Applying a Linguistic Complexity Checklist and Formulae to the 2013 Grade 4 Mathematics National Assessments

Lucy Sibanda & Mellony Graven

[1] *Department of Education,, Rhodes University, South Africa..*

[2] *Department of Education, Rhodes University, South Africa.*

[1] lcysbnd@gmail.com, [2] m.graven@ru.ac.za

This article emerges from the first author's broader PhD study that investigates the nature of the linguistic complexity of the Grade 4 Department of Education (DoE) Annual National Assessments (ANA) test items and how learners (with a poor command of the language of learning and teaching) and teachers experience them. This paper reports on the findings of a content analysis done on the 2013 mathematics ANA test items using Shaftel, Belton-Kocher, Glasnapp and Poggio (2006)'s linguistic complexity checklist and formula. Results point to some serious linguistic challenges of test items particularly in relation to: recurrent use of 7 or more letter words, homophones, prepositional phrases and specific mathematics vocabulary across the majority of questions. The study recommends a consideration of the linguistic complexity of test items, accompanied by trialling of the items with learners, by test designers prior to their use in national assessments. We argue that this consideration is especially important at the Grade 4 level where the majority of South African learners will only have had a few months of mathematics instruction in English before they write these assessments in English.

Introduction

The study is situated within the South African literacy and numeracy context, where international studies such as TIMSS (see Reddy, 2006); regional studies such as SACMEQ (see Taylor, 2009; Spaull, 2011) and national mathematics assessments such as the ANAs (DBE, 2012; 2013) reveal the underperformance of learners confirming Fleisch's (2008) contention that primary education is in crisis especially in reading, language and mathematics. Additionally, inequality in performance is growing. Thus while in the 2003 TIMSS study SA was the lowest performing of 50 countries, equally of concern is that SA had the largest variation in scores with learners in African schools achieving scores half of those of historically White schools. Furthermore, mathematics scores for African[7] schools decreased significantly from TIMSS 1999 to TIMSS 2003 which was not the case for other SA schools, pointing to increasing inequality of mathematics performance.

The Department of Basic Education (2011) attributes South African learners' poor performance in numeracy benchmark tests to inadequate language capabilities since many learners did not understand what was expected of them during the assessments. In South Africa, most learners learn mathematics in English, a language that is not their Home Language (HL). It has been found that most learners who perform poorly in Grade 12 mathematics rarely use English at home or come from homes where English is rarely used (Simkins in Taylor, Muller & Vinjevold, 2003). In rural schools, learning and teaching occur in a context of limited English language infrastructure where "English is only heard, spoken, read and written in a formal school context" (Setati & Adler, 2000, p. 251).

[7] Under apartheid four racially classified categories of schools existed: Black; Coloured, White and Asian. Previously Black schools are often referred to as African schools.

In 2011 the Department of Basic Education introduced the Annual National Assessments to be conducted in all government schools at Grades 1-6 and Grade 9 as part of their Foundations for Learning Campaign. The ANAs aim to expose teachers to better assessment practices, help districts to identify schools most needful of assistance, and inform parents about their children's performance (DBE, 2011). The pivotal role of the ANAs requires the development of confidence in them as fair and valid measures of learners' competence and performance with the levels test items neither too high nor too low.

In the Foundation Phase (FP) (where use of home language in classrooms is encouraged in the national language policy context), ANAs are provided in learners' home languages as requested by schools, but in the Intermediate Phase (IP) (where the language policy demands a switch to either English or Afrikaans), the ANAs are set in English or Afrikaans. Thus the department's website states:

> The tests are administered in all the eleven official languages in the FP and in the two languages of teaching and learning in the IP and Senior Phase. Necessary adaptations are effected for learners who experience various kinds of learning disabilities to ensure that every learner has the opportunity to demonstrate what they know and can do in the assessment (DBE, 2014, no page).

The point about learning disabilities and necessary adaptations is interesting. While we consider the multilingualism of our South African learners as a proficiency the extent to which learners are disadvantaged by having to write the assessments in English rather than in their home language perhaps requires the same attention as those learners disadvantaged by learning disabilities to 'ensure that every learner has the opportunity to demonstrate what they know and can do in the assessment'.

