

# Potential Sources of Comprehension Difficulties in Advanced Secondary School Science Textbooks: The Case of Uganda

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## Abstract

*This paper is based on a doctorate study that investigated curricular and teacher-training implications of the quality of texts used in the teaching and learning of science in Ugandan secondary schools. In most sub-Saharan Africa, science and technology are prioritised as the key to modernisation of the economies from agricultural to industrial-based. Unfortunately, despite such attempts as giving special incentives to science teachers and students to improve enrolment, teaching, learning, and performance, the situation is still far from satisfactory. The paper argues that a crucial factor that influences the success and/or failure of the teaching and learning of science subjects is the quality of the textbooks: how well (or badly) they are written in relation to their purpose and intended audience. Drawing on a number of approaches to discourse analysis, excerpts selected at regular intervals from the science textbooks used in schools in Uganda are analysed. The analyses reveal textual flaws, particularly in the way relations between propositions are constructed and signalled, that are likely to make them more difficult for students to comprehend. The paper further explores how the flaws might be rectified.*

## 1. Introduction

It is widely recognised that students in Uganda perform poorly in science subjects (Uganda National Examinations Board, 1996-2006). Students' poor performance in science subjects at an average failure rate of 30% can be attributed to a multiplicity of factors including but not limited to shortage of properly trained science teachers, teachers' morale, and absence of infrastructure facilities, overcrowded classrooms, inadequate evaluation and assessment mechanisms. Added to these (and probably most important) is the language used for communicating knowledge, especially in contexts where the medium of instruction and learning is a second language. It is no longer debatable that language can easily impose limitations on learning. This becomes even more critical in the sciences where the understanding of a great many concepts requires the learner to be familiar with certain complex modes of thought used by scientists. Considering that students are meeting the science concepts for the first time, the success, or otherwise, of their learning process may therefore be heavily influenced by the clarity and accessibility of the language used.

The teacher is clearly a critical element in the teaching-learning process; but many educationists contend that textbooks are the single most important contribution to improved learning in the schools (cf. Craig, 2006; Johnsen, 1993; Gopinathan, 1983, Chambliss & Calfee, 1989). Comparing the textbook to the teacher, Davies (1986) notes that the textbook may be seen to be more accessible as a source of information; for the textbook has the advantage of being permanently available for reference, for questioning, sifting and testing.

However, textbooks can only be a valuable aid to learning if they are well-written and the intended ideas are properly presented (Coulthard, 1994; Crookes, 1980). There is the obvious potential disadvantage that it is not possible for students to have dialogue with the writers so that they can pose questions about what is not clear. In addition, in a country such as Uganda the need for the textbooks to be well-written is greater in that the language of the textbooks that the students are supposed to learn from might not be their first language. There is also the question of students' reading ability: unless students are conversant with the rhetorical organisation of expository texts, they are most likely to encounter difficulties.

In the appraisal of school textbooks, orthodox methods have used readability formulae to establish levels of textbook difficulty. Attention has often been focused on such syntactic difficulties as the number of words and syllables per sentence, the proportion of words in dependent clauses, subordinate clauses, order of clauses (direct or inverted), extent of use of modifiers, and so on (Kintsch & van Dijk, 1983; Aukerman, 1972).

However, other possible sources of reading comprehension difficulty, including lack of background knowledge about the subject, and the ways in which the texts are organised, are equally important, but these seem not to have received as much attention. Hence it is worth undertaking an analysis of textbooks used for learning science at the Advanced Level of secondary school with a view of establishing whether they are badly written, and, if so, to identify as precisely as possible the ways in which they are badly written. The focus therefore shifts from features of the wording of individual clauses (as in the studies cited above) to the relationships between propositions in the texts: how the propositions are related and whether or not the relationships are explicitly and clearly signalled.

In the present paper, derived from a broader study into the language of science textbooks and the effects on student comprehension and learning (Ssebbunga-Masembe, 1997), we set out to describe the approach taken to the analysis of the textbooks, and to present an illustrative sample of the main kinds of flaws that emerged in the writers' handling of relations between propositions.

