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CONTENTS

READABILITY OF SCIENCE TEXTS IN USE IN ZIMBABWE SECONDARY SCHOOLS

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ABSTRACT

The reading levels of three recommended Junior Certificate and Ordinary Level science texts in Zimbabwe schools have been investigated. Four different readability formulae were applied in the study.

It was found that the reading level of one of the texts is about 14 years. Two other texts which appear in more than one volume show expected variation in reading age. None of the texts or volumes exceed 17 years in reading age and neither does any fall below 11 years. The weaknesses of readability formulae are noted in the study while the findings are discussed to highlight areas for text improvement and caution in assigning texts to streamed classes.

INTRODUCTION

Texts are highly valued in the educational system. This appears to be a historical fact. Indeed, for a long time in many countries, a particular text was synonymous with the prescribed syllabus in a given subject. This used to be true of subjects such as History, Geography, Mathematics, Chemistry and Biology in West Africa until about two decades ago.

Experience and anecdotes from elsewhere suggest that the situation might not have been peculiar to that region even if such features did show at different phases of educational development. Yet, it is also true that growth of texts also symbolises in some degree the competing interest groups covertly or overtly staking claims of effective communication of science ideas of varying magnitudes in education. Africa and the rest of the developing world is a particularly fertile ground for the battle of texts. In the midst of this situation, professionals and researchers have the singular objective of selecting for students texts from which the students can meaningfully learn.

In some cases, those who train teachers consider the issue sufficiently problematic to include in the course outline for pre-service teachers. The point at issue is that fancy, tradition and rule of thumb can no more suffice for selecting texts. The desirability of objective criteria has thus emerged. One of such objective criteria is readability formulae to study some of the science textbooks in use in Zimbabwe's secondary schools.

LITERATURE REVIEW

In reviewing the literature on this subject, it is tempting to limit the scope of review to strictly readability studies. Sufficient though that might prove, we consider it pertinent to point out that this subject is of interest to a large group of scholars. This is because the topic is a subset of the issues in reading. Reading itself is a subset of the issues in language, and language is a part of the wider issue in learning. It is no surprise therefore that in more than one way, educationists, linguists, psycho-linguists, psychologists and medical scientists have made varying degrees of inputs, which account for our understanding on the subject. We now ask the question: what is readability? Readability is the term used to describe the ease with which a book can be read and comprehended by the reader. The focus has been on books written in English and meant for use in schools. The results of readability measures are reported as read-

ing levels in years. Thus, when a book is reported to be for a reading level of 14 years, it means normally, it could be read and comprehended by the average 14 year old!

Generally, there are two approaches for assessing readability. One is pooled teacher rating. The other is the application of some tested readability formulae. A third procedure referred to as the cloze procedure (Taylor, 1953; and Thelen, 1974) does slightly more than predict readability. It does provide a measure of the degree of comprehension.

Pooled teacher rating would on the average be reliable provided a fairly large number of experienced teachers were available to do it (Lunzer and Gardner, 1979). The cloze procedure on the other hand involves classroom experimentation with pupils. The method involving the use of formulae is the one that proves feasible in the circumstance of this study. There are a variety of such formulae, nine of which were considered to be generally good (Harrison, 1980 p.51). The underlying assumptions of each of the formulae are similar. Most of the formulae adopt certain linguistic features as determining variables of readability. The two most commonly used variables are sentence length and word familiarity or word difficulty. Word difficulty is nominally associated with word length which is measured in syllable count. A direct relationship is proposed to exist between readability and short sentences on the one hand and words of low syllable count on the other. A further critical assumption of the measure is that comprehension is also deemed to be predicted. It has been pointed out (Gibson and Levine, 1979; Harrison, 1980) that several important factors which affect reading (e.g. print, size, format, conceptual difficulty) have been neglected by the formulae. Even what they provide for in sentence length as a remote measure of syntax is not adequate. Perhaps the greatest weaknesses are to be found in the lack of reckoning of the reader factor such as interest and motivation. In what has come to be recognised as mathemagenic behaviours (Rothkopf, 1970) readers are known to interact positively with the content they read through questioning, paraphrasing, imagining, etc.