Results of the ANAs for the past three years are cause for concern. The 2012 and 2013 reports for the ANAs (DBE, 2012, 2013) reveal that learners performed poorly in mathematics across grades. In the FP, learners performed better but as they proceeded to IP, the levels of achievement decreased significantly. The 2013 ANA results for Mathematics, for example show learner results decreasing from an average of 60% in Grade 1 to 14% in Grade 9. Important, however, is the large drop that occurs in results from Grade 3 to Grade 4 (i.e. from an average of 53% to 37% for 2013) (DBE, 2013). This begs the question as to the role language plays in this large drop in performance from the FP to IP. The teaching of First Additional Language (FAL) from Grade 1 was made compulsory in 2012 by the Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011). However, the current Grade 3s and 4s did their Grades 1 and 2 under the National Curriculum Statement (NCS) dispensation when teaching in the FAL was not compulsory. If some of these learners used isiXhosa (or other South African languages) as language of teaching and learning (LoLT) in Grade 1 and 2 and only started using English in Grade 3, then it would be naive to expect them to have already acquired the basic vocabulary in English which they need to communicate and learn in that language.

This makes the analysis of the linguistic complexity of the Grade 4 ANAs imperative seeing that the grade marks the transition between the FP and IP. In South Africa Grade 4 is a critical stage where many learners experience four significant transitions from the FP. The first transition from Grade 3 to Grade 4 is from using isiXhosa (in the Eastern Cape where the study is being done) to using English as the LoLT in Grade 4. The second transition is from reading mostly narrative, story-like texts whose language closely approximates ordinary language of everyday social interaction in the FP, to reading expository texts with more content-dense vocabulary in Grade 4 (Chall, Jacobs, & Baldwin, 1990). The third transition

is the movement from 'learning to read' to 'reading to learn' (DoE, 2008). In the FP, learners are trying to develop the skill and art of reading but, when they come to Grade 4, they are expected to read different content subjects and learn from what they read. The mechanics of reading, which underpin learning to read, are supposedly developed in the home language (HL) in the FP and used in English in Grade 4 to access information from texts. The fourth transition is the movement from more concrete thinking in the FP to more abstract thinking in the IP. Mathematics abstraction is particularly critical for progress in the IP.

Theoretical perspective, methods and analytic tools

This study is guided by an assumption that language is central in the learning of mathematics. It is framed by a socio-cultural view of language and learning, with Vygotsky's (1976) influential work informing the theory of language and learning. Hallidayan (1978) language theory, was also used, which cohered well with Vygotsky' theory because for both, language is central to learning.

The broader PhD study from which this paper emerges researches two key questions. The first explores the linguistic complexity of the Grade 4 2013 ANA document (i.e. test/ documentary analysis). The second question investigates, through a case study approach of two township mathematics classrooms, the way in which the participating Grade 4 learners and teachers experience the linguistic challenges of the ANAs. This paper reports only on the findings of the content analysis on the 2013 mathematics ANA test items using Shaftel et al.'s (2006) linguistic complexity checklist and formula. Shaftel et al (2006)'s checklist was selected after a thorough literature review, which indicated that was sufficiently comprehensive and took into account key complexity issues raised by mathematics education and language literature. A brief review of some of the broader literature that informs Shaftel et al. (2006)'s complexity tool and formula is given below before describing Shaftel et al.'s checklist and formulae that provides the analytical tool for this paper.

According to Bergqvist, Dyrvold and Osterholm (2012) mathematics is linguistic in nature because it has words, symbols, sentences and grammatical structures which are essentially part of the language. These linguistic features serve to describe mathematical concepts, which cannot be described in everyday language. For Halliday (1975, p. 65) mathematics register is 'a set of meanings that belong to the language of mathematics and that a language must express if it is used for mathematical purposes.' According to Halliday (1993), the difficulty of mathematics also lies in the grammar of the language used and not only with the vocabulary. He identifies some features that have tremendous effect on the performance of English as second language learners. These include long phrases in questions, complex sentences, syntactic ambiguity, special mathematical expressions, lexical density and many more. The grammatical density of sentences engendered by the linguistic features described above present linguistic challenges that confound young learners.

Another source of complexity is the dissonance between ordinary language and mathematical language. According to O'Halloran (2005, p.75) 'the major process type found in mathematical language appears to be the relational process.' This process is usually absent in English and when learners encounter it in mathematics they are challenged.

To compound the limited exposure to the English as the LoLT, mathematical language has been found to be complex even for English HL speakers learning mathematics in English (Halliday, 1989). The level of complexity for second language learners can only be greater as questions that are cognitively undemanding to English native speakers may be quite exacting to second language learners learning mathematics in English (Cummins and Swain, 1986).