## **2. The analytical approach**

The analysis had two objectives. While a supplementary part of the analysis sought to show how the identified faults could be corrected and/or improved, the primary objective was to identify possible proposition-relational flaws that can lead to reading comprehension difficulties – especially for inexperienced readers. Three theoretical orientations informed the analysis: Systemic Functional Linguistics, de Beaugrande and Dressler's Text-Linguistics, and the Clause Relational Approach. We will first briefly consider each in turn.

### **2.1 Systemic Functional Linguistics**

Systemic Functional Linguistics (SFL) is concerned with the function of language. Unlike the structural approaches that emphasise language elements and their combinations, SFL puts more significance on what the language does and how it does it (see Halliday, 1973, 1994). Within SFL a number of sets of choices can be focused on in the analysis of how texts hang together (e.g. reference: personal, demonstrative, comparative; substitution: verbal, clausal, nominal; and ellipsis: clausal, nominal, and verbal – see Halliday & Hasan, 1976). Additionally (and of more relevance for this analysis) is the logico-semantic phenomenon of conjunction and the ways in which relations between propositions can be signalled: in particular conjunctive Adjuncts (e.g. *neither, however, consequently*), hypotactic conjunctives (e.g. *because, although, after*), and paratactic conjunctives (e.g. *thus, but, and*).

### **2.2 de Beaugrande and Dressler's Text-Linguistics**

Taking cognisance of the issues raised by SFL, de Beaugrande and Dressler (1981: 73ff) establish the following textual features as particularly significant in how propositions may be related: (i) functional sentence perspective in terms of theme-rheme; given-new; (ii) recurrence with regard to repetition of elements or patterns; (iii) tense, aspect, and junction as signals for the relationships between and among propositions in the text; (iv) pro-forms used in substituting content-carrying elements with short place holders such as demonstrative and personal references; (v) use of parallelism in repeating a structure using new elements; and (vi) ellipsis used in repeating a structure together with the content, but leaving out some expressions.

### 2.3 The Clause Relational Approach

Winter (1977) and Hoey (1983, 1988) note that a Clause Relational Approach to discourse analysis is based on the assumption that the moment we place two sentences together for the purpose of communicating with somebody else, these two sentences enter into a relation in which the understanding of the one sentence in some way depends on the understanding of other sentences in the text. In other words, when sentences are read together, their interpretation takes into account their juxtaposition.

There are three groups of lexical items that facilitate the signalling of text patterns and relationships, categorised into Vocabularies 1, 2, and 3 (Winter, 1977). Vocabulary 1 consists of such items as *because, if, when, while, although, though, after, as, before, in order that*, which: (a) signal the relationship between clauses; (b) combine two clauses into a single complex clause; and (c) are themselves grammatical items. Vocabulary 2 consists of such items as *therefore, so, yet, then, meanwhile, afterwards, consequently, in comparison, on the contrary, in addition, similarly, for example, in particular*, which: (a) signal the relationship between sentences or groups of sentences; (b) leave the clauses/sentences separate; (c) are themselves grammatical items. Vocabulary 3 consists of such items as *cause, result, consequence, comparison, additional, similar, example, means, illustrate, purpose, effect, situation, summarise, exception*, which: (a) may signal the relationship between sentences, groups of sentences or part of sentences; (b) are part of the grammar of the clauses in which they appear; and (c) are themselves lexical items.

### 3. The approach in action

Drawing on the principles underlying the framework outlined above (especially the discussion in Hoey 1983), it was predicted that there would be three main possible sources of problems in the textual organisation: (i) misleading a reader to expect a certain type of proposition-relationship and patterning, when instead another type is used (mis-signalling); (ii) a failure to make sufficient use of the signalling devices (under-signalling); and (iii) a hole in the proposition-relationship patterning due to the absence of a proposition-relational member in the proposition-relationship network (inter-proposition-relational gap and/or unpredictable proposition-relations).