This factor is known to facilitate comprehension in a way which no formulae could readily predict. Can comprehension be predicted by the formulae? It has been pointed out that comprehension is fairly difficult to measure (Anderson, 1972; Mitchell, 1979).

The significance of these weaknesses in the underlying assumptions of the readability formulae cannot be overstated. If we were to assume that the omission of print size, format and illustrations can be rationalised in these days of modern technology, the same cannot be said for conceptual complexity, syntax and reader variables.

A short sentence is not always the easiest to comprehend. Proverbs are probably the examples par excellence in this regard. The root to their comprehension is often contextual and source dependent. Long sentences are neither necessarily easy nor difficult. Besides, it has been observed that sentence length might be a function of the subject involved. An analysis by ASE (1980) showed that the average sentence length in ordinary reading materials is 11 words while it is 21 words in scientific prose.

A view of this nature might have prompted Slater and Thompson (1984) and Maxwell (1978) to critique readability formulae as being inapplicable to scientific texts or writings. It is not only on sentence length that different disciplines might operate differently on readability. On the issue of conceptual difficulty, the differences might be more marked. It has been said that an index of conceptual difficulty is not accounted for in the formulae (Harrison, 1980 p.22) because conceptual difficulty has proved difficult to measure. Perhaps the truth is that the possibility that a scientific concept can be comprehended is not amenable to being predicted in vacuo.

It is precisely as the reader interacts with the concept that what is measurable emerges. It is fairly difficult to suppose that it can be rated by its syllabic status. Let us consider the following: atom, mole, energy, flux, genes, field, cell, nerve, wave;

each of these is relatively short, yet each could convey contextual meanings of immense conceptual difficulty in contemporary school science. On the other hand, some relatively long words or terminologies e.g. electrolysis, germination, fertilisation, radiation; might not deserve the difficulty rating which their polysyllabic status would offer.

This issue becomes particularly interesting in science when the range of learning materials provided is used to effect e.g. text, laboratory manual, workbook, teacher's guide, data book, etc. Admittedly, even the readability of each of these could still deserve to be measured! The point at issue is that concepts are central in science and almost all the learning resources are directed at achieving their acquisition. Newton, (1984) reported on the way students use science texts. He found that students use texts in a variety of ways but the order of priority that emerged is as follows:

1. to find information to do questions and exercises after the lesson;
2. for revision after the lesson;
3. supplementary reading after the lesson;
4. working in a topic from text during the lesson;
5. to find help during the lesson;
6 to prepare before a lesson for a topic to be covered during the lesson; and
7. for questions and answers during the lesson.

From Newton's findings it can be pointed out that students hardly ever read the text in preparation for a lesson. This could well be an index of attitude to the subject or presumed difficulty of the subject. It does show, however, that their interaction

with the text is fairly organised and often at times parallel to the dictates of the teacher (Newton, 1984) or style of science programme followed. Our argument therefore is that the hallmarks of good science texts and the demands of science education do not strictly feature in the critical variables of readability formulae. In a way, although we have emphasized the case in respect of science, Gibson and Levine (1979 p.436) have observed the inadequacy of readability formulae and they remarked:

> If we are to do research on learning from reading, we need a theory of comprehension that tells us what units to measure as dependent variables as well as what independent variables to manipulate.

To the extent that this supports our case, we agree. A pertinent issue to raise now is the adequacy of the 'word lists' which are used to assess unfamiliar words. The two weaknesses are the culture source and content base. As for the former, our observation is as much a cautionary note applicable on the results as it is a challenge for us. On the latter, it is a universal defect which would affect all readability assessment in science. The above criticism notwithstanding, readability formulae have been meaningfully applied in some investigations. Yoloye (1975) used readability formulae to train a group of evaluators and further used them to evaluate some newly developed science curriculum materials. The outcome of the assessment provided him with some indications to direct the procedures of the biology text to seek improvement. The Nigeria Integrated Science Project (NISP) was found to have a higher language level (Jegede, 1982) than was suitable for the target schools. The significance of such language difficulty for learners in a second language situation was further highlighted. Certainly, the general complaint about science texts as being difficult to read prompted extensive interest in the subject in the U.K. particularly in the late seventies. Thus, Gould (1977), Carrick (1978) and Knutton (1983)

conducted studies of significant interest to professionals in science education. The research interests were also a follow up of the Bullock (1975) report.

