given info or general knowledge.	**Teacher B**: The chemical formula for oxygen is?
	Question that set up a choice between two options.	**Teacher B**: Do you think coal is going to run out?

The results of the coding of Teacher A's questions is given in the graph below:

Fig 5.13 Results of coding of School A questions: connectivity

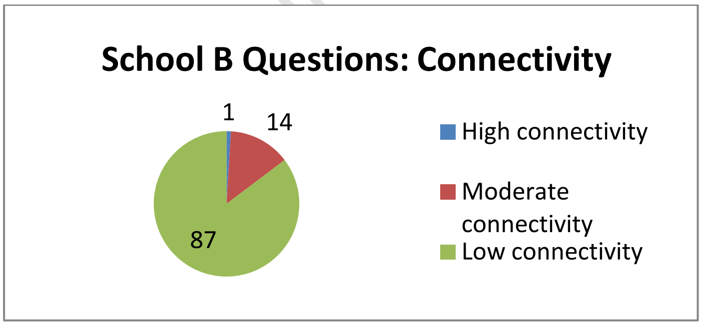


The results show that the majority of Teacher A's questions fall within the categories 'moderate' or 'high' connectivity with only seventeen of the total 110 questions exhibiting 'low connectivity' . Of the 45 questions coded as 'moderate' connectivity, 36 involved questions requiring a general recall of previous work. The teacher utilized a strict pedagogic routine whereby each reading of the text was followed by questions asking the students to tell back what had just been read. These questions were generally very open ended such as, "Josh can you tell back what we have just read?" Once the specific student called upon had narrated what he could remember, the teacher would open the question to the rest of the class with an invitation such as, "Would anyone like to add to that?" Once this recall of the reading was completed, the teacher would generally move on to asking questions that mostly fell within the category of principled questions. Furthermore, the high number of 'moderate' connectivity questions was attributable to the teacher's routine of recapping previous work at the beginning of each lesson. This involved a large portion of questions requiring detailed and elaborated memory recall of previous work.

The questioning activity of Teacher A requires a substantial cognitive demand on the part of the students. Students are given ample opportunity to explore interconnected and in-depth scientific meanings. Thus the questioning strategy of Teacher A presents a pedagogy that seeks to induct learners into a scientific way of thinking that emphasizes explicit, articulated conceptual understanding and interconnectivity.

The results of the coding of Teacher A's questions is given in the graph below

Figure 5.14 Results of coding of School B questions: connectivity



Teacher B's questioning is dominated by questions falling within the category of low connectivity. Only one question was coded as exhibiting high connectivity and fourteen questions were coded as moderately connected. However, the vast majority, 87 in total, were coded as exhibiting low connectivity. Of these 87 questions, 50 were coded as "single word or phrase factual recall questions." A typical example of this sort of question would be: "Plants give you coal, animals give you?" the answer is the single word 'oil'. A further 30 low connectivity questions were questions that require the students to identify scientific concepts linked with a particular exemplar. An example of this sort of question would be: "Ok what type of energy is converted when plants and animals have food?" and "A battery has (what kind of energy)?" These sorts of questions were coded as low connectivity as they do not explore scientific meaning at any depth and do not require the student to articulate or reflect deeply on scientific meaning or the interconnection of ideas. The questions generally represent a low level of specialization and cognitive demand. The questions thus present science as a myriad of unconnected facts: students are apprenticed into thinking about science knowledge as a body of facts to be memorised. The questions illicit answers that are divorced from explanations. Students are not taught to think in terms of the interconnectedness of science knowledge made possible by interconnected meanings.

5.4.4 Student Activities

Student activities have to do with classroom time spent completing group or individual tasks set by the teacher. In School B the students were given various worksheets on energy and energy transfers to complete individually, which used 15% of class time. In School A the students engaged in two activities: Firstly, the teacher divided the students into pairs. Each student was then given two-three minutes to tell the other student what she could recall about the topic of renewable resources. The second activity involved writing a page on "Why we need to conserve non-renewable resources?" These activities utilized 27% of pedagogic time at School A.

The activities will be analysed in terms of whether they require restricted or elaborated responses and finally whether they require connected meaning responses. The approach taken to these three aspects will be similar to that taken in the previous sections of the analysis.

5.4.4.1 Activities: elaborated/restricted

I begin with the coding of the activities with regard to length of the responses required by the activities. This section looks at whether the activities require the students to construct responses that embody extended meanings or restricted meanings. The external language of description for this category in the previous section on teacher questions was re-used for this coding (see Fig 5.9). The worksheets that were utilized at School B consisted of a 53 question units.[5] Of these 53 questions eight required relatively extended responses, typically single sentence length answers. These questions included definitions such as, “Define the following types of energy: a) kinetic energy b) potential energy”. Other questions, requiring extended responses, included brief explanations such as, “Explain what type of energy the apple has in picture A”. However, the majority of questions, 45 in total, required highly restricted responses. These questions included, fill-in-the-blank space questions, true or false questions, and check the correct box type questions. Therefore, the activities at School B strongly tended toward extracting restricted responses from students. Therefore, students were not given much opportunity to construct written scientific meanings of any length, complexity or explicitness.

In contrast, the two activities comprising School A’ activity both required highly elaborated responses. The first activity required the students to produce an uninterrupted two-three minutes of verbal meaning connected to the general idea of non-renewable resources. The second activity required extended written meaning of no less than a full page of writing. Teacher A describes the activity in the following:

> **Teacher B**: What I want you to do now is I want you to do a little bit of writing. Now, I want you to write an account of the reasons why we need to

[5] A copy of the activity sheets can be viewed in Appendix D

conserve non-renewable resources. Now obviously you must talk generally, what are why a non-renewable is non-renewable and to talk about and to then use specific examples. Particularly we spoke about phosphates and fossil fuels. Ok so you do it in rough first and remember to write in paragraphs and full sentences. Ah once your done please bring it to me and we will edit it together.

Therefore, the activities at School A were coded as requiring highly elaborated extended responses from the students. The students were required to construct lengthy scientific meaning in both verbal and written form.

5.4.4.2 Activities: connective complexity

The coding of the activities with respect of connective complexity utilized the same coding instrument as utilized in the previous section (see Fig 5.12). Many of the questions that form part of the activity worksheet at School B were the same questions utilized by the teacher as she marked the worksheet in class time. Of the 53 questions forming the worksheets at School B, 48 were coded as exhibiting low connectivity, five were moderate and there were no examples of high connectivity questions. Therefore, the activity at School B required mostly the reproduction of procedural knowledge.

School A's activity was structured around two questions which were coded as "questions requiring extended general recall of previous work or reading" Therefore, the activity at School B was coded as requiring moderate connective complexity. This activity was not coded as principled as it did not require the students to explore any new connections between scientific concepts nor did it require further inference or generalization. However, the activity did require the students to articulate known scientific knowledge in explicit, elaborated and connected ways.

5.5 Conclusion

This chapter has laid out the results of the analysis of the pedagogic practices of the two grade seven classrooms. The analysis of the pedagogy indicates noticeable differences in the way science it taught in the two classrooms. Two pedagogic modalities can be derived from the analysis: localized and generalized pedagogic practices. These pedagogic types are characterized by considering the allocation of pedagogic time and the nature of the pedagogic activity.

Localized pedagogic practices are characterized as follows: Firstly, these pedagogic practices utilize substantial portions of time for non-science related discussion and teacher explanations. Furthermore, the time spent on reading is characterized by weak classification of teacher voice and text. The questions posed by the teacher require mostly single word responses and do not require exploration of the connections between scientific concepts. Moreover, teacher explanations draw strongly on experiences and objects familiar to the students and present science as a fragmented collection of facts. Finally, the activities set in response to the scientific knowledge presented require mostly restricted responses and do not require students to produce connected scientific meanings.

In contrast, generalized pedagogic practices minimize time spent on non-science related discourse and teacher explanations. The pedagogy displays a strong classification of teacher and text voice. Furthermore, the questions and activities of this pedagogic modality often require students to produce extended responses that explore the connectedness of scientific knowledge. Moreover, the teacher's explanations of science minimally recruit everyday knowledge and present science as a principled, connected discourse.