The study used samples of text from a number of science textbooks used at 6<sup>th</sup>-form level in secondary schools in Uganda. The text samples were selected randomly at regular intervals, with the proviso that each extract should be relatively self-contained (this was made easier to implement by the fact that the textbooks were generally made up of fairly short sections each

dealing with a different aspect of the topic of that unit). Based particularly on Hoey and Winter's approach, three methods were used in the analysis: identification and use of lexical signals and repetition; projection into dialogue using the question-answer technique; identification and use of parallelism in structures.

### 3.1 A sample extract

These techniques, and the potential textual flaws that they threw up, can be illustrated using the following extract (sentences/independent clauses are numbered for ease of reference):

Text 1: *Cloud Chamber Tracks*

*(1a) The appearance of the cloud tracks depends on the particles concerned (1b) and can be used as a means of identification. (2a) The comparatively massive  $\alpha$ -particles pursue straight paths, pulling electrons off atoms as they go (2b) and creating up to 10000 ion-pairs per centimetre of their path. (3) The resultant cloud tracks are straight and thick. (4a) By contrast, the very light  $\beta$ -particles suffer frequent repulsions from the electrons near which they pass (4b) and make ionizing collisions far less frequently. (5a) They make only a few hundreds of ion-pairs per centimetre of their path (5b) and consequently they display thin irregular cloud tracks. (6)  $\gamma$ -rays do not produce cloud tracks along their own paths. (7a) A gamma photon may, however, interact with an atom in its path (7b) and give up either a part or the whole of its energy in ejecting an electron from it. (8a) The electrons then behave like  $\beta$ -particles (8b) and produce irregular cloud tracks of their own which branch out from the direction of the gamma.*

This extract is about the characteristics of cloud tracks formed by different kinds of atomic particles as they pass through a piece of laboratory equipment called a cloud chamber. The writer wants the reader to know the causes of the different features and behaviours of cloud tracks. To do this, the text is organised on the basis of a combination of Preview-Detail and Matching Contrast proposition relations as diagrammatically illustrated below.

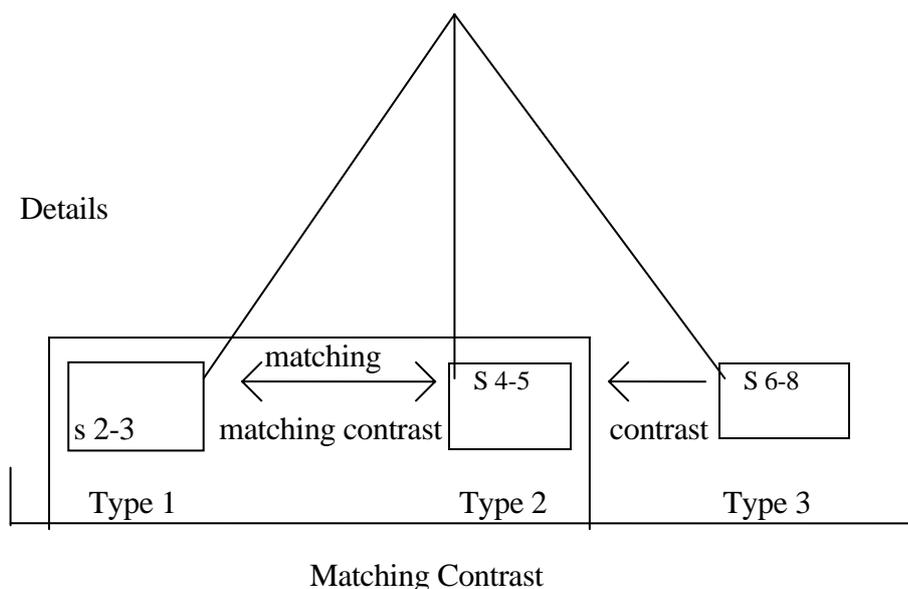


Figure 1: Organisation of the text “Cloud Chamber Tracks”

One way of justifying the presence of the clause relations shown above is by projecting the discourse into dialogue. For example, the Preview-Detail relation can be probed as follows:

A: *The appearance of the cloud tracks depends on the particles concerned and can be used as a means of identification.*

B: Give me an example where the appearance of the cloud tracks depends on the particles concerned.

