Introduction:

The meaning conveyed in a rap song may be a mystery to many people; this indecipherability is simply because the listener does not have an adequate grasp of the particular language style used in rap music. Were the listener a member of the rap community, they would have no difficulty understanding the meaning of the song because the specialised language required for comprehension would be transparent to them. Just as with rap music, members of the science community have no trouble using the scientific style of language; it is transparent to them. However, with no explicit understanding of what the style consists of, they may have difficulty describing it to others with no prior exposure to it. One such group with no prior knowledge is secondary science students. They are expected to use the scientific language style to learn and express themselves, but have no knowledge of how.

This essay explores the specific language style found in secondary science classrooms. Firstly, the characteristic language features of three samples of text will be discussed. The samples are from secondary science textbooks. The analysis will be performed at the word, sentence and paragraph level using modern descriptive grammar and Flesch-based scales. After discussing the samples individually, the descriptions will be synthesized into an account of the characteristic language style likely to be encountered by secondary science teachers and students. Followed by an exploration of the features of this style of language that are likely to cause problems for students.

Sample 1:

The first sample analysed was from senior secondary physics textbook titled *Macmillan Physics 1* (Butler, 2000) and was on the topic of the brightness of stars, see appendix 1.

First, an qualitative grammatical analysis was performed on the sample by studying the language at word, sentence, paragraph and document levels. As a whole, the sample text was found to value precision and clarity. Its purpose was to define, describe and explain. At the word level, nouns were very prominent, especially technical and semi-technical words. General content words also occurred frequently. At the sentence level, precision significantly affected language use, with articles, modifiers and propositions featuring recurrently. At the paragraph level, clarity was key, with the author using reference, conjunction and repetition cohesive devices. The verb voice was primarily active.

Following the observational approach, a more quantitative analysis was performed using the readability statistics feature of Microsoft Word. This indicated that the text sample had a Flesch-Kincaid Grade Level of 11 and a Flesch Reading Ease of 43. Therefore, the target Stage 6 age group should be able to comfortably read this text. However, the text sample had 4 sentences per paragraph, 17 words per sentence and 5 characters per word. This suggests that it is moderately dense and may present problems for some students. The quantitative analysis agrees that the verb voice is primarily active; 16% of sentences are passive.

Sample 2:

The second sample analysed was from stage 5 science textbook titled *Core Science 4* (Haire, 2000) and was on the topic of genetic mutations, see appendix 2. As with the first sample, qualitative grammatical analysis and then a quantitative analysis were performed on the text.

This sample, as a whole valued precision and clarity. It primarily involved definitions and explanations. At the word level, again nouns were very prominent, especially technical and semi-technical words. Precision determined the language use at the sentence level; articles, modifiers and propositions were common. At the paragraph level, clarity determined language use, with this author using reference, conjunction and repetition cohesive devices. However, in this text sample, conjunctive cohesive markers, such as *therefore* or *however*, were used extensively. They were used in the context of improving precision, perhaps however to the detriment of text cohesion. Branching was also used within sentences, again to aid in precision. However, this language technique also compromised the cohesion of the text. Again the verb voice was primarily active.

The quantitative analysis demonstrated that the text sample had a Flesch-Kincaid Grade Level of 10 and a Flesch Reading Ease of 46. The target Stage 5 age group should have little difficulty reading this text. The text sample had 4 sentences per paragraph, 14 words per sentence and 5 characters per word. These are similar values to the Stage 6 text again indicating that the text is somewhat dense. In this case it would cause difficulty for the younger age group. With 27% of sentences are passive, the verb voice is primarily active as found in the quantitative analysis.

Sample 3:

The third sample analysed was from a stage 4 science textbook titled *Longman Science 1* (Bilali, 1999) and was on the topic of the respiratory system, see appendix 3. As with the previous two samples, a qualitative grammatical then quantitative analysis was performed on the sample text.