The pedagogic practices of Schools' A and B can be categorized as examples of generalized and localized pedagogic practices respectively. The table below provides a summary of the features of the two pedagogic types identified:

Figure 5.15 Summary of the analysis of pedagogic activities

	Classification of voice: Teacher/Text	Classification of Knowledge: Everyday/Scientific	Connective complexity	Elaboration	Time on non-science related discussion	Time on teacher explanation
Generalized Practice	C^{++}	C^{+}	High	Extended	Minimal	Minimal
Localized Practice	C^{--}	C^{-}	Low	Restricted	Substantial	Substantial

Chapter 6: Discussion and conclusion

6.1 Introduction

This thesis has set out to compare two grade seven science classrooms and generate a model for considering the relationship between text and pedagogic practice. The first section of this final chapter summarizes the findings of the analysis chapters, addressing the three sub-questions posed in the introductory chapter. The second section relates the answers of the three sub-questions to the central question of the thesis: the relationship between pedagogic text and pedagogic practice. In this section I explore how features of dependent and independent texts differently orientate pedagogic practice in ways that have potential consequences for the specialization of student consciousness. Therefore, in this second section I integrate the central question of the thesis with the underlying concern regarding specialization of consciousness.

6.2 Summary of the analysis in relation to the 3 sub-questions

6.2.1 In what ways are the written texts differently constituted?

The analysis showed that both texts utilized icons that were weakly classified (everyday/specialized knowledge) in expressions and content. Therefore, the iconic mode messages of both Text A and Text B fell predominantly in the public domain. However, marked differences in the constitution of the texts emerged in the analysis of the symbolic mode.

Text B's symbolic mode was weakly specialized in both expression and content, constituting a predominantly public domain message. Furthermore, Text B was shown to embody an unelaborated message: that is a summary style text that assumes the operation of a supplementary pedagogic voice. Furthermore, the analysis suggested that the "everyday coping" emphasis was the dominant recontextualizing principle underlying the text. These textual characteristics were identified as elements of a dependent textual type.

In contrast, Text A's symbolic mode was strongly specialized in both expression and content, constituting a predominantly esoteric domain message. Furthermore, Text A was shown to embody an elaborated message: that is a detailed, explanatory text that does not assume the operation of a supplementary pedagogic voice. Furthermore, the analysis suggested that the 'science and society' emphasis was the dominant recontextualizing principle underlying the text. These textual characteristics were identified as elements of an independent textual type.

6.2.2 In what ways are the texts mediated differently through pedagogic practice?

The analysis showed that the two classrooms utilized pedagogic time in different ways. The following three observations emerging from the analysis were most noticeable. Firstly, in School B, a far greater amount of time was spent on activities not constituting opportunity to learn science in comparison to School A. Secondly, Teacher B used substantially more time offering explanations in comparison to Teacher A. Lastly, Teacher A apportioned more time to questioning of students than Teacher B.

Furthermore, the classification of teacher's voice and the text's voice varied greatly in the two classrooms. Teacher A's voice was strongly bounded from the text's voice. The two voices were kept apart in pedagogic time and the specialized nature of Text A with its densely nominalized grammar allowed for a clear boundary between the two voices. In contrast, the classification of teacher's voice and text voice in Class B was weak. The teacher's voice continually punctuated the text's voice in pedagogic time. Furthermore, the unspecialized nature of the Text A's expression allowed for a blurring of the distinction between the text and teacher's voice.

A further difference between the two practices was the amount of everyday knowledge utilized by the teacher in explanation of scientific concepts. Teacher B often recruited everyday examples, drawing on the student's actual experiences, to explain scientific concepts. Furthermore, Teacher B used concrete everyday objects as part of her explanations. In contrast, Teacher A utilized very little everyday knowledge in her explanations and recruited no mundane objects as part of the explanatory process.

The analysis also suggested that School A presented science knowledge as a highly connected system and provided students opportunity, through questions and activities, that attempted to draw out connected meanings in extended responses. In contrast, the pedagogy at School B tended to present science knowledge as an unconnected, fragmented knowledge system requiring restricted and procedural responses from the students.

Two pedagogic modalities were derived from the analysis: localized and generalized practices. The localized modality emerged from the pedagogic practice of School B, while the generalized modality emerged from the pedagogic practice of School A. The characteristics of these modalities are summarized in Figure 5.15 in the previous chapter.

6.2.3 What are the dominant recontextualizing principles underlying the texts?

The science texts at School A and School B are grounded in two very different recontextualizing principles. The science text used in the three lessons at School B would seem to predominantly embody a curriculum emphasis most congruent with what Roberts terms the 'everyday coping' emphasis (1983). The recontextualizing principles of Text B view school science as a discourse needing to relate science to the students' real life. This results in, amongst other things, the choice of informal unspecialized linguistic forms in which to express meaning. Therefore, an underlying pedagogic approach, with emphasis on relevance and proximity to the student's actual everyday experience, drives the constitution of the science text at School B.

In contrast, the recontextualizing principles of Text A are derived from broad social, political, environmental and economic concerns. Science concepts are introduced as helpful ways of understanding and dealing with large scale societal issues. The text is, in a sense, introducing the student to the concerns and science knowledge that together make up the field of conservation. Thus scientific knowledge is explained and exemplified, not via the everyday, but rather through reference to broad macro relationships relating to ecology and its particular concerns and values. This curriculum emphasis is closest to what Roberts calls the 'science and society' emphasis. In contrast to the 'everyday coping' emphasis the 'science and society' emphasis does not directly attempt to reconstitute science knowledge in accordance with the characteristics of common sense knowledge.

6.3 The relationship between text and pedagogic practice and its potential implications for the specialization of student consciousness

In this section I highlight some of the ways, suggested by the analysis, in which the differing constitution of dependent and independent science texts relates to pedagogic practice. This discussion explores the potential relations between dependent and independent texts and the features of localized and generalized pedagogic practices. I discuss three possible connections and speculate regarding the implications of these connections for the specialization of student consciousness.

- Classification everyday/science knowledge in text related to classification of everyday/science knowledge in pedagogic practice.
- Classification of symbolic mode expression and textual elaboration linked to classification of teacher and text voice in pedagogic practice.
- Textual elaboration and connectivity related to the degree of elaboration and connective complexity of questions and activities in pedagogic practice.

Each of these will be discussed further in the following sections.

6.3.1 Classification everyday/science knowledge in text content related to classification of everyday/science knowledge in pedagogic practice.

The classification of everyday/science knowledge in dependent and independent texts can potentially be related to two features of science pedagogy: the amount of non-science related discussion and the extent to which the teacher recruits everyday knowledge to explain science. I argue that these factors have implications for specialization of consciousness that need to be considered separately.

The analysis revealed that a far greater quantity of pedagogic time at School B was spent on discussion unrelated to science knowledge in comparison to School A. A closer look at the origins of the non-science discussion showed that a substantial number of these discussions originated from thoughts initiated by non-science related content in the text. This relationship can be approached theoretically via Dowling's explanation of the classification of mathematical expression from other discourses. Dowling refers to classification as measurable with respect to the quantity of connotative links able to be made from the expression to other discourses (1998: 117). Thus, a science text is weakly classified from everyday knowledge when the discourse makes available many connotative links with everyday knowledge in respect of both form and content. Therefore, the weak classification of science and everyday knowledge in Text B is related to strong and prolific connotative links to non-science related knowledge. Both Teacher B and her students frequently picked up on these links resulting in a proliferation of non-science related discourse in the classroom. These connotative links to everyday knowledge are weaker and less prolific in Text A and thus, possibly, facilitates less non-science related discussion. Therefore, I argue that the rich connotative link to the everyday set up by the weak classification of dependent pedagogic texts may result in discussions unrelated to science that will weaken the overall specializing potential of the pedagogy.

Moreover, Teacher B utilized everyday knowledge and objects in explanations to a greater extent than Teacher A. Furthermore, the teacher's use of everyday knowledge in her explanations can be partially related to the weak classification of Text B as Teacher B recruited everyday objects and examples mentioned in the text as part of her explanations. Moreover, an overriding difference between the two pedagogies centres on the use of everyday knowledge in pedagogy both in terms of expression and content. However, the recruitment of everyday knowledge in the explanation of science has a nuanced relationship with the specialization of consciousness.