A: *The comparatively massive  $\alpha$ -particles pursue straight paths, pulling electrons off atoms as they go and creating up to 10000 ion-pairs per centimetre of their path.*

B: Give me an example where cloud tracks can be used as a means of identification.

A: *The resultant cloud tracks [from the comparatively massive  $\alpha$ -particles] are straight and thick, etc.*

A matching contrast proposition relationship may be highlighted/signalled through use of such means as repetition, conjuncts (or if none is present, the possibility of inserting one in the discourse), syntactic and/or semantic parallelism, lexical items, presence of antonyms, negation, denial paraphrase or signalling in the immediate context (cf. Hoey, 1991). In the sample extract above, we can identify the following discourse signals that indicate the intended organisation.

The clearest signal that a matching contrast relation is being established is the conjunct ‘by contrast’ in (s4a): ‘By contrast, the very light  $\alpha$ -particles suffer frequent repulsions from the electrons near which they pass’. This is reinforced by lexical contrast between ‘comparatively

massive’ in (s2a) and ‘very light’ in (s4a), and between ‘straight and thick’ in (s3) and ‘thin and irregular’ in (s5b). Within each pair in this contrast, there is also a cause-effect relation, signalled by the lexical item ‘resultant’ in (s3) and the conjunct ‘consequently’ in (s5b). The matching contrast relationship between (s2)-(s3) and (s4)-(s5) can be represented in tabular form as shown in Table 1, which also brings out some less obvious parallels between the description of the two particles (the shared elements to which the differences are ‘pegged’ are in italics).

$\alpha$ -particles	<i>by contrast</i>	$\beta$ -particles
comparatively massive $\alpha$ - <i>particles</i>		very light $\beta$ - <i>particles</i>
pulling <i>electrons</i> off atoms		suffer frequent repulsions from the <i>electrons</i>
<i>creating</i>		<i>making</i>
up to		only
10000		a few hundreds of
<i>ion-pairs</i>		<i>ion-pairs</i>
<i>The resultant</i>		<i>Consequently</i>
<i>cloud-tracks</i>		<i>they display ... cloud tracks</i>
are straight and thick		thin irregular

Table 1: Matching relationships between sentences (2a) and (4a)

The relationship of this pair to the description of the third particle in (s6)-(s8) is less clearly signalled. It would be possible to insert either of the conjuncts ‘however’ or ‘on the other hand’ at the start of (s6). The negation in (s6) ‘do not produce cloud tracks’ plays the same role of showing the matching contrast relationship. This negation provides a denial paraphrase which is another lexical way of signalling the matching relationship. In (s6) the attribute of ‘producing cloud tracks’ which  $\langle$ -and- $\otimes$  particles are capable of is denied for the  $\odot$ -rays which are being compared to them.

### 3.1.1 Problems associated with the way the intended relationships are expressed

The sample text also illustrates some of the textual problems that were identified. Despite the presence of the above noted textual features, there are potential areas of difficulties associated with how these very features are expressed – especially for inexperienced learners who are meeting the topic under discussion for the first time.

First, the first sentence says: (1a) *The appearance of cloud tracks depends on the particles concerned* (1b) *and can be used as a means of identification*. The second part (1b) of this sentence is likely to cause difficulties because the writer seems to assume that the reader can

easily understand the relationship existing between the first part of the sentence and the second. This, however, might not be the case because the fact that the different particles make different cloud tracks, and that this very fact can be used to explain how the particles can be identified, is only implicitly indicated. The sentence connector used *and* is not an unambiguous signal of the intended cause-consequence relationship between (s1a) and (s1b). Hence the likely proposition-relational problem can be categorised as **mis-signalling**.

Additionally, what is to be 'identified' is not explicitly stated and this implicit statement of the relationship existing between the two propositions, coupled with the learner's lack of prior domain-specific knowledge about cloud tracks, could be a source of reading comprehension difficulties. This problem could be overcome by rephrasing the sentence as follows: (1) *The appearance of the cloud tracks varies according to the particles concerned.* (2) *The different types of tracks can therefore be used as a means of identifying which type of particle is passing through the cloud chamber.* With texts organised on preview-detail relationships, the preview consists of non-specific information. The specific information is given as the detail to make the generalisation specific. For that reason, sentence (1b) needs to clarify what specifics the reader should expect. This would contribute towards helping the reader formulate questions that can be used in interrogating the text.