Similarly, this sample valued precision and clarity, however, brevity was also valued. The primary purpose was to describe, with some explanation and definition. At the word level, nouns were very important, especially technical and semi-technical words. At the sentence level, precision determined the language use, and articles, modifiers and propositions were employed. At the paragraph level, clarity and brevity was important, so cohesive devices such as reference, conjunction and repetition were used. As with the second sample, conjunctive cohesive markers and sentence branching were used to aid precision, possibly to the determent of text cohesion. Again, this text is primarily in the active voice, although not as significantly as the previous two samples.

The quantitative analysis established that this sample had a Flesch-Kincaid Grade Level of 7 and a Flesch Reading Ease of 68. The text sample had 6 sentences per paragraph, 14 words per sentence and 4 characters per word. The target Stage 4 age group should have little difficulty reading this text. However, a group of stage 4 students may have a more diverse reading ability coming from the primary education system than stage 5 or 6. Therefore, a Flesch-Kincaid Grade Level of 7 may be appropriate. The text is not as dense as the previous two samples but some grade 4 students may find it so. The brevity of the text would be an asset to such students. With 41% of sentences being passive, just over half of the text is in the active voice, confirming the observational analysis results.

Synthesis:

Based on analysis of these three samples, see appendix 4, it is possible to construct a description of the characteristic features of the language style likely to be encountered in secondary science.

We can see that this language style values precision, clarity and possibly brevity. It is primarily concerned with defining, explaining and describing concepts and physical systems.

At the word level, nouns were very prominent, especially technical and semi-technical words. At the sentence level; articles, modifiers and propositions were common. And at the paragraph level cohesive devices were used effectively to maintain clarity. Branching within sentences occurred frequently enough to be included as a characteristic feature. The verb voice was primarily active.

Word stacks and grammatical metaphor were found extensively in other samples not included in the analysis. As such, they should also be considered characteristic features of the language style.

There appears to be a tension between precision and clarity within this style of language. A concept or physical system requires many affirmative and negative technical and semi-technical nouns and adjectives to define it precisely. However, to maintain clarity this wordiness is limited, and the result is brevity. This tension is an asset to those familiar with the language style but could cause confusion for those unexposed to the style.

Student difficulties:

Since secondary science students essentially have no prior exposure to the language style they encounter in the classroom, we can expect that some of them will experience difficulty understanding aspects of it. And without a pragmatic understanding of the style, students will experience difficulty extracting science information masked by the language style.

The secondary science teacher can use this language style effortlessly. This can be a problem when the teacher is unaware that the students' do not share this grasp of the specialised language. A student's frustration may be mistakenly diagnosed as a learning problem, poor cognitive ability or even misbehaviour, when really; she is simply unable to deal with the specialised language style.

Based on the synthesis of characteristic features of the language style, it is possible to predict areas where students may encounter difficulty.

The most obvious feature that could cause difficulty is the numerous technical words such as capillaries, photometry and chromosomes. However, the semi-technical words also present problems; words such as visibility, replication and contracting (O'Toole, 2003). Clearly the technical words would require an explanation if students are to grasp the associated meaning. However, the majority of text within these samples is dedicated to that exact purpose; explaining, defining and describing the concepts associated with these technical words. Therefore the technical words receive adequate explanation from the text and from the teacher. The problem is that this explanation relies on many semi-technical words. If students do not understand the meaning of the sometimes ambiguous semi-technical words then they will not understand the meaning of the text. At best they will find the text frustrating to read and possibly become unmotivated towards the science topic being covered. Therefore, technical, semi-technical and ambiguous general content words could be an area of difficulty for students.

The cohesive devices used frequently in the style could present significant difficulty to students who do not understand their usage, especially the reference cohesive device (Shi, 2004). If students do not understand this then they will have a very hard time following a passage of text for through an extended explanation or argument.

Language techniques used to improve precision, sometimes to the determent of clarity, could cause problems for students. Word stacks, branching sentences and conjunctive cohesive markers are chief examples. Without them, the text would lack the required precision but with overuse the clarity of the text is lost. Therefore, although they are an integral part of the language style they could easily confuse students.