Everyday knowledge in the curriculum is understood as both necessary and potentially problematic in respect to the specialization of student consciousness. Everyday knowledge forms the necessary bridge between a specialized discourse, such as science, and the relatively unspecialized consciousness of the student. In this regard Dowling writes, "If an activity were to make no references outside of itself, then it would be unable to create apprentices" (1998, 136). It is this need to utilize a common familiar discourse, a discourse outside of the specialized discourse of science, which necessitates the introduction of familiar, everyday knowledge in science pedagogy. However, the use of everyday knowledge limits the extent to which scientific knowledge is able to be expressed. The extensive use of everyday knowledge may result in scientific knowledge being back-grounded to the point that very little science knowledge is made available to the students. Furthermore, everyday knowledge will usually make the knowledge presented context-specific with weak potential for realizing generalizable meanings.

Therefore, although everyday knowledge acts as a gateway into specialized scientific knowledge, a full expression of scientific knowledge cannot be achieved through it. As a result, a curriculum that does not move progressively toward stronger classification of everyday knowledge and science knowledge and more specialized linguistic form, will arrive at a point at which student consciousness is no longer being specialized with regard to science knowledge. This is the point at which the utilization of everyday knowledge works against the specialization of student consciousness. Conversely, a pedagogic text that is too strongly classified may result in alienation of students.[1] The discourse may be too specialized for students. The text, by failing to draw on enough familiar knowledge, may present a discourse that is unable to be understood. This dilemma is articulated succinctly by Bernard Charlot:

> Very often an attempt is made to solve school failure by linking everything to the pupil's daily life. This connection, however, can constitute both a support and an obstacle at the same time. It is a support because it gives meaning to what the school teaches. It is an obstacle when it hides the specific meaning of the school activity (2009: 91).

Therefore, it would be over-simplistic to assume that either strong or weak classification of everyday and scientific knowledge in a pedagogic text or practice necessarily implies greater potential for the specialization of student consciousness with respect of scientific knowledge.

A further consideration of textual classification concerns the role densely nominalized, academic style texts play in the development of a consciousness that will allow for ready access to scientific knowledge. Once again the answer is not clear from the analysis. It can be argued that dependent texts, such as those utilised by teacher B, have very weak potential to develop the semantic abilities needed to successfully engage with scientific texts. Since scientific knowledge is predominantly constituted in written language embodying grammatical metaphor, students need to be given opportunity to work with texts that, to some degree, mimic the linguistic forms taken by specialized texts in order to develop the necessary capabilities for engaging these texts. In this sense Text B's lack of linguistic

[1] Alienation occurs when the students are unable to access the text and the knowledge it contains due to the gap between the students current level of specialization and the level of specialization required to gain even partial access to the meanings presented by the text. Dowling writes that "The use of highly technical language to a lay audience is clearly an excluding strategy" (Dowling, 1998: 52). Alienation results in no specialization of the students' consciousness; in this sense they are excluded from gaining access to specialized knowledge.

specialization potentially excludes students from developing a consciousness that will allow them access to scientific discourse and knowledge (Martin, 1993: 202).

However, overly specialized language forms may also result in the inability of the students to access the meaning of the text. The dense nominalization and technicality may alienate the student and work against specialization of consciousness. Furthermore, since this research did not include any measurement of the specialization of student consciousness, the thesis merely raises the question of the implications of specialized textual expression for specialization of consciousness rather than answering it.

6.3.2 Classification of symbolic mode and restricted textual elaboration linked to pedagogic practice exhibiting weak classification of teacher and text voice.

The linguistic features of the written texts were shown to have implications for the nature of the resulting pedagogic practice in terms of the classification of text voice and teacher voice. The analysis suggested that dependent texts facilitate a pedagogic practice with strong classification of teacher voice and text voice while dependent texts facilitate weak classification.

The study showed that Teacher A’s voice was strongly classified from the text’s voice. In contrast, Teacher B’s voice displayed weak classification from the text’s voice. The blurring of the boundary between text voice and teacher voice at School B was congruent with Text B’s informal linguistic style. The use of minimal nomanalization, colloquial vocabulary and direct speech in which the students are directly addressed by the text and given instructions, results in the written text mimicking spoken language. Consequently, the linguistic features of the written text and spoken discourse of the teacher are often indistinguishable. In contrast, the dense nominalization and formal linguistic style of Text A ensures a noticeable linguistic differentiation between teacher voice and text voice at School A.

Furthermore, the restricted nature of Text B invited the interpellation of the teacher's voice such that the two voices blended in pedagogic time. The analysis showed that Text B often exhibited the characteristics of a summary text including many sentence fragments, bulleted points, and blocked off sections. Furthermore, the analysis showed that Teacher B often interrupted the reading of the text with her own voice in order to bring clarification or to offer further explanation. Therefore, it was argued that the restricted nature of the text in School B lent itself to a pedagogic practice in which the teacher's voice blends with the text's voice in order to supplement for the text's brevity. This blending of teacher voice and text voice in pedagogic time is considered to contribute to a blurring of the distinction between the two voices, and thus a weakening of classification with respect to these voices as well as weakening the authority of the text.

The opposite observation was made regarding Teacher A, whose voice rarely interrupted the text, resulting in a strong classification of teacher voice and text voice. This aspect of pedagogic practice was also potentially linked to the elaborated nature of Text A, which did not require a supplementary voice. The teacher tended to read out lengthy chunks of text without interruption, resulting in a clear distinction between text voice and teacher voice in pedagogic time. Therefore, the elaborated nature of Text A was related to the strong classification of teacher voice and text voice.

The strength of the classification of teacher voice and text voice set up differing structures of epistemic authority in the two schools. In school A, the text's voice is positioned as the highest epistemic authority. This is made evident by the way in which Teacher A consistently deferred to the text as the primary source of knowledge and authority. Student questions were usually dealt with by students being directed back to the text. Furthermore, the teacher rarely introduced new knowledge not dealt with in the text. The teacher primarily functioned as a mediator between the students and the text. Thus, in School A, the students and the teacher are positioned under the authority of the text in respect of science knowledge. The teacher's voice is strongly bounded from and subordinated to the text's voice. The strong classification of teacher voice and text voice facilitates this particular epistemic authority structure. Furthermore, the use of a specialized, elaborated, principled and connectively rich text set up the possibility of an epistemic hierarchy with the text at the top.

Conversely, in School B, the teacher's voice and the text's voice share seemingly similar epistemic status. The text in conjunction with the teacher voice functions as the source of science knowledge. The weak classification of teacher voice and text voice allow for this sharing of epistemic authority. Therefore, in School B the student's voice is subordinated to both the teacher's voice and the text's voice, both of which enjoy similar epistemic authority. Furthermore, the use of a comparatively restricted, procedural and connectively impoverished text required the foregrounding of the teacher's voice and necessitated the comparatively low epistemic status of the text. The analysis is highly suggestive that that text specialization has direct implications for the epistemic hierarchy of science pedagogy in respect to the student-teacher-text triad.

Painter regards an orientation to meaning that privileges textual information and inference over information or inference from observation or informal spoken discourse as an important aspect of a semantic approach that is compatible with the acquisition of specialized knowledge (Painter, 1999: 84). In School A's approach, students are potentially apprenticed into regarding textual information as authoritative and they are given ample opportunity to make inferences from knowledge they have clearly received from the text. The teacher's voice, which represents a spoken discourse, is subordinated to the written discourse. Thus an orientation to learning is set up in which students are apprenticed into valuing written text as the authoritative source of knowledge as well as being given opportunity to learn and make inferences from written texts. In School B this visible privileging of written discourse over spoken discourse is not evident. The strict separation of text voice and teacher voice that allows for the privileging of the text voice does not occur. Instead, the text voice and teacher voice often merge into a single indistinguishable voice. Therefore, the students are not orientated to learning through text but are still heavily reliant on context embedded spoken discourse as the vehicle through which science knowledge is construed.