In the study reported by Knutton (1983) 21 school chemistry texts in the U.K. were investigated. For most of the ordinary level texts, the average reading level was about 15.5 years. There were a few texts with slightly higher reading levels. The average reading level of the Certificate in Secondary Education texts was found to be about 14.5 years, while junior chemistry texts averaged about 13.5 years. While recognising that there were texts with higher reading levels than was desirable, he observed that there were considerable improvements in the readability of texts when compared with those that were in use in the early seventies. He further indicated evidence that authors and publishers were apparently mindful of readability even to the extent of using it to advertise the texts. Given such noticeable positive trends in the U.K., it is probable that parallel trends would be observed in science texts used in schools in Africa.

In summary, literature shows that readability formulae adopt a simplistic approach in examining a very complex problem. It is however, recognised that in the absence of an acknowledged versatile approach for predicting the worth of a book to prospective readers, the approach fills a vacuum. In the particular case of developing countries undertaking the business of education in a second language, the question of readability deserves attention.

Thus, we can for now use the approach to examine the texts in use and hopefully obtain desirable facts for improving the texts, particularly those which are produced locally.

PROBLEM

What is the readability level of science textbooks used in secondary schools in Zimbabwe at ZJC and "O" level?

METHODOLOGY

As with most school subjects, there are usually main texts and supplementary texts. There are also a variety of main texts. It is not unusual therefore to find a class in which different pupils use different texts. We have therefore selected texts which feature amongst those on schools' approved lists. We are unable to ascertain the proportion of schools that use them for now but our experience with teachers and visits to schools suggest that the selected books are in common use. The selected texts are shown in table 1.

TABLE 1
TABLE OF SELECTED TEXTS

Form 3 – 4
W. Stout, (1987). *Science in Zimbabwe.* Zimbabwe: John Murray; Academic Books
Form 1 – 2
W.A. Dock (1982). *Zim-Sci (Students).* Zimbabwe: Ministry of Education and University of Zimbabwe
A.J. Mee (1985). Science 2000. Zimbabwe: Zimbabwe Educational Books

Continuous prose passages in a range of 5% or 10% of the texts were selected for analysis. This is far in excess of a minimum of three passages prescribed by (Harrison, 1980 p.101). Four readability formulae were applied. These are the Spache (1953) formula, the Flesch (1984) formula, Dale – Chall (1984) formula and Mugford 1970 formula.

The Schools Council Effective Reading Project (Lunzer and Gardner, 1979) had rated the Dale - Chall formula the most valid of all. Harrison (1980 p.115) had shown that the Flesch and Dale – Chall formulae are particularly suitable for texts for the range 11 – 17 years. The Spache formula is considered valid for a reading level of below 12 years and the Mugford formula for a reading level of 13 years. The underlisted linguistic variables were investigated in each prose passage selected.

Linguistic Variables investigated (Adapted from Harrison, 1980)

- Words per sentence
- Sentences per 100 words
- Number of syllables per 100 words
- Number of syllables per word
- Number of polysyllables
- Percentage of words not on 769 word list
- Percentage of words not on 3000 word list
- Mugford word length score.

DISCUSSIONS OF RESULTS

Tables 2, 3 and 4, show the reading levels of the texts as predicted by each of the formulae. The results obtained can be examined in at least three different ways.

TABLE 2
READABILITY OF SAMPLED PARAGRAPHS IN *SCIENCE IN ZIMBABWE*
READING LEVEL

Page	Spache	Flesch	Dale-Chall	Mugford
10	08.50	11.60	10.50	08.50
30	10.10	14.20	13.50	12.50
42	09.00	12.90	11.90	11.00
70	08.95	12.90	12.25	10.60
97	09.41	11.40	12.20	10.00
116	10.14	19.40	16.20	14.00
140	09.83	12.50	11.70	10.50
141	09.83	12.50	11.70	10.50
150	10.20	15.00	11.70	10.50
165	11.00	17.01	15.78	14.70
171	10.95	14.20	14.05	12.00
184	09.80	11.80	11.02	10.90
209	09.79	11.60	11.65	09.45
217	10.30	17.30	15.70	15.00
237	09.56	14.60	14.00	13.00
245	08.37	13.40	12.80	10.60
Average	09.73	14.00	13.00	11.68