Let us now turn to the way the matching contrast relationships are organised. Despite the presence of the clear signal of contrast *by contrast* in the third paragraph, the organisation of the matching contrast relationships illustrated in table 2 above presents another possible proposition-relationship problem of the type referred to as **under-signalling**. For instance, as noted above (s2) provides the reason why  $\gamma$ -particles pursue straight paths and this is supposed to be contrasted with the reason in (s4a), i.e. why  $\alpha$ -particles pursue irregular paths. The problem with the reason in (s2b) and (s2c) is that it is not clearly signalled. One cannot easily recognise from this sentence that the reason why the comparatively massive  $\alpha$ -particles pursue straight paths is because they pull electrons off atoms, and the reason why their paths are thick is because they create many ion-pairs.

Another proposition-relational problem is that the reader needs to understand, without it being made explicit, that *pulling electrons off atoms* in (s2b) is intended to contrast with *suffering repulsions from electrons* in (s4a), and that *suffering repulsions* leads to *irregular tracks* – the latter description is not mentioned until (s5b) and *consequently* in this clause appears to signal that the irregularity of the tracks is the result of the small number of ion-pairs created as

mentioned in (s5a). This proposition-relational **gap** can be illustrated by setting it out in tabular form as shown in table 2 below.

	$\alpha$ -particles	$\beta$ -particles	$\gamma$ -rays
Nature of paths	√	?	√
Nature of tracks	√	√	√
Reason	?	√	√

**Table 2: Graphic representation of the clause relational gap**

The third problem with this text relates to the writer's failure to make the on-going matching contrast of the particles quite explicit when the text turns to  $\ominus$ -rays in (s6). The sentence reads: (6)  *$\ominus$ -rays do not produce cloud tracks along their paths*. It would be more helpful to spell out the relationship between  $\ominus$ -rays with regard to the features that have been discussed for  $\langle$ -and  $\oplus$ -particles.

In several places, therefore, the writer leaves it to the reader's abilities of inference to fill in the missing information. In the event of failing to make the required inference, the reader would most likely face difficulties trying to understand the intended meaning because of inability to establish coherence in the textual propositions, both through parallelism of information and through lexical repetition making these parallelisms explicit. The connections can, of course, be made fairly easily by a reader who already knows the subject, or who is skilled at interpreting textual signals; but the intended readers fall into neither of these categories, and the writer therefore has more of a duty to make the relations explicit.

### 3.1.2 How the identified proposition-relational problems can be corrected

The proposition-relational problem identified in sentence (s2) and (s4) can be corrected by spelling out through repetition and parallelism the contrasting relationships that the writer wants to make between  $\alpha$ -particles and  $\beta$ -particles as follows: *pursue irregular paths* is added to (s4), so that now this sentence can be contrasted with, and at the same time provide parallelism to (s2)'s *pursue straight paths* to read thus:

(3a) *The comparatively massive  $\alpha$ -particles pursue straight paths...*

(6a) *By contrast, the very light  $\beta$ -particles pursue irregular paths...*

Similarly, the reason which was identified to be missing for (2a) is added to provide an explanation for the pursuance of straight paths by  $\alpha$ -particles. This reason is meant to be contrasted with the reason for (4a) in (4b), to read as follows:

(3b)...because they pull electrons off atoms as they go and are not deflected by them

(4b) ...because they suffer frequent repulsions from the electrons near which they pass

The failure of the writer to clearly bring out the contrasting relationship existing between the last particle ( $\gamma$ -ray) and the others is corrected by the addition of this phrase ‘unlike  $\alpha$ -particles and  $\beta$ -particles’ to (s6). This correction also highlights the parallelism between (s3a), (s6a) and (s9). The sentences then read as follows:

(s3a) *The comparatively massive  $\alpha$ -particles pursue straight paths.*

(s6a) *By contrast, the very light  $\beta$ -particles pursue irregular paths.*

(s9)  *$\gamma$ -rays, unlike  $\alpha$ -particles and  $\beta$ -particles, do not produce cloud tracks along their own paths.*