6.3.3 Textual elaboration and connectivity related to the degree of elaboration and connective complexity of questions and activities in pedagogic practice

The analysis showed that School A's pedagogy consistently required students to make lengthy verbal and written responses regarding science knowledge. The pedagogy was marked by open-ended questions and the encouragement to elaborate further. Therefore, students were given regular opportunity to speak and write about science in an elaborated fashion. In contrast, School B's pedagogy provided very little opportunity for students to construct lengthy scientific discourse. The questions and activities mostly required short or often single word responses. Thus, students were given little opportunity to articulate elaborated scientific meanings. A further noticeable difference between the two pedagogic practices was the level of connective complexity exhibited. The explanations offered by Teacher B and the type of responses she sought to elicit from students often presented science knowledge as piecemeal and fragmented. In contrast, students at School A were offered a highly connected science discourse and were required to explore this connectedness in the questions and activities presented in the lessons.

The analysis is suggestive of a relation between the degree of elaboration and connectivity of the pedagogic text and the extent to which pedagogic practice displays elaboration and connectivity. Both teachers based their questioning of students and in class activities on the knowledge presented in the texts made available to the students. In this way the type of questions and activities used by the teachers were strongly related to the texts. Thus the unelaborated and unconnected nature of the knowledge presented in Text B acted as a limiting factor with respect to the type of meanings the teacher required the students to construct in answering questions and completing activities. The text may potentially present a semantic ceiling for pedagogic practice - questions and activities are semantically bounded by the nature of the pedagogic text.

Once again I relate these findings to the way in which these pedagogic approaches potentially orientate the student's scientific thinking. Bernstein and other sociologists have begun to describe some of the basic differences between specialized academic knowledge and mundane everyday knowledge. These differences include the idea that specialized knowledge is integrated and connected, while everyday knowledge tends to be segmented. More specifically, Dowling's categories of procedural and principled knowledge are strongly related to the differences between everyday knowledge and academic knowledge. According to Dowling " The general quality which distinguishes principled from procedural discourse is that the formed exhibits connective complexity, whereas the latter tends to impoverish this complexity, minimizing rather than maximising connections and exchanging instructions for definitions" (1998, 146).

I argue that a localized pedagogic practice presents science as an unconnected (fragmented) discourse. A localized practice gives students little opportunity to think about science in principled ways, develop a consciousness that is able to understand the connected nature of scientific knowledge and produce principled discourse. Within this modality, students are orientated to thinking about science within an everyday knowledge framework as a fragmented discourse. In contrast, a generalized practice potentially orientates students toward the principled nature of scientific discourse, providing ample opportunity in verbal and written form to construct principled meanings.

6.4 Conclusion

The aim of this study was to produce theoretical generalizations rather than empirical ones. Due to the small sample size, the pedagogic texts and practices described in this thesis are not necessarily representative of two teacher's usual approach to science teaching or the approach of the two schools. The primary aim of this thesis was to develop a theoretical model for the exploration of the relation between text and pedagogic practice. Furthermore, the model specifically highlights aspects of text and pedagogy that have potential implications for the specialization of student consciousness.

In this thesis two text types were identified: independent and dependent. These text types emerge out of contrasting recontextualizing principles: the dependent text type can be related to the 'everyday coping' emphasis, while the independent text type can be related to 'science and society' emphasis. Furthermore, two pedagogic modalities emerged from the analysis: localized and generalized practices. It is certainly not the case that dependent texts necessarily entail the emergence of a localized pedagogic practice, while dependent texts entail the emergence of generalized practice. There are, no doubt, many factors other than text which account for the nature of the pedagogic practice in a grade seven science classroom.

However, the study suggests various links between pedagogic text and pedagogic practice. The analysis points to a relation between text and the classification of teacher voice and text voice. Secondly, the study points to a potential link between text and the amount of non-science related discourse. Furthermore, text may be related to the extent to which a pedagogic practice offers elaborated and connected science knowledge and the level of elaboration and connectedness of the practice's questions and activities. Finally, the analysis suggested that the classification of everyday and scientific knowledge in teacher explanations may also be related to text. Moreover, each of these potential implications of text on pedagogic practice was shown to have potential implications for the specialization of student consciousness with respect to science knowledge. However, all the above assertions are tentative and need to be tested utilizing a far larger and varied sample. Further, possible research could involve analysing the shifts in pedagogic practice when the same teacher utilizes a dependent text and then an independent text.

This thesis has highlighted the potential significance of different pedagogic science text types for pedagogic practice and the implications these might have for students' access to the specialized discourse of science. Furthermore, the study provides a model for further investigation into the relation between pedagogic text and pedagogic practice.

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List of Appendices

Appendix A: Full copy of Text A and Text B

Text A:

Ecology and conservation are now an essential part of school curriculums all over the country. A special program conducted aboard the sloop Clearwater *(right) is working to save the Hudson River.*

Many fish populations have been overexploited. In the North Atlantic, such species as cod, haddock, and flounder have become dangerously scarce. Salmon populations in the Pacific Northwest and groupers in the Gulf of Mexico have also declined sharply.

Most commercial fishing takes place in the highly productive waters near shore. Competition for those prime locations has caused local fish shortages and, in many cases, heated international arguments. Nations have occasionally mobilized warships to protect their fishing fleets and offshore waters against intruders. Such difficulties have usually been resolved by treaties that have included such conservation measures as restricted areas, closed seasons, quotas, and limitations on fishing gear. For many of the world's fisheries, however, there are no international agreements other than the provisions of the "Law of the Sea" and several international commissions establishing guidelines for specific fisheries.

Until 1977, the Law of the Sea provided that each nation with a coastline had control of fisheries up to 12 miles (19 kilometers) offshore. Beyond that limit, the sea was open to all. The result was intense rivalry and overfishing. Then, in 1977, most nations of the world declared Exclusive Economic Zones, laying claim to fisheries up to 200 nautical miles (230 miles or 370 kilometers) from shore and permitting wiser management of marine resources.

Sea animals other than fish are also sometimes dangerously overharvested. Marine mammals are a valuable resource, and various international commissions have been set up to study and recommend guidelines for harvesting these animals. In 1972, the U.S. Congress passed the Marine Mammal Protection Act, which banned whaling from any U.S. ship and placed strict limitations on the harvesting of dolphins and other marine mammals. In the late 1980s, legislation was passed to prevent the accidental trapping of dolphins and marine turtles in sweep nets used to gather tuna, shrimp, and other commercial catches. By the mid-1980s, the majority of the nations of the world had signed agreements prohibiting the harvesting of all whales, many species of which were on the verge of extinction. Today, Norway and Japan continue to hunt minke and a limited number of sperm whales. Iceland, which had originally agreed to the ban, announced in 2003 that it would resume commercial whaling.

Marine mineral resources as well as marine life are increasingly exploited. Offshore drilling for oil has grown tremendously since the 1960s, with its attendant danger—pollution of the sea. Increased demand for resources is driving many nations to begin intensive exploration of the ocean and its floor.

NONRENEWABLE RESOURCES

Nonrenewable resources are those that form so slowly—often over thousands to millions of years—that, for all practical purposes, their quantities can be regarded as fixed. Coal, oil, natural gas, iron, lead, phosphates, and many rocks and minerals are nonrenewable. Once such resources are depleted, there is no

Text A

Detergent-related pollution problems (above) are becoming less frequent thanks to biodegradable surfactants and a reduction in phosphate use.

way to replenish them except to recycle waste materials or develop synthetic substitutes.

Conservation of Phosphates

The element phosphorus is an important nutrient, absolutely essential to life in plants and animals. It is so vital to agriculture that the amount found naturally in most soils has to be supplemented with phosphorus-bearing minerals known as *phosphates*, which are mined from the earth and used as chemical soil fertilizers. For decades, phosphates were a common ingredient of detergents because they acted as emulsifiers to break down oil and dirt particles.

In nature, phosphates are relatively scarce and are constantly circulating through land, water, and living things in a system known as the *phosphorus cycle*. Plants absorb phosphates from the soil or water, animals eat the plants, and the phosphates are returned to the environment when the animals excrete wastes or die.

When large amounts of phosphates are introduced to soil and water through fertilizers, detergents, and other human uses, the natural cycle is disrupted. Excess phosphorus is washed into rivers and lakes, stimulating massive blooms of algae and other plants, which, when they die, deplete dissolved oxygen and hasten the natural aging, or eutrophication, of the water. Large quantities of phosphates that would ordinarily circulate back into the soil are trapped in sediment at the bottoms of the oceans.