The brevity and densely packed nature of this language style could present difficulty to students. Intuitively, a student may assume that if a sentence is brief it contains little information. However, this assumption is incorrect when dealing with the secondary science language style. Within a concise section of text there is commonly a rich content of information presented in a very precise way. Students unaware of this may miss information integral to understanding of a passage of text.

Conclusion:

This essay has defined the characteristic language style found within secondary science classrooms and explored the features of this style that could cause difficulty for students expected to operate within this language style. By quantitatively, qualitatively and grammatically analysing samples from textbooks found in current secondary science classrooms we were able to synthesis an account of the characteristic features of the language style. We found that it values precision, clarity and brevity. And is primarily concerned with defining, explaining and describing. By looking more closely at the grammatical features of the style we were able to identify features that could cause difficulty for students unfamiliar, yet expected to function, with this language style. The features of concern were the technical, semi-technical and ambiguous general content words, and cohesive devices, word stacks and branching sentences. The denseness of the text, and hence unpacking required by students to understand the text, was also a concern.

The accuracy of the analysis is questionable due to the small sample size; however, the results are similar to those found in the literature (O'Toole, 2003). It should be noted that this language style is not limited to written text and the analysis should apply similarly to the language style found spoken in secondary science classrooms, however, this has not been verified. To conclude, Secondary science teachers need to become aware and reflective on their effortless use of the language style found in the classroom. It may not be such an effortless experience for their students.

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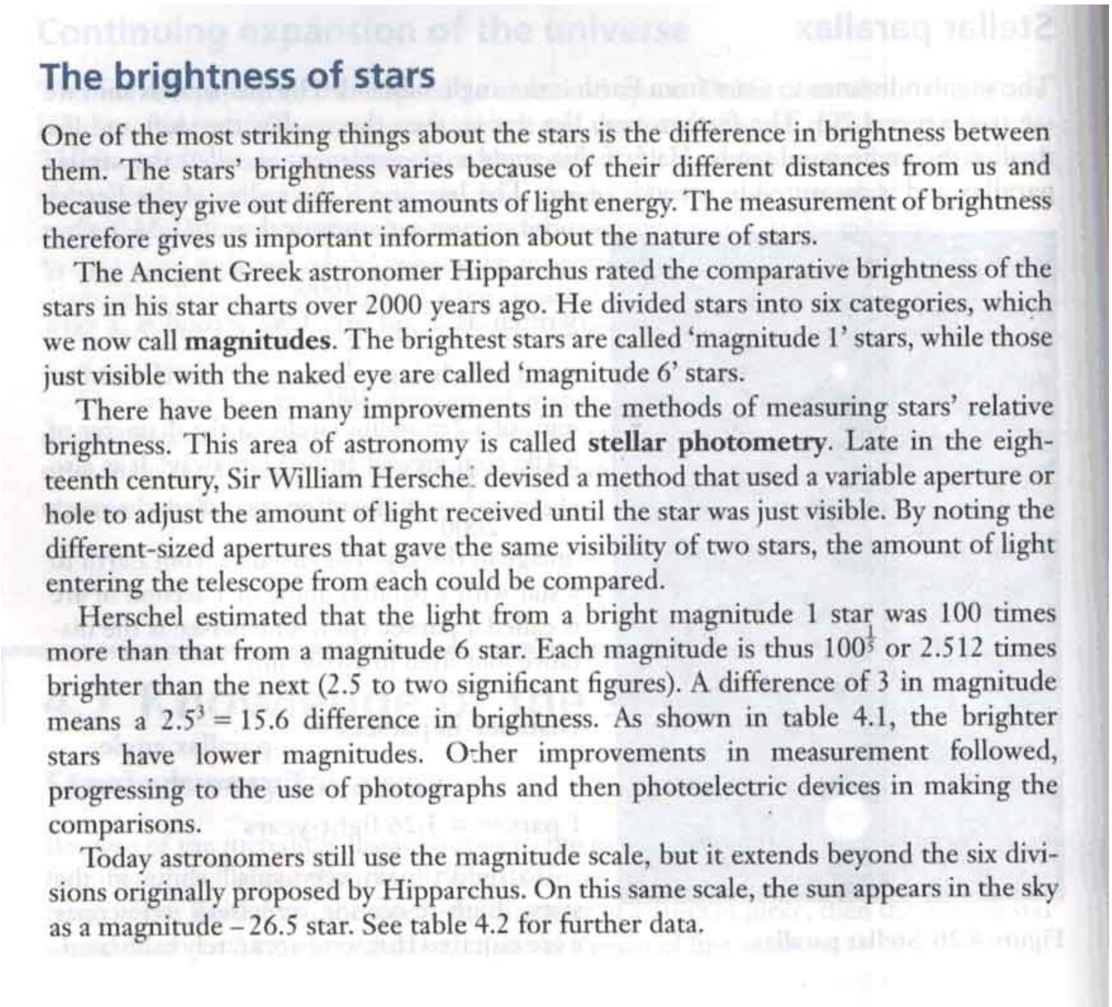
Appendix 1:

Stage 6 Text Sample

Butler, M., Hopkins & D., Willis, J. (2000). *Macmillan Physics 1 : preliminary course*. South Yarra: Macmillan Education Australia Pty Ltd. p. 244.

Scanned Image



The brightness of stars

One of the most striking things about the stars is the difference in brightness between them. The stars' brightness varies because of their different distances from us and because they give out different amounts of light energy. The measurement of brightness therefore gives us important information about the nature of stars.

The Ancient Greek astronomer Hipparchus rated the comparative brightness of the stars in his star charts over 2000 years ago. He divided stars into six categories, which we now call **magnitudes**. The brightest stars are called 'magnitude 1' stars, while those just visible with the naked eye are called 'magnitude 6' stars.

There have been many improvements in the methods of measuring stars' relative brightness. This area of astronomy is called **stellar photometry**. Late in the eighteenth century, Sir William Hersche. devised a method that used a variable aperture or hole to adjust the amount of light received until the star was just visible. By noting the different-sized apertures that gave the same visibility of two stars, the amount of light entering the telescope from each could be compared.

Herschel estimated that the light from a bright magnitude 1 star was 100 times more than that from a magnitude 6 star. Each magnitude is thus $100^{\frac{1}{5}}$ or 2.512 times brighter than the next (2.5 to two significant figures). A difference of 3 in magnitude means a $2.5^3 = 15.6$ difference in brightness. As shown in table 4.1, the brighter stars have lower magnitudes. O:her improvements in measurement followed, progressing to the use of photographs and then photoelectric devices in making the comparisons.

Today astronomers still use the magnitude scale, but it extends beyond the six divisions originally proposed by Hipparchus. On this same scale, the sun appears in the sky as a magnitude −26.5 star. See table 4.2 for further data.

Text – From OCR Software

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Text Analysis by Microsoft Word

Counts

Words	303
Characters	1562
Paragraphs	5
Sentences	18

Averages

Sentences per Paragraph	3.6
Words per sentence	16.8
Characters per word	5.0

Readability

Passive Sentences	16%
Flesch Reading Ease	42.6
Flesch-Kincaid Grade Level	11.4

Appendix 2:

Stage 5 Text Sample

Haire, N., Kennedy, E., Lofts, G., Evergreen, M. J., (2000). Core Science 4. Milton: John Wiley & Sons Australia, Ltd. p. 184.

Scanned Image

DNA is very stable and it can be replicated into an exact copy of itself. This occurs by the helix unwinding and the base-pairing of a new chain of nucleotides onto the unwound chains. This results in the passing on of genetic information that is unchanged from one generation to the next. However, occasionally errors can occur as the DNA is being copied. This means the instructions originally carried by the code are not followed exactly.

Uneven sharing of chromosomes and other genetic errors can occur during cell division and DNA replication. Such changes to genes and chromosomes in living things are called **mutations**.

Mutations

Mutations can happen by pure chance or be due to a particular cause such as ultraviolet radiation or too much exposure to X-rays. Any factor that triggers mutations in cells is called a **mutagen**. The chemicals formalin and benzene (which used to be common in pesticides) are examples of mutagens.