Finally, the conjunct *consequently* is added to (s8) in the original version. This signal word serves the purpose of making explicit to the reader the cause-effect relationship existing between the propositions, which parallels the cause-effect relations in the description of the two other particles. The ‘improved’ text therefore reads as follows:

Cloud Chamber Tracks (improved version)

(1a) The appearance of the cloud tracks depends on the particles concerned. (2) *The different types of cloud tracks can therefore be used as a means of identifying which type of particle is passing through the cloud chamber.*

(3a) The comparatively massive  $\alpha$ -particles pursue straight paths (3b) *because they pull electrons off atoms as they go and are not deflected by them.* (4) They create up to 10000 ion-pairs per centimetre of their path. (5) The resultant cloud tracks are straight and thick.

(6a) By contrast, the very light  $\beta$ -particles *pursue irregular paths* (6b) *because they suffer frequent repulsions from the electrons near which they pass.* (7) They make ionizing collisions far less frequently - only a few hundreds of ion-pairs per centimetre of their path. (8) *Consequently, they display thin irregular cloud tracks.* (9)  *$\gamma$ -rays,*

*unlike  $\alpha$ -particles and  $\beta$ -particles, do not produce cloud tracks along their own paths. (10) A gamma photon may, however, interact with an atom in its path and give up either a part or the whole of its energy in ejecting an electron from it. (11) Consequently, the electrons behave like  $\beta$ -particles and produce irregular cloud tracks of their own which branch out from the direction of the gamma.*

### **3.2 A Sample Extract**

Let us now turn to another example which is built on the Problem-Solution pattern, titled ‘Magnifying power of a lens’:

*Magnifying power is an entirely different concept from magnification. Magnification, the ratio of image size to object size, is easily and precisely measurable with a scale. Magnifying power, on the other hand, is the ratio of the apparent size of an object seen with an instrument to the apparent size seen without the instrument. The problem is in the definition of apparent size.*

*Apparent size depends on distance. The closer an object is to the eye, the larger it appears. Of course, if you get the object too close your eye cannot focus on it. Apparent size could be expressed as the size of the image on the retina, but this would be a little difficult to measure. However, the size of the image on retina depends on the angular size of the object, as shown by  $\theta$  in figure 12-25, and this can be measured easily. The magnifying power of an instrument is defined as the ratio of the angular size of an object viewed with the instrument to the angular size of the object viewed without the instrument. Figure 12-25, shows that the size of image on retina depends on the distance between object and viewer and is directly related to the angular size shown as  $\theta$ .*

*The concept of angular size is probably new to you, but it is simply the angle between lines drawn from the eye to the two ends of the object. A small coin a meter away may have an angular size of about 1%; a person at 15 meters is about 5%; and at 20 meters is about 7%.*

#### **3.2.1 The author’s intended patterns of text organisation**

The organisation of the text is built on a problem – solution pattern, which combines with matching and cause-consequence relations at the lower-levels. There is a multi-layering of relations in which sentences (1-3) introduce the situation; sentence (4) presents the aspect of the situation that requires a response (problem); sentences (5-8) deal with a first response which does not solve the problem; sentence (8b) provides a negative evaluation of the first response; sentence (9a) provides another response; sentence (9b) gives a positive evaluation; and sentences (10-13) deal with the basis of the evaluation.

The statement in (s4) tries (unsuccessfully) to state a problem. This problem is recognised by the lexical signals ‘problem’ in (s4), ‘cannot’ in (s7), the near synonym of the word problem ‘difficult’ in (s8b), and the use of the negative signals ‘too’ and ‘little’ intimates a potential problem. In addition to the above signals is the amplification (though mis-leading) given in (s7).

The Solution (response) is signalled by the lexical items ‘could be’ in (s8) for the first response which does not solve the problem, and ‘can be’ in (s9b) for the response that solves the problem. In addition to these lexical items, the contrasting parallelism set up in the evaluation sentences (8b) and (9b) helps to reinforce, and at the same time highlight the Solution in the two sentences as follows:

(8) Apparent size could be expressed as the size of the image on the retina, but this would be a

little difficult to measure.