Present world reserves of phosphorus in phosphate-bearing rocks are estimated at 3 billion to 6 billion tons. At current rates of phosphate-fertilizer use, these supplies should last for 400 years. But the demand for fertilizers is likely to increase as the growing world population demands more-intensive agriculture. If this should happen, the reserve of mineral phosphates could run out in less than a century.

Conservation of phosphates, then, has two desirable effects. First, it reduces water pollution and maintains the natural cycle of minerals in living things. Second, it conserves a resource that, if used with care, can help feed a burgeoning world population.

Conservation of Fossil Fuels

Reserves of coal, oil, and natural gas—the most widely used sources of power—are dwindling in many parts of the world. These energy-yielding substances are called *fossil fuels* because they were formed from the remains of plants and animals buried millions of years ago. Burning them supplies 88 percent of human energy needs around the world, making them the most important of the nonrenewable resources. When the supplies of fossil fuels are exhausted, people will be forced to make drastic changes in the way they live.

As demand for fossil fuels has increased, exploration and exploitation have increased as

Text A

well, reaching even into the oceans. The continental shelves—those portions of the continents extending from the shore outward beneath the surrounding oceans—have proven to be abundant sources of oil in some areas. Also, land areas once remote or inaccessible are now being tapped for their oil and natural-gas reserves. The Arctic slopes of Alaska and the frigid wilderness of northern Siberia are notable examples.

Until the 20th century, the use of fossil fuels was limited primarily to coal. The introduction of internal-combustion engines, however, created a tremendous demand for petroleum derived from oil. Widespread use of electricity also increased the demand for new and better oil- and gas-powered generating plants. By about 1960, natural gas had joined oil and coal as an important source of energy to provide heat and power production.

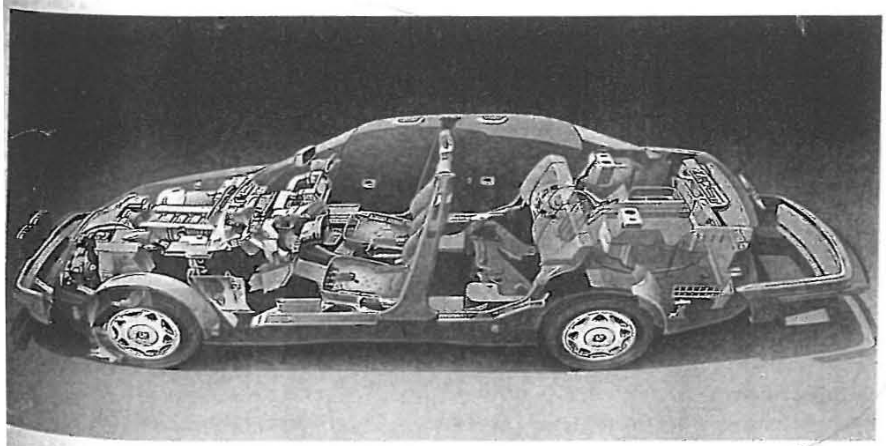
As the use of fossil fuels has increased, so have environmental, economic, and political problems. Oil and natural-gas exploration opens up vast regions of essentially untouched land to easy access, threatening wilderness areas with environmental damage and disrupting the varied wildlife in sensitive ecosystems. Uneven distribution of the resources has created political tension and occasionally armed conflict, especially in the Middle East, where approximately three-fourths of Earth's supply of oil and natural gas is located. Transport of fossil fuels across land and oceans has resulted in accidental spills that kill wildlife, contaminate water and air, and cost millions of dollars to clean up. The burning of oil, natural gas, and coal releases gases that are a major cause of air pollution.

The costs and hazards of fossil fuels have spurred efforts to conserve available supplies and to develop various alternatives to them. A significant portion of world energy needs is being satisfied by nuclear power, which has its own list of undesirable side effects, including the difficulty of safely disposing of radioactive waste and the possibility of disastrous accidents. Terrorism and other security threats at nuclear facilities have also become pressing concerns. Many environmental scientists are convinced that future power needs must be—and ultimately will be—met by the various nonpolluting sources, such as the Sun and the wind, but the technology available so far has not made the alternative sources economically practical for large-scale power production.

A PHILOSOPHY OF CONSERVATION

Defending the world's dwindling wilderness areas, championing the intelligent use of resources, developing new technologies that make industry and power production safer and cleaner—these are all challenges faced by ecologists and conservationists.

Environmental problems are indeed serious and can seem daunting, even insurmountable, when approached as a whole. But conservation efforts have proven time and again that there is truly cause for hope. Based on the belief that the world is worth protecting, conservation teaches that human beings and all other living things are integrated in a complex relationship with Earth. Work done today will make the world a better place tomorrow, when it is inherited by future generations.



Companies have placed new emphasis on making products that can be efficiently disassembled into reusable or recyclable parts. This sort of environmentally sensible policy has paid off well for BMW, whose passenger vehicles (left) include numerous recycled components (blue) and reusable parts (green).

Text B1

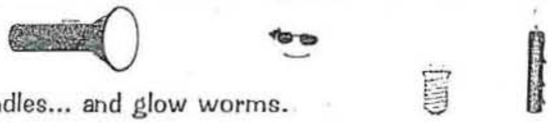
Eight Types of Energy

There are *eight types of energy*. Make sure you can *recognise* each type and give an *example*.

1) Electrical Energy

This is a very *useful* form of energy, because it's easily *converted* into other forms — wherever there's a *current* flowing, there's *electrical energy*.

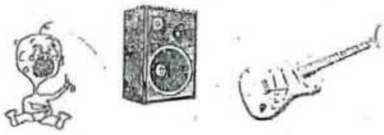
2) Light Energy



Anything *luminous* gives off *light* energy,
— things like the Sun, light bulbs and candles... and glow worms.

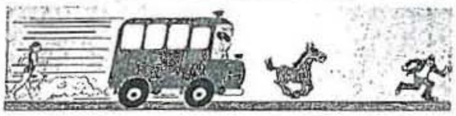
3) Sound Energy

Anything *noisy* gives off *sound* energy,
— things like vocal chords, speakers and instruments.



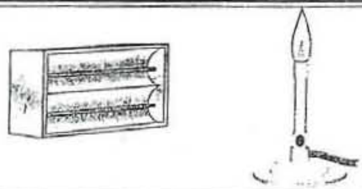
4) Kinetic (Movement) Energy

Anything that *moves* has *kinetic* energy...

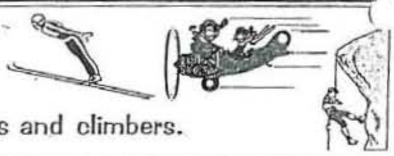


5) Thermal (Heat) Energy

Everything has *some* heat energy.
The *hotter* something is — the *more heat* energy it has.

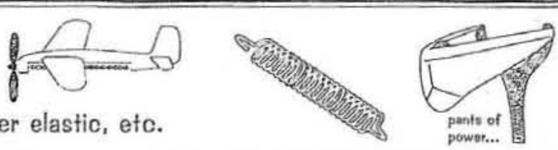


6) Gravitational Potential Energy



Anything that is *above the ground* has *potential* energy,
— i.e. anything that can fall, like ski jumpers, aeroplanes and climbers.

7) Elastic Energy



Anything *stretched* has *elastic* energy,
— things like rubber bands, springs, knicker elastic, etc.

8) Chemical Energy

Anything with *stored energy* which can be released by *chemical reaction* — things like food, fuels and batteries.

Types of Energy, phew — I'm worn out after all that...

There you are then, eight types of energy to learn, remember that temperature is not a form of energy, it just measures how hot something is. *Learn* the *eight types* then *cover the page* and *write them down*. Make sure you can list *three examples* for each type of energy. Grrreat...

Text B1

Conservation of Energy

Scientists have only been studying energy for about two or three hundred years and so far, they've come up with two *"Pretty Important Principles"* relating to energy. *Learn* them *really well:*

THE PRINCIPLE OF CONSERVATION OF ENERGY

Energy can never be *CREATED* nor *DESTROYED* — it's only ever *CONVERTED* from one form to another.