One is the variation of reading level predicted by different formulae for a given passage or text (inter-formulae variation). Another is the variation of reading level within a text as predicted

by a given formula (intra-text variation). The third is the reading level (average) predicted for each text by a given formula (inter-text variation)

TABLE 3
READABILITY OF SAMPLED PARAGRAPHS IN *'ZIM-SCI' STUDENTS GUIDES*
READING LEVEL

Year/Unit	Page	Spache	Flesch	Dale-Chall	Mugoford
II	7	09.50	11.70	10.75	10.00
	15	08.50	11.00	10.95	09.50
	23	09.80	11.70	11.50	10.00
	37	08.50	10.50	10.53	09.00
Average		09.08	11.23	10.93	09.63
III	15	11.00	16.71	15.50	13.50
	26	11.00	16.71	16.00	14.00
	35	11.32	16.41	16.00	15.00
	51	10.50	12.80	12.23	10.70
Average		10.96	15.66	14.93	13.30
IV	34	11.18	17.30	15.57	13.50
	38	12.68	06.41	05.60	14.00
	56	10.00	15.21	14.50	12.50
Average		11.30	16.30	15.22	03.33

TABLE 4
READABILITY OF SAMPLED PASSAGES IN *SCIENCE 2000*

READING LEVEL

Bk	Vol. Page	Spache	Flesch	Dale-Chall	Mugford
I	7	8.62	11.90	11.15	9.30
	36	8.29	13.00	11.50	9.50
	45	8.74	12.30	11.30	10.50
	61	8.75	14.00	12.80	12.50
	78	9.70	17.00	15.55	14.50
	86	8.50	13.00	12.60	12.30
	92	10.21	18.80	16.75	15.50
	101	9.54	16.40	15.30	14.40
	117	9.11	13.40	12.14	11.70
	126	10.54	21.50	15.53	16.52
Average		9.20	15.13	13.46	12.60
II	14	9.80	14.60	13.05	12.70
	45	8.64	12.20	10.90	9.70
	59	9.24	14.40	12.62	11.50
	72	8.11	13.20	11.85	11.30
	78	9.10	17.00	14.60	13.57
Average		9.00	14.28	12.60	11.75

INTER-FORMULAE VARIATION

It was observed that irrespective of the passage or text, different formulae predicted different reading levels. In some cases, the differences are minor, in other cases, they are high. We recognise this as attributable to properties of the different formulae and consistent with results which have been quoted else-

where, Harrison (1980 p. 58). In addition we recognise the status of 'experimental errors' on our part. We consider it pertinent to point out though that all through the results the Spache formula showed the lowest readability rating over 12 years. This tends to confirm its unsuitability for analysis at this level. Yet, it was included to ensure that if any passage deserved to be credited with extreme ease of readability, the opportunity would not be lost. This seems well borne out in a fair number of the passages.

The Flesch formula was found to produce the highest readability score, although in many cases sufficiently close to the results from the Dale–Chall formula which is credited with being the most valid. The Mugford formula showed intermediate rating between Spache formula and the other two.

INTRA-TEXT VARIATION

With the exception of Zim-Sci texts which are essentially monographs on a given theme or concept, the texts deal with wide ranging topics and themes in one volume. It is no surprise therefore, that intra-text variation exists irrespective of the formula that was used. This, however, should prove instructive in the selection of themes for schemes of work in schools. In situations where such texts serve different age groups of students, it would prove beneficial to defer the topics involved for higher level classes. It might also prove useful for the authors to take another look at some of the relevant passages shown to have high readability levels for improvements.

INTER-TEXT VARIATION

The texts are shown to have different levels. The levels shown are within the age levels within secondary schools in Zimbabwe and similar to results obtained elsewhere (Harrison, 1980 p.122: Knutton, 1983). We do not consider the variations alarming to the point of drawing attention to any specific text. However, in a situation where classes are streamed and texts are assigned on

the basis of the same syllabus being followed by different ability groups, one would need the assurance that authorities are aware of the readability levels of texts chosen.

While the results have shown that the readability levels are within the age groups in Zimbabwe Secondary Schools, we deem it necessary to say that it also means that those texts would have yielded the same readability score anywhere else. Thus, if by some chance, any of the books claimed language facility suitable for countries in which English is a second language, readability scores have not shown this.