(9) However the size of the image on retina depends on the angular size of the object, and this

can be measured easily.

The evaluation of the solution to the problem is at two levels. The first presents the response as inadequate signalled by the conjunct ‘but’, followed immediately by the signalling of another problem [i.e. measuring the size of the image on the retina] in sentence (8b) with the word ‘difficult’. It is the negative evaluation of the first response. The conjunct ‘but’ indicates that the following clause contains material which is incompatible with the preceding proposals for overcoming the Problem. However, this incompatibility is immediately cancelled out in (s9a) by the conjunct ‘however’. The second (a positive one) is signalled by ‘can’ in (s9b) and certifies this alternative Response as the appropriate Solution. The parallelisms read as follows:

(8b)...*but this would be a little difficult to measure*

(9b)...*and this can be measured easily*

The basis of the above Evaluation (s9b) is presented in sentences (s11-s13) as evidenced by the presence of the lexical item ‘shows’ in (s11), as well as the following parallelism in (s9a) and (s11):

the size of the image on retina depends on the angular size of the object, as shown by 0 in figure 12

Figure 12-25 shows that the size of image on retina depends on the distance between object and viewer and is directly related to the angular size shown as 0.

### 3.2.2 Problems associated with the way the intended patterns are expressed

Although there are signals of the organisation (as outlined above), the text could easily cause reading comprehension difficulties to learners at school. First, the fact that the text is discussing a certain Problem is not expressed explicitly. In fact a closer examination of the text reveals that there is a clause relational gap in the patterning of clause relationships as shown here below:

(2) Magnification [is] the ratio of X to Y  
[and] is *easily measurable*.

(3) Magnifying power [is] the ratio of A to B  
? {[and] -----}?

The writer's attempt to make the above matching contrast does not come out properly because, while s/he explicitly mentions that magnification is easily measurable, s/he does not say that magnifying power, on the other hand, is not easily measurable. It is left to the reader's powers of inference that magnifying power is not easily measurable because apparent size is hard to define.

The other clause relational problem could be traced from sentence (4): *The problem is in the definition of apparent size*. This sentence refers to a problem in measuring apparent size. This is a fairly clear signal (though it does not actually tell us what the problem is) which sets up the expectation of some kind of explanation of what the problem is. Given this expectation, sentence (7), *Of course, if you get the object too close your eye cannot focus on it* – is in fact misleading.

It is misleading because the two negative words *too* and *cannot* appear to fulfil the expectation by specifying the problem. However, in fact they present a completely new problem. They do not provide a direct follow up of the problem for which the expectation was set up earlier on in sentence (4). What the two negative words suggest is that there is a problem which arises only when the object is extremely close to the eye. Unfortunately, this has nothing to do with the definition of apparent size, which the writer is presenting as the problem. Thus, the choice of the grammatical items *too* and *cannot* seems to be inappropriate in view of the super-

ordinate relational structure of a problem-solution pattern. In the same (s7) there is use of the expression ‘of course’ at the beginning. The use of this expression which is normally used as a way of signalling a side-step does not do so clearly enough. Therefore, it does not in any way help in highlighting the problem (which is the issue at stake). From the clause relational point of view, (s7) is a case of **mis-signalling**.

Magnifying power of a lens (improved version)

Magnifying power is an entirely different concept from magnification. Magnification, the ratio of image size to object size, is easily and precisely measurable with a scale. Magnifying power, on the other hand, is the ratio of the apparent size of an object seen with an instrument to the apparent size seen without the instrument. Unfortunately, it cannot be easily measured because of a problem in the definition of apparent size.

Apparent size depends on distance. The closer an object is to the eye, the larger it appears. [*Of course, if you get the object too close your eye cannot focus on it.*] If the same object is further away from the eye, its apparent size will be smaller. Apparent size could be expressed as the size of the image on the retina, but this would be a little difficult to measure.