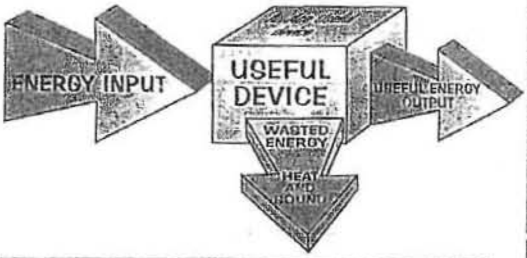
That means energy never simply *disappears* — it always *converts* into another form. This is another *very useful principle:*

Energy is *ONLY USEFUL* when it's *CONVERTED* from one form to another.

Think about it — all *useful machines* use *one kind* of energy and *give out* another.

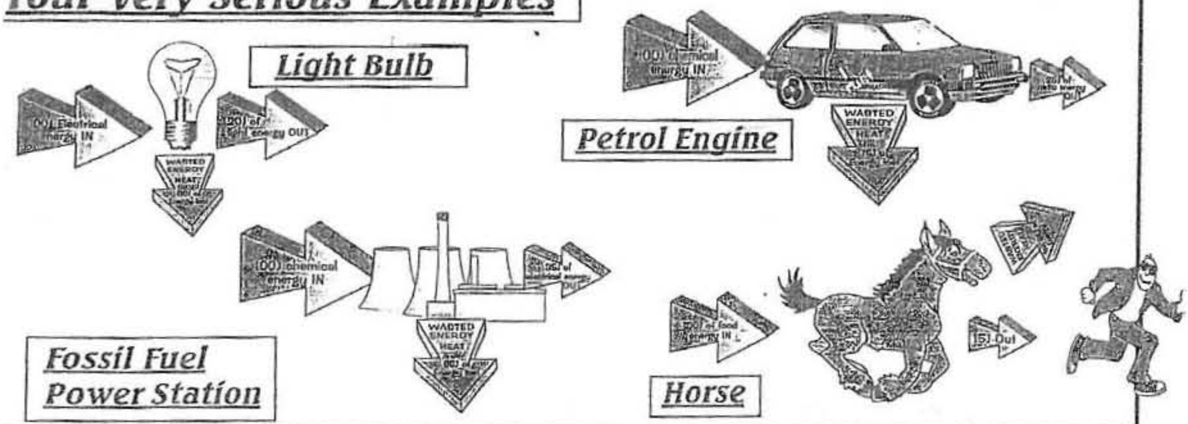
Most Energy Transfers are Not Perfect

1) Useful devices are *useful* because they *convert energy* from *one form* to *another*.
2) *Some energy* is always *lost* in some way, nearly always as *heat*.
3) As the diagram shows, the *energy input* will always end up coming out partly as *useful energy* and partly as *wasted energy*, — but *NO ENERGY IS DESTROYED:*



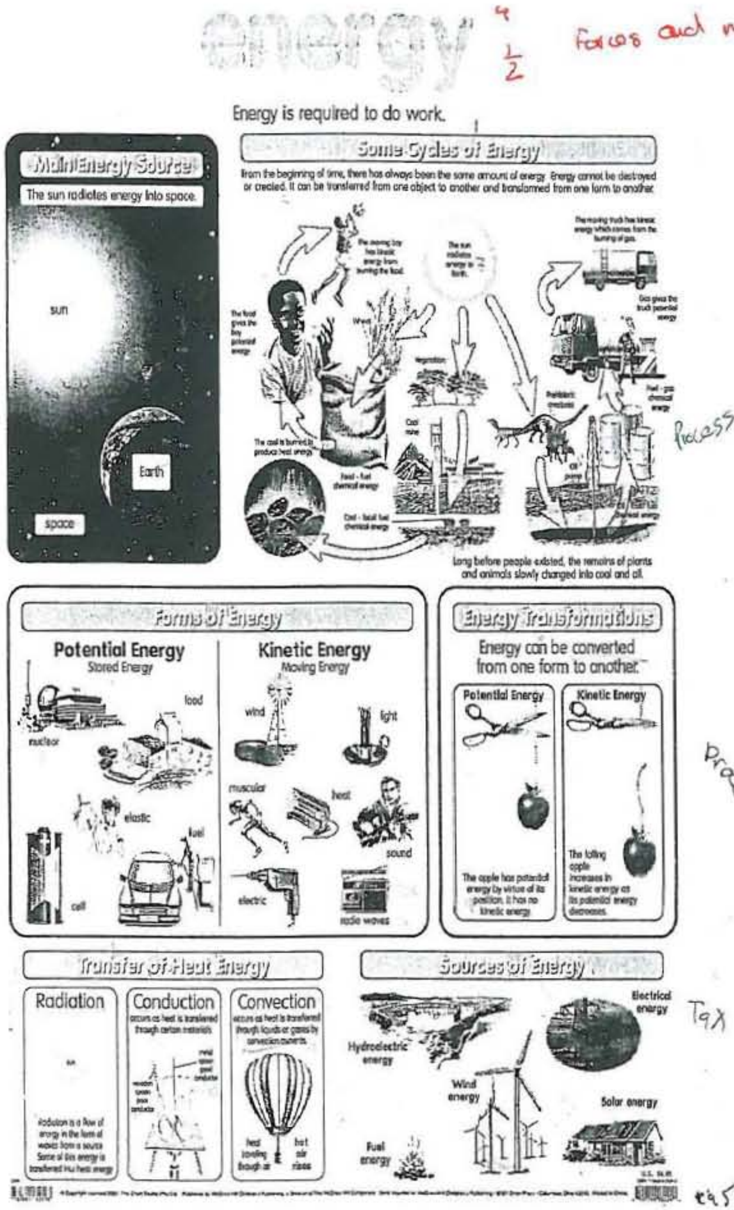
Total Energy INPUT = The USEFUL Energy + The WASTED Energy

Four Very Serious Examples



I've said it so many times now — it's making me horse...

Remember, energy is *never lost completely* — if you think you've lost some, you can bet your bottom dollar it'll have *leaked away* as something less useful — i.e. *heat or sound*. *Energy* is *very strange* — it swirls around you every day of your life, it comes in many, many different forms, and you can *never see it* — only the *effects* of it. It's just like *REVISION*.



What Is Energy?

In nature things are always changing. For example:

- A marble is placed at the top of a ramp; it rolls downhill.
- We rub the palms of our hands together; they get warm.
- We put a fire under a pot of water; the water boils.
- We switch on an electric heater; it heats the room.
- We fill a car with gasoline; we go from one place to another.

At the end of the eighteenth century, and into the nineteenth century, scientists studied these changes, and the processes needed to bring them about. They developed the science of Thermodynamics. There are several laws of Thermodynamics:

- The first law of Thermodynamics tells us that in all these processes, there is "something" that stays constant and never changes.
- This "something" is a very abstract concept, to which scientists eventually gave the name "energy."
- The first law tells us that in all processes, energy is conserved; the law is also known as the law of conservation of energy.

Fun Research

Visit the library or the Internet, and find out who Isaac Newton was. Report your findings on his research and life in a notebook.

More About Energy

Energy is linked to the concept of work. When we apply a force to a body in order to change its position, we say that we do work on the body.

- We define the work done as the product of the force in the direction of movement and the distance moved.
- Force is measured in Newton (N), and distance in meter (m), so the unit of work is Newton meter (N.m), which we call the joule (J).

Once work has been done on body A, it is possible that work can be done by body A on another body. For example: when we wind a clock, we do work on the clock spring. The spring does work on other mechanisms (cog-wheels, clock hands, etc). This ability to do work is what can be described by the word "energy."

Forms of energy:

Energy comes in different forms. Broadly, all forms of energy can be subdivided into potential energy and kinetic energy.

- kinetic energy (KE) includes all forms of energy associated with movement or motion.
- potential energy (PE) includes all forms of energy associated with the position or configuration (shape) of a system. It is also used to describe energy that is being stored and waiting to be "released."

Examples of Potential Energy Converting to Kinetic Energy

Boy with elastic slingshot - see poster.