According to Schleppegrell (2007, p. 140), "Learning the language of a new discipline is part of learning the new discipline; in fact, the language and learning cannot be separated." Abedi (2006) notes that when assessments have complex language, this negatively affects the performance of learners and the performance gap between English language learners and HL speakers of English is increased. For Abedi, assessments where the linguistic component engenders unwarranted complexity to the mathematical component are unfair and invalid. Abedi (2006) also argues that standardised achievement tests that are prepared for English language learners but take no consideration of their language proficiency pose more challenges for the learners and cannot portray what learners really know.

For this paper we draw on Shaftel et al.'s (2006) linguistic complexity checklist and formula as an analytic tool for the content analysis of the 2013 Grade 4 mathematics test items. The larger analysis of test items using the broader Systemic Functional Linguistics that was conducted is beyond the scope of this paper. Thus we only expand here on Shaftel et al.'s (2006) analytic framework.

Shaftel, et al. (2006) investigated the influence of the language characteristics of mathematics assessments given to English language learners in English on Grade 4, 7 and 10 learners. Shaftel et al. (2006) analysed individual test items in a multiple-choice format that were presented as word problems, though the number of words per item differed. The learners' performance was determined by the item difficulty as well as the ability to answer the question correctly. Items were coded according to their linguistic complexity, taking into consideration the "total number of words, sentences, and clauses in each item; syntactic features such as complex verbs, passive voice, pronoun use and vocabulary in terms of both mathematics vocabulary and ambiguous words" (Shaftel et al., 2006, p. 11).

The results for Shaftel et al. (2006) study revealed that the mathematical and linguistic features of the test items measured, had an impact on learner performance, "with a moderate-to-large effect at Grade 4, a medium effect at Grade 7, and a smaller effect at Grade 10" (p. 120). At Grade 4, prepositions, ambiguous words, complex verbs (verbs with three or more words), pronouns, and mathematics vocabulary showed unique effects on item difficulty. The greater the number of linguistic elements per item, the more difficult the item.

For this study, test items are defined as each item for which a learner got some marks. Unlike in Shaftel et al.'s (2006) study that looked only at multiple-choice items our analysis includes the ANA multiple-choice and other word problems not in multiple-choice form.

Shaftel et al.'s Linguistic Complexity Checklist Index was developed as an analytic tool to analyse the linguistic complexity of items. We use this tool because it is specifically designed for assessing mathematical test items. Four levels of language have been established and these are: basic level, word level, sentence level and paragraph level. Shaftel et al. (2006) list some individual language features that they considered to be challenging. These are:

A. Basic level: Number of words in an item

B. Word level: words of 7 letters or more; Relative pronouns (e.g. that, whom, whose); Slang / ambiguous / multiple meaning or idiomatic words (e.g. change, set); Homophones (e.g. two/too, prize/price); Homonyms (e.g. there, their, they're); Specific mathematics vocabulary (e.g. pentagon, symmetry)

C. Sentence level: Prepositional phrases (e.g. beginning with, from, by, at); Infinitive verb phrases (to make, to sell); Pronouns (e.g. his, her, they); Passive voice (were sold, were rounded off); Complex verbs of 3 words or more (e.g. could have been);

Complex sentences (e.g. with subject and predicate); Conditional constructions (e.g. if….then); Comparative constructions (e.g. less than, greater than)

D. Paragraph level: references to specific cultural events.

The Linguistic Complexity Index (LCI) is then calculated as: LCI = (Sum A + Sum B + Sum C + Sum D) ÷ Number of sentences. For example, LCI = (Sum of words +Sum of pronouns, ambiguous words, homophones etc + Sum of prepositional phrases, passive voice etc + Sum of specific cultural events) ÷ Number of sentences.

Analysis of the 2013 ANA test items

The linguistic features of each item were evaluated using the Linguistic Complexity Checklist. In each item, the number instances of use of linguistic features were counted, as shown in the table below, added and the result was divided by the number of sentences, see bottom row of table for the LCI of each item. For the purpose of this analysis, an item subsumes sub questions. So for example, item 4 comprises two questions namely 4.1 and 4.2, with the instruction 'Complete each of the following number patterns:' applicable to both questions. Therefore, the 18 items analysed contain 31 questions. Each question is analysed individually using the LCI features and formula. For those sub questions where the instruction is given at the start of the item the instruction is analysed together with the first sub question only. This means for example, item 4, the instruction 'Complete each of the following number patterns:' is only analysed together with the first pattern in 4.1 and not again for 4.2. The reason for this is that learners are likely to read the instruction part and then go on to answer the first question followed by subsequent questions without going back to read the instruction for each sub question.