However, the size of the image on retina depends on the angular size of the object, as shown by  $\theta$  in figure 12-25, and this can be measured easily. The magnifying power of an instrument is therefore defined as the ratio of the angular size of an object viewed with the instrument to the angular size of the object viewed without the instrument. Figure 12-25, shows the size of image on retina depends on the distance between object and viewer and is directly related to the angular size shown as  $\theta$ .

This improved version of the text illustrates how the faults in the clause relational patterning of the text can be corrected. First, the super-ordinate relational structure (problem-solution), which was not clearly spelt out, can be put right by filling in the missing member in the clause relational gap that was identified in sentence (4). When this is done, the sentence reads: (4) *unfortunately, it cannot be easily measured because of a problem in the definition of apparent size.*

Now this statement explicitly establishes that there is a problem, whereas the one in the original version of the text presupposes the existence of the problem. The use of the item ‘unfortunately’ at this point in the discourse (as elsewhere) indicates a negative evaluation which should be contrasted with the positive evaluation given in (s2). As it provides a negative evaluation, it warns the reader that there is a problem in the offing; and indeed the problem is stated in the same sentence (4). The item ‘unfortunately’ is reinforced by the phrase ‘cannot be easily measured’ in the same sentence. Additionally, this new clause relational member provides a contrasting parallelism to (s2)’s ‘...is easily and precisely measurable’: (s2) *Magnification is the ratio of image size to object size, and is easily and precisely measurable with a scale.* (4)

*Unfortunately, it cannot be easily measured because of a problem in the definition of apparent size.*

Second, the clause relational problem that was identified as starting from (s4) - (s7) can be corrected by reducing the status of the problematic (s7), by enclosing it in parentheses: (6) *The closer an object is to the eye, the larger it appears. [(7) Of course, if you get the object too close your eye cannot focus on it].* The use of the parentheses helps to show the reader that what is enclosed is a deliberate digression. Furthermore, it shows that what is enclosed is subordinate to the proposition that was set up in (s4).

The third important amendment is made immediately after the sentence in parentheses. A new sentence is inserted between (s7) and (s9). It becomes (s8). The reason for this new sentence is to make clear the matching contrast relationship between (s6) and (s8a) in the original version. This contrast then prepares the reader for the signal of the main problem which appears in the next sentence (8b): difficult. The two sentences being contrasted now read as follows:

(6) *The closer an object is to the eye, the larger it appears.*

(8) *If the same object is further away from the eye, its apparent size will be smaller.*

Last but not least, there is need for the insertion of a conjunct such as ‘therefore’ in sentence (10) to clarify to the reader the evaluation-solution relationship existing between sentences (9) and (10), as well as help the reader to see that the new definition of magnifying power being put forward in (s10) is the solution to the problems which were mentioned in (s4) and (s8a). Thus sentence (10) reads: *The magnifying power of an instrument is therefore defined as the ratio of the angular size of an object viewed with the instrument to the angular size of the object viewed without the instrument.*

#### **4. Conclusion**

Concerning the improved versions of the texts, a major consideration which writers have to bear in mind is the type of audience to which their writing is addressed. The level of education, background knowledge, and linguistic competence are critical considerations. If the writer shares a common knowledge base with the audience, it makes sense to leave a great deal of the argument and/or discussion unspecified, because it is possible for the reader to put together the loosely organised and/or un-explicit pieces of the message through drawing inferences (cf. Brandt, 1986; Bisanz and Voss, 1985; Gibbs et al, 1982).

However, when the intended audience are school learners the results of Ssebunga's (1997) study show that it might be erroneous to assume too much common and domain-specific knowledge, because a mismatch would inevitably result in the above-mentioned proposition-relational difficulties as school learners' background knowledge of both the world and the science subjects is undoubtedly limited. Hence the textbook author needs to work from an initially limited knowledge, using a variety of linguistic techniques to guide the reader's response rather than assuming initial understanding (cf. Applebee, 1982: 368).

The same goes for the proposition-relational members that have been filled in the proposition-relational gaps. The repetition, paraphrase, parallelism and other cohesive relationships which in other contexts might seem over-used serve a pedagogical objective for texts meant for school readers. Besides, it is better to err on the side of explicitness in such contexts.

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