- As the boy pulls back on the elastic band, he has to do work in stretching the elastic.
- The stretching of the elastic changes its shape or configuration (position of the molecules realtive to each other).
- Once the elastic is fully stretched, the elastic then has the ability of doing work on the stone. This work will not be done until the boy releases the elastic. So while the elastic remains in the stretched position (no matter how long this is for) we say that is is storing elastic potential energy.
- As soon as the slingshot is released, the elastic contracts and the stone flies out. The moving stone has kinetic energy.
- There will also be some other forms of energy produced, such as sound energy, heat energy, vibrational energy, etc.
- The law of conservation of energy then tells us that the initial potential energy equals the sum of the final kinetic energy (sound energy, heat energy, vibrational energy, etc).

Apple attached to string - see poster.

- As the apple is raised (its position is changed), work has to be done on the Earth's gravitational field. This gives the apple gravitational potential energy.
- The higher the apple is raised, the greater its PE.
- When the string is cut, the apple falls. As it does so, it gains kinetic energy. Some of the initial PE may also be converted to other forms of energy (e.g., heating the air as it falls).

Fuels

A fuel is a chemical substance in which energy (i.e., the potential for doing work) is stored. For instance gasoline is a hydrocarbon that, when burnt, produces heat, which then can drive an internal combustion engine. Food is also a fuel. In the alimentary canal (stomach, intestines, etc.) biochemical reactions result in energy being absorbed by the body. Further biochemical reactions enable the body to function and to do work like walking, running, climbing stairs, and lifting things.

Text B3

NERGY AND CHANGE

- **Energy –** The ability to do work
- **Energy Resources** -non Renewable-Fossil fuels e.g. coal, oil, natural gas
  Renewable e.g. sun,water,wind
- **2 forms of energy** - POTENTIAL(stored)
  -KINETIC(movement)
- **System :** A set of parts that work together to do some work

  A system -receives energy
  - uses some of that energy to do useful work
  - wastes some of that energy
- **Energy givers and receivers**- Some part of the system receives the energy and then gives it to the next part of the system.
  In every system there are energy receivers, when these parts have received energy they become energy givers.

igure 2: *Hair dryer*

Figure 3: *Windmill*

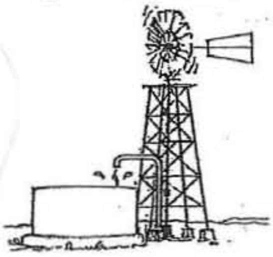


Figure 4: *Thando gets a hair-cut*

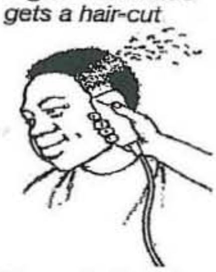


Figure 5: *Ploughing the land*

Figure 6: *Ploughing the land with a tractor*

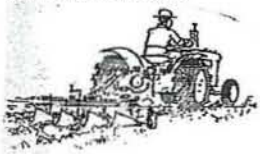


Figure 7: *Heating water on a stove*

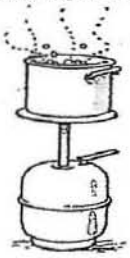
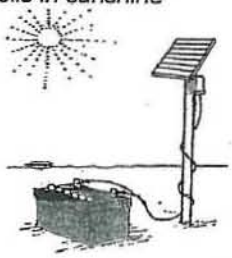


Figure 8: *Listening on a cell-phone*

Figure 9: *Charging a battery from photovoltaic cells in sunshine*



Energy givers →	systems	→ energy receivers
electricity →	hair-dryer	→ hair
.... →	windmill	→ pump
.... →	hair-clipper	→ cut-up hair
grass it ate →	ox	→ plough
.... →	tractor	→ ....
.... →	gas stove	→ ....
.... →	cell-phone	→ loudspeaker

Appendix B: The TIMMS scheme of school science content domains and topics

Content Domain	Topic
Physics	Physical states and changes in matter
	Energy types, sources and conversion
	Heat and temperature
	Light
	Sound and vibration
	Electricity and magnetism
	Forces and motion
Earth Science	Earth's structure and the physical features
	Earth's processes, cycles history
	Earth in the solar system and the universe
Environmental Science	Changes in population
	Use and conservation of natural resources
	Changes in environments
Life Science	Types, characteristics and classification of things
	Structure, function and life processes in organisms
	Cells and their functions
	Development and lifecycles of organisms
	Reproduction and heredity; diversity, adaption and natural selection
	Ecosystems and human health
Chemistry	Classification and composition of matter
	Particle structure of matter
	Properties and uses of water
	Acids and bases
	Chemical change

Appendix C: lists of technical terms in the texts

The table below lists the 55 technical terms from Text A

Indexical	Common	Other
Nonrenewable resources	Waste material	Nutrient
Natural gas	Energy	Agriculture
Phosphates	Electricity	Enviroment
Synthetic substitutes	Heat	Excrete
Element	Power	Algae
Phosphorus		Sediment
Chemical soil fertilizers		Phosphate bearing rocks
Detergents		Population
Emulsifiers		Mineral phosphates
Particles		Conservation of phosphate
The Phosphorus cycle		Exploitation
Dissolved oxygen		Continental shelves
Eutrophication		Continents
Energy yielding		Economic
Fossil fuels		Wildlife
Internal combustion engine		Ecosystems
Petrolium		Political tension
Generating plants		Armed Conflict
Nuclear power		Contaminate
Radioactive		Air Pollution
Power production		Conserve
Technologies		Side effects
		Enviromental scientists
		Nonpolluting
		Wilderness areas
		Industry
		Ecologists
		Conservationists
Total: 22	Total: 5	Total: 28

The table below lists the 16 technical terms from Text B1

Indexical	Common	Other
Conservation of energy	Converted	
Energy transfers	Heat	
Energy input	Current	
Sound energy	Temperature	
Electrical energy		
Light energy		
Kinetic energy		
Thermal energy		
Gravitational potential energy		
Elastic energy		
Chemical reaction		
Total 11	Total 4	Total 0