Changes in the letters of a word can change the word's entire meaning. Read the sentences below as they are, then delete, insert, or invert (turn around) the letters in boldface italics and read them again.

Changes like these in the DNA sequence change the 'meaning' of the code. Minor mutations in body cells seem to have no adverse effect. The body's immune system usually recognises the changed cells and destroys them quite readily.

However, in some cases the mutation has a more severe effect. A necessary enzyme, for example, is not made or a faulty version is produced. Too much or too little of a particular protein could be the problem. A diabetic is not able to produce insulin because of a defective gene. Consequently, blood glucose levels can not be regulated without treatment.

Certain mutations result in uncontrolled cell division, which can result in cancerous **tumours**. Plants can suffer from tumours too.

Not all mutations are harmful. Some species of organisms, such as insects, depend on them for survival. Pesticides may kill the majority of insects sprayed but there will be some that have slight variations or mutations in their genes, which give them resistance. The mutated genes are passed on to the offspring, who will gain that resistance too. The insects without the resistance will die out. Resistance by bacteria to antibiotics occurs in a similar way. While resistance in certain insects may be good news for them, resistance to antibiotics in bacteria means it becomes very difficult to treat conditions caused by certain bacteria.

Text – From OCR Software

DNA is very stable and it can be replicated into an exact copy of itself. This occurs by the helix unwinding and the base-pairing of a new chain of nucleotides onto the unwound chains. This results in the passing on of genetic information that is unchanged from one generation to the next. However, occasionally errors can occur as the DNA is being copied. This means the instructions originally carried by the code are not followed exactly.

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Text Analysis

Counts

Words	413
Characters	2087
Paragraphs	8
Sentences	29

Averages

Sentences per Paragraph	4.1
Words per sentence	14.2
Characters per word	4.9

Readability

Passive Sentences	27%
Flesch Reading Ease	46.4
Flesch-Kincaid Grade Level	10.3

Appendix 3:

Stage 4 Text Sample

Bilali, S. Boot, F., Heffernan, D., Miller, R., (1999). Longman Science 1. Melbourne: Addison Wesley Longman Australia Pty Ltd. p. 127.

Scanned Image

Breathing in and out

Air is taken in through the nose, where it is warmed and moistened. Dust particles are filtered out. Air travels down the throat into a large tube, the trachea or windpipe (Figure 6.4A). The air enters when the chest expands and leaves when forced out by the chest contracting.

Windpipe

The *windpipe* (**trachea**) is a ringed tube and is very flexible. The rings are made of *cartilage*—you can feel cartilage in the tip of your nose and the top of your ear. Cartilage prevents the windpipe from collapsing when you breathe in. At its lower end the trachea is divided into two tubes called **bronchi**. These tubes lead into the lungs. Inside your lungs the bronchi further branch into smaller and smaller tubes, ending with a cluster of air sacs. These air sacs are surrounded by capillaries where gas exchange occurs (Figure 6.4B). Oxygen from the air sacs moves into capillaries and into the bloodstream. Carbon dioxide in the blood moves into the air sacs and is then breathed out by the lungs.

Text – From OCR Software

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Text Analysis

Counts

Words	178
Characters	833
Paragraphs	4
Sentences	12

Averages

Sentences per Paragraph	6.0
Words per sentence	14.4
Characters per word	4.5

Readability

Passive Sentences	41%
Flesch Reading Ease	67.5
Flesch-Kincaid Grade Level	7.4

Appendix 4:

Analysis Item	Stage 4	Stage 5	Stage 6
Words	178	413	303
Characters	833	2087	1562
Paragraphs	4	8	5
Sentences	12	29	18
Sentences per Paragraph	6.0	4.1	3.6
Words per Sentence	14.4	14.2	16.8
Characters per Word	4.5	4.9	5.0
Passive Sentences	41%	27%	16%
Flesch Reading Ease	67.5	46.4	42.6
Flesch-Kincaid Grade Level	7.4	10.3	11.4