This resulted in the following questions having a 0 linguistic complexity index: 3.2, 4.2, 6.2, 6.3, 6.4 and 16.2 (i.e. they had no language). Table 1 below shows the frequency of use of language features in the 2013 ANAs.

Table 7. Frequency of use of language features in all 2013 ANA questions

Question	A-No of words per sentence	B-Words with 7 letters or more	No. of pronouns	No. of ambiguous words	No. of homophones /homonyms	C-No. of passive sentences	No. of complex verbs	No. of infinite verbs	No. of specific math vocabulary	No. of prepositional phrases	No. of conditional constructions	D-No. of references to culture\holidays	No. of sentences	Total no. of features	LCI
1.1	8	2	1	0	3	0	0	0	2	1	0	0	2	19	9.5
1.2	8	2	0	0	3	0	0	0	1	2	0	0	1	18	18
1.3	13	1	0	0	5	0	0	0	1	4	0	0	1	25	25
1.4	6	1	1	1	2	0	0	0	1	1	0	0	1	14	14

1.5	**5**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**10**	**10**
1.6	**6**	**0**	**1**	**1**	**2**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**13**	**13**
2	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**
3.1	**6**	**3**	**1**	**0**	**2**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**15**	**15**
4.1	**7**	**3**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**15**	**15**
5.1	**10**	**1**	**2**	**0**	**5**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	**23**	**11.5**
5.2	**12**	**0**	**2**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**18**	**18**
6.1	**5**	**3**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**12**	**12**
7	**9**	**5**	**0**	**0**	**4**	**0**	**0**	**0**	**2**	**3**	**0**	**0**	**2**	**25**	**12.5**
8	**18**	**1**	**1**	**2**	**2**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**1**	**29**	**29**
9.1	**19.5**	**7**	**2**	**2**	**8**	**0**	**1**	**1**	**0**	**5**	**0**	**0**	**2**	**46.5**	**23.3**
9.2	**16**	**1**	**3**	**0**	**5**	**0**	**1**	**1**	**0**	**3**	**0**	**0**	**1**	**30**	**30**
10	**9.5**	**5**	**0**	**1**	**5**	**0**	**0**	**0**	**2**	**5**	**0**	**0**	**2**	**29.5**	**14.8**
11	**11**	**2**	**0**	**0**	**1**	**1**	**0**	**0**	**2**	**2**	**0**	**0**	**1**	**20**	**20**
12.1	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**7**	**7**
12.2	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**6**	**6**
13	**8**	**3**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**1**	**17**	**17**
14	**7.6**	**0**	**1**	**1**	**3**	**1**	**0**	**0**	**0**	**3**	**0**	**0**	**3**	**20.6**	**6.9**
15.1	**10**	**6**	**1**	**0**	**3**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**2**	**27**	**13.5**
15.2	**10**	**2**	**0**	**0**	**3**	**0**	**0**	**0**	**2**	**3**	**0**	**0**	**1**	**22**	**22**
15.3	**6**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**1**	**14**	**14**
15.4	**9**	**4**	**3**	**0**	**2**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**2**	**23**	**11.5**
16.1	**17**	**4**	**1**	**0**	**2**	**0**	**0**	**0**	**5**	**2**	**0**	**0**	**1**	**33**	**33**
17	**16**	**4**	**0**	**1**	**2**	**0**	**0**	**0**	**4**	**2**	**0**	**0**	**1**	**30**	**30**
18.1	**21**	**10**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**38**	**19**
18.2	**8**	**2**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**1**	**15**	**15**
18.3	**14**	**3**	**2**	**1**	**2**	**0**	**0**	**0**	**1**	**3**	**0**	**0**	**1**	**27**	**27**
19	**9**	**3**	**2**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**18**	**18**

Note: questions 3.2; 4.2; 6.2; 6.3; and 6.4 all have an LCI of 0

Discussion of findings

Word level

At the word level, the number of words with plus or minus 7 letters, number of pronouns, number of ambiguous words and number of homophones in each item were considered to increase complexity.

The number of words with plus or minus 7 letters.