The table below lists the 51 technical terms from Text B2

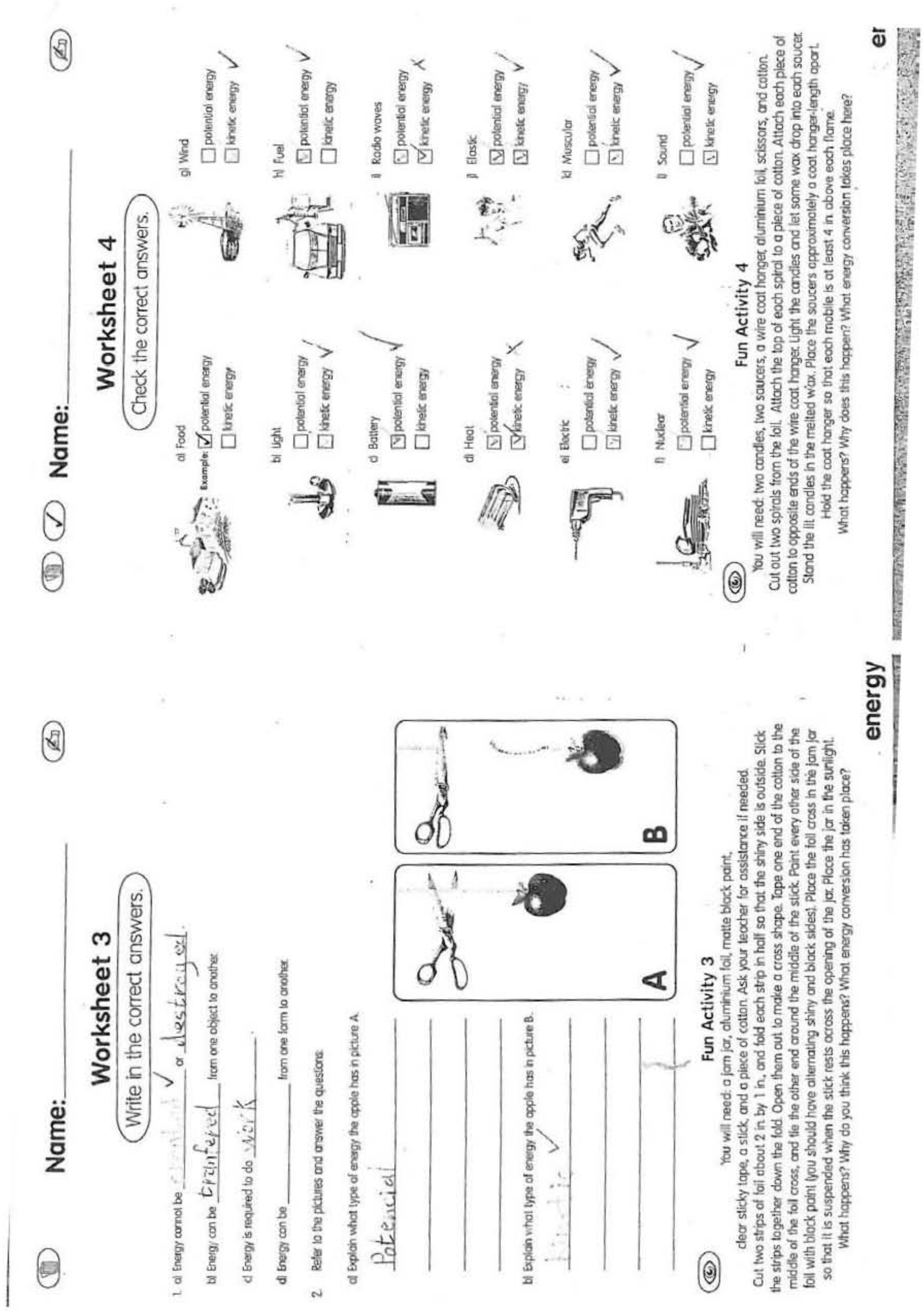
Indexical	Common	Other
Radiate	Energy	Alimentary canal
Cycles of Energy	Work	Intestines
Potential energy	Transferred	
Chemical energy	Transformed	
Kinetic	Fuel	
Nuclear	Gas	
Radio waves	Cell	
Muscular energy	Heat	
Electric energy	Light	
Radiation	Converted	
Conduction	Process	
Convection	Conserved	
Conductor	Force	
Convection currents	A body	
Hydroelectric Energy	Product	
Solar Energy	Distance	
Thermodynamics	System	
Conservation of energy	Absorbed	
Newton meter		
Joule		
Mechanism		
Configuration		
Molecules		
Elastic Potential energy		
Vibrational energy		
Gravitational field		
Gravitational potential		
Chemical substance		
Internal combustion engine		
Biochemical reactions		
Total: 30	Total: 18	Total: 2

The table below lists the 12 technical terms from Text B3

Indexical	Common	Other
Energy Resources	Energy	
Non-renewable	Work	
Fossil Fuels	System	
Renewable	Electricity	
Natural gas		
Potential energy		
Kinetic		
Photovoltaic cells		
Total 8	Total 4	Total 0

Appendix D

Copy of the student activities from School B



Name:

Worksheet 3

Write in the correct answers.

1. a) Energy cannot be created or destroyed.
   b) Energy can be tranfered from one object to another.
   c) Energy is required to do work.
   d) Energy can be ____________ from one form to another.
2. Refer to the pictures and answer the questions.
   a) Explain what type of energy the apple has in picture A.
   Potencial
   b) Explain what type of energy the apple has in picture B.
   kinetic

A B

Fun Activity 3

You will need: a jam jar, aluminium foil, matte black paint, clear sticky tape, a stick, and a piece of cotton. Ask your teacher for assistance if needed.

Cut two strips of foil about 2 in. by 1 in., and fold each strip in half so that the shiny side is outside. Stick the strips together down the fold. Open them out to make a cross shape. Tape one end of the cotton to the middle of the foil cross, and tie the other end around the middle of the stick. Paint every other side of the foil with black paint (you should have alternating shiny and black sides). Place the foil cross in the jam jar so that it is suspended when the stick rests across the opening of the jar. Place the jar in the sunlight. What happens? Why do you think this happens? What energy conversion has taken place?

energy

Name:

Worksheet 4

Check the correct answers.

a) Food — Example: ☑ potential energy ☐ kinetic energy

b) Light — ☐ potential energy ☑ kinetic energy

c) Battery — ☑ potential energy ☐ kinetic energy

d) Heat — ☑ potential energy ☑ kinetic energy

e) Electric — ☐ potential energy ☑ kinetic energy

f) Nuclear — ☐ potential energy ☐ kinetic energy

g) Wind — ☐ potential energy ☐ kinetic energy

h) Fuel — ☑ potential energy ☐ kinetic energy

i) Radio waves — ☐ potential energy ☑ kinetic energy

j) Elastic — ☑ potential energy ☑ kinetic energy

k) Muscular — ☐ potential energy ☑ kinetic energy

l) Sound — ☐ potential energy ☑ kinetic energy

Fun Activity 4

You will need: two candles, two saucers, a wire coat hanger, aluminium foil, scissors, and cotton.

Cut out two spirals from the foil. Attach the top of each spiral to a piece of cotton. Attach each piece of cotton to opposite ends of the wire coat hanger. Light the candles and let some wax drop into each saucer. Stand the lit candles in the melted wax. Place the saucers approximately a coat hanger-length apart. Hold the coat hanger so that each mobile is at least 4 in. above each flame. What happens? Why does this happen? What energy conversion takes place here?

er

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Name: Emma

Worksheet 1

Write in the correct answers.

1. What is energy described as?
Example: The ability to do work. movement
2. What is the Earth's main source of energy?
Sun
3. Refer to the cycles of energy on the poster and answer the following questions.
a) Name three sources of energy.
Kinetic Potenial and Chemical.
b) What type of energy does a stationary truck have?
Potencial.
c) This type of energy is converted into another type of energy when a truck moves. Into what type of energy is it converted?
Kinetic
d) What type of energy is converted when plants and animals have food?
Pontential
e) What type of energy does food give plants and animals?
Potential
f) How were coal and oil formed in prehistoric times?
When the plants and animals died they eventualy became oil and coal.
4. Define the following types of energy.
a) Kinetic energy
Movement
b) Potential energy
Something that is going to have energy.

Fun Activity 1

Refer to the following examples and write down the energy conversion for each one.
You will need to use reference books for this.

Example:	Energy Conversion
a) A radio which is turned on	Electrical energy to sound energy
b) An electric heater	Potenial energy to heat energy
c) A running girl	Potenial energy to Kinetic
d) A shining flashlight	Potenial energy to kinetic light
e) A rubber band is released	Potenial energy to Kinetic
f) A boiling kettle	Potenial to Kinetic electrical to kinetic
g) Rubbing hands together	Potenial to kinetic and heat energy
h) Burning coal	Potenial to heat
i) Photosynthesis	Chemical energy to kinetic energy.

Name: Emma

Worksheet 2

Check or write in the correct answers.

1. a) What does the sun radiate into space?
Example: ☑ energy
☐ liquids
☐ gases
b) How does heat energy from the sun reach the Earth?
☑ through radiation
☐ through convection
☐ through conduction
c) The remains of dead animals can form oil over a long period of time.
☑ true
☐ false
d) Fuel is a source of potential energy.
☐ true
☑ false
e) A moving truck has potential energy.
☐ true
☑ false

2. a) Write down four examples of potential energy from the poster and state what these types of energy have the potential to become.

Example: nuclear energy	can become: heat energy
i food - kinetic energy	can become: kinetic energy
ii elastic - kinetic energy	can become: kinetic energy
iii fuel - kinetic energy	can become: kinetic energy
iv cell - kinetic energy	can become: kinetic energy

b) Write down six types of kinetic energy from the poster and give an example for each.

Example: wind	comes from: a windmill
i radio wave	comes from: Electrical
ii music	comes from: food
iii light	comes from: candle
iv eletric	comes from: in food kinetic energy
v sound	comes from: radio vocal cordes
vi falling apple	comes from: ~~tree~~ kinetic energy

Fun Activity 2

Collect as many pictures as possible from magazines and newspapers that show different types of energy.
Arrange them in the form of a collage on an piece of posterboard.
Don't forget to write the heading "Energy" in the middle of the page.