The particularly time-consuming aspect of calculating readability levels using the Spache and Dale-Chall formulae involve using some given 'word lists'. A complaint against the approach is that it is tedious. One would consider it worthwhile if it were a culture-fair list or at least a science list. We suppose that there is some challenge in that. Furthermore, if there be any desire to borrow materials for popularising science, some content in existing texts are of useful readability levels for consideration.

SUGGESTIONS FOR FURTHER WORK

It was pointed out at the beginning of this report that the subject of readability is of interest to several groups of scholars. We recognise that the central issue is the place of language in education. Further work therefore needs to be viewed from a deeper perspective than we have been able to explore. One way to explore the deeper perspective is to recall that readability studies are premised on the expectation that students can read. Contemporary classroom experience in developing countries does not suggest that all our students can read, and read efficiently. We are indeed satisfied that many of them do not have appropriate books to read, hence we are not equipped to probe or develop reading skills to desirable levels.

It is our view therefore, that the following steps are imperative:

- a study of reading ability of learners at varying levels of primary and secondary education and
- the use of readability prescriptions to guide the development of basic texts for popularising science particularly at the primary school level and possibly for adult education.

It is our hope that these steps would widen our visions about the issues and hopefully provide clearer directions on how to make the best of science texts.

CONCLUSIONS

We have found that the readability levels of three texts selected to range between 13 and 16 years. Our findings provide some indications of passages in the various texts which could be improved upon at least for readability. We consider it pertinent to point out that in view of the marked variation within and amongst texts, authorities and teachers who assign texts need to exercise care. In addition, we have restated that the issue of readability is related to the central issue of language in education. Therefore, we consider it necessary that further work be done to probe the central issues of reading and provide for reading in the context of science education. Lastly, it is desirable that further data and information be obtained by classroom experimentation using the cloze procedure in order to determine not only the readability but also the comprehensibility of the texts.

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APPENDIX 1

SOME READABILITY FORMULAE

1. SPACHE FORMULA

U.S. GRADE	= 0.121 x Words per sentence + 0.082 x Percent Unfamiliar Words + 0.659
U.K. GRADE	= U.S. GRADE + 5

2. DALE – CHALL FORMULA

U.S. GRADE	= 0.157 x Percent unfamiliar words + 0.0496 x Words per sentence + 3.6365
U.K.GRADE	= U.S. GRADE + 5

APPENDIX 2
TITLES OF PARAGRAPHS SAMPLED IN TEXT

TEXT: *SCIENCE IN ZIMBABWE*

PAGE	TITLE
10	Management of the soil ecosystem–Improving soil fertility
30	Variation and inheritance in plant - Inheritance
42	Ruminant digestion
70	Conservation
97	Iron from Iron Ore
116	Industrial preparation detergents from petroleum
117	Industrial preparation detergents from petroleum
140	Conduction
141	Conduction
150	Engines - spark plug
165	Metals
171	Concrete
184	Efficiency of a machine
209	Choosing a source of water
217	Pollution
237	Causative organisms
245	Useful micro-organisms

TEXT: *ZIM-SCI – STUDENTS GUIDE*

YEAR II UNIT HI FORCES IN A CTION

PAGE	TITLE
7	Finding out about forces – pulling things
15	Finding out about forces – stopping things
23	Finding out about forces – measuring force
37	Finding out about forces – measuring work

TEXT: *ZIM-SCI - STUDENTS GUIDE*
YEAR III UNIT 3

PAGE	TITLE
15	Heat and Temperature
26	Convection
35	Energy and the Living World
51	Geothermal Energy

TEXT: *ZIM-SCI STUDY GUIDE*
YEAR IV UNIT 10, Electricity and Magnetism

PAGE	TITLE
34	Use of a relay in a car starter - motor
38	Symbol of the transformer
56	Explaining Electrolysis +

TEXT: *SCIENCE 2000 BOOK ONE*

PAGE	TITLE
7	Using a thermometer
36	Making waves
45	Energy and Living things
61	Compounds
78	Hidden or latent heat
86	Water pollution
92	Reproduction
101	Parental Care
117	Pushing the Current
126	The bicarbonate indicator