Thirty out of the thirty-six questions contained words with 7 or more letters. The questions that had the highest number of words with 7 or more letters were questions 9.1 (with 7 words), question 15.1 (with 6 words) and questions 7 and 10 (with 5 words). For example, question 9.1 asked, "Write down the flight number of a flight which will depart for its destination before midday." These represented 83% of the total 36 questions which demonstrates the linguistic challenge in terms of item length for the vast majority of questions. This is of concern given Bergqvist, Dyrvold and Osterholm's (2012) observation that this language feature is the major source of linguistic complexity. Thus that words with 7 or more letters featured so much in the items shows the potential to hinder the comprehension of many test items.

Number of pronouns

Seventeen of the thirty-six questions (47%) contained pronouns most of which were interrogative pronouns like 'what', 'which', and demonstrative pronouns like 'that'. Other pronouns that were marginally used were indefinite pronouns like 'each', 'much' and subjective pronouns like 'she', 'it', and objective pronouns like 'her' and 'its'. Questions 9.2 and 15.4 had the highest number of pronouns (3). Pronouns might be expected to cause confusion for less skilled English language learners because 'they introduce a (possibly ambiguous) reference to another sentence element' (Shaftel et al., 2006, p. 121). An example is question 15.4 "Mom shared a cake equally amongst Mary and her 3 friends." For a less skilled English language learner, it may be confusing whether the pronoun her is referring to Mary's friends or mom's friends. Although they may bring difficulty to mathematical texts, pronouns are essential in sentence constructions as they serve to indicate possession and to form questions among other uses. That pronouns featured in slightly above half the items shows the potential to militate against the comprehension of significant number of test items.

Number of ambiguous words

According to Halliday (1989), syntactic ambiguity is the presence of two or more possible meanings within a single word or sentence. This is common in mathematical texts. For the present study, ambiguous words were those with multiple meanings where assignment of the unintended meaning compromised the comprehension of the item's demands and inevitably the response given. For example, in question 7, 'The difference between 1 613 and 859 is seven hundred and fifty-four.' In this case, difference is not used in the everyday meaning which means 'dissimilar or unlike.' Here it refers to the answer you get after subtracting a number. From this example we note that ambiguous words may bring complexity and can be confusing to learners who are not proficient in the English language used to learn mathematics. Nine questions (25%) contained ambiguous words. Other examples of ambiguous words were 'factor', 'multiple' and 'hands' in questions 1.6, 1.4 and 8 respectively. Although ambiguous words could potentially confound the learners, they were not as prevalent as the other two features discussed above which reduced their potential to impact learners' test performance negatively.

Number of homophones

Homophones are two or more words that have the same sound or spelling but differ in meaning. These words can make reading tricky as not knowing the definition of a particular homophone can change the meaning of what is read, thus affecting comprehension. Altogether 27 (75%) questions contained homophones. Question 9.1 had the highest number of homophones (8). Examples are write/right, buy/by, of/off and board/bored. For the last example given, the sentence reads, 'Look at the departures board at the airport' – the word 'board' if read as meaning 'bored' would change the meaning of the sentence. Questions 1.3, 5.1, 9.2 and 10 all had five homophones each. Homophones are another major source of ambiguity, and the ambiguity of language could hinder and cause confusion in understanding of test items. The fact that homophones appeared in the vast majority of the questions attest to their potential widespread effect on the learners' test performance.

Sentence level

At sentence level the linguistic features that were analysed were number the of passive sentences, number of complex verbs, number of infinitive verbs, number of specific mathematical vocabulary, number of prepositional phrases and number of conditional constructions.

Number of passive sentences

In passive sentences, the sentence begins with the object rather than the subject, which is highly unlike the everyday use of language. For example question 1.2: 'The number 6 555 rounded off to the nearest 100 is….' A learner may find this question difficult to understand because of the passive voice 'rounded off' used. The question could be more easily understood if it was asked in passive voice like 'Round off 6 555 to the nearest 100'. The more common voice construction in English is the active voice, not the passive voice, and thus passive voice constructions can be especially insidious, for failure to understand them correctly can actually lead to a misinterpretation of vital information (Tanko, 2010). According to Hinkel (2002, p.1), learning and teaching the 'meanings, uses, and functions of the passive voice represents one of the thorniest problems in second language grammar instruction', and many second language learners of English appear to have difficulty with passive constructions. Although complex to unravel particularly for second language learners with limited English language proficiency, passive constructions were marginally employed in the test items. Only 2 questions (5.5%) were in passive form. These were questions 1.2, 11 and 14. Each of these questions had one passive sentence.

Complex verbs

Complex verb phrases in this study are phrases with at least two verbs. This suggests the use of multiple or difficult verb tenses (Shaftel et al., 2006). In general, complex verb phrases consist of one or more auxiliary verbs plus a main (lexical) verb. Four complex verb phrases in 4 questions (11.1%) were found. They were found in questions 3.1, 5.2, 9.1 and 9.2. An example, question 9.1 and 9.2 asks learners to write down flight numbers 'which will depart' and in question 5.2, 'buys and sells'. Though representing linguistic difficulty, complex verbs were infrequently used in the test items.

Number of infinitive verb phrases

An infinitive phrase is the infinitive form of a verb plus any complements and modifiers. Infinitive phrases are without a doubt the most complicated of all verbs. They can be used as adverbs, adjectives, and nouns. Because infinitives begin with the word 'to' they are

occasionally misidentified as prepositional phrases. Nine infinitive verb phrases were found (25%). Question 15.1 had two infinitive verb phrases. An example is 'Use the fraction wall to calculate 1/4 + 2/4 '. In the given example, learners are likely to confuse the infinitive verb with prepositional phrases and this compromises the comprehension of the questions. The other questions had one infinitive verb phrase each. Although these affected only one quarter of the questions, they represent a substantial effect relative to other features at the syntactic level.

Number of specific mathematics vocabulary

Specific mathematics vocabulary was found across 23 questions (64%) of the test items. This is to some extent expected in a mathematics assessment since mathematics is a language. Examples include 'ratio' (in question 1.3), 'multiple' (in question 1.4) 'factor' (in question1.6), 'number patterns' (question 4.1), 'number sentence' (question 7) and many others. Mathematical reading is dense, each vocabulary word is conceptually-packed, full of specific mathematics vocabulary which children are not often exposed to in their homes and social environments (Murray, 2004), and without understanding of specific vocabulary, many learners struggle to understand concepts (Lee, 2007). For example, question 16.1 as shown in Figure 1 below.

Hexagon	Pentagon	Quadrilateral	Triangle

From the above frame choose the word to name each of the 2-D shapes.

Figure 11. Question 16.1

That math specific vocabulary appeared in the vast majority of the questions may have affected learner performance while adding to the linguistic complexity. However, this is somewhat unavoidable as understanding mathematical vocabulary is imperative to mathematical problem solving. Wolf and Leon (2009) report that the overall amount of academic vocabulary in word problem items was most predictive of item difficulty for English learners in a study they carried. While to some extent unavoidable we must take into account that the vast majority of South African Grade 4 learners have only just switched from mother tongue instruction in the FP and thus have only had a few months of instruction of mathematics in English. Thus we would argue that given this reality wherever possible, where difficult mathematical vocabulary can be replaced with simpler ones, this would be preferable in assessments of learners having only recently switched to learning English mathematics vocabulary.

Number of prepositional phrases

A prepositional phrase is a word group that begins with a preposition. A preposition is a joining word that links a noun to another word in a sentence. 26 questions (72%) contained prepositional phrases. Questions 10.5 and 9.5 contained the highest number of these phrases (5) and question 1.3 had four. Examples include, question 10: 'look at the grid below and write down the position of the picture'. Prepositional phrase was one of the linguistic feature with high frequency. Prepositional phrases potentially confound English language learners because they mark the existence of an additional phrase in the sentence and hence another concept to be understood (Shaftel et al., 2006). They are, however, necessary when describing how nouns relate to one another. That prepositional phrases featured so much in the items shows the potential to hinder the comprehension of many test items.

Number of conditional constructions

Conditional sentences are statements discussing known factors or hypothetical situations and their consequences. They are conditional because the validity of the subject of the sentence is conditional on the existence of certain circumstances, which in the case of this question, may be understood from the context. Failure to get a correct answer for the first part of the sentence means failure to get the answer for the second question. Question 5 is the only question with the conditional construction feature: 'How much does Mrs Mazibe make if she buys and sells 10 apples?' Of all the features at the syntactic level, conditional constructions were the least manifest.

Paragraph level

Paragraph level complexity is considered when there is reference to cultural events. Analysis of the questions, however, shows no added complexity in this respect (see table above). Shaftel et al.'s, (2006) contention that complexities at the word level are less inhibiting than those at the syntactic level and that complexities at the paragraph level are most inhibiting, if true, implies that the absence of linguistic complexities at the paragraph level is a welcome relief to the other noted complexities above. The figure below summarises the frequencies of complexities across categories and shows that linguistic complexities were most manifest at the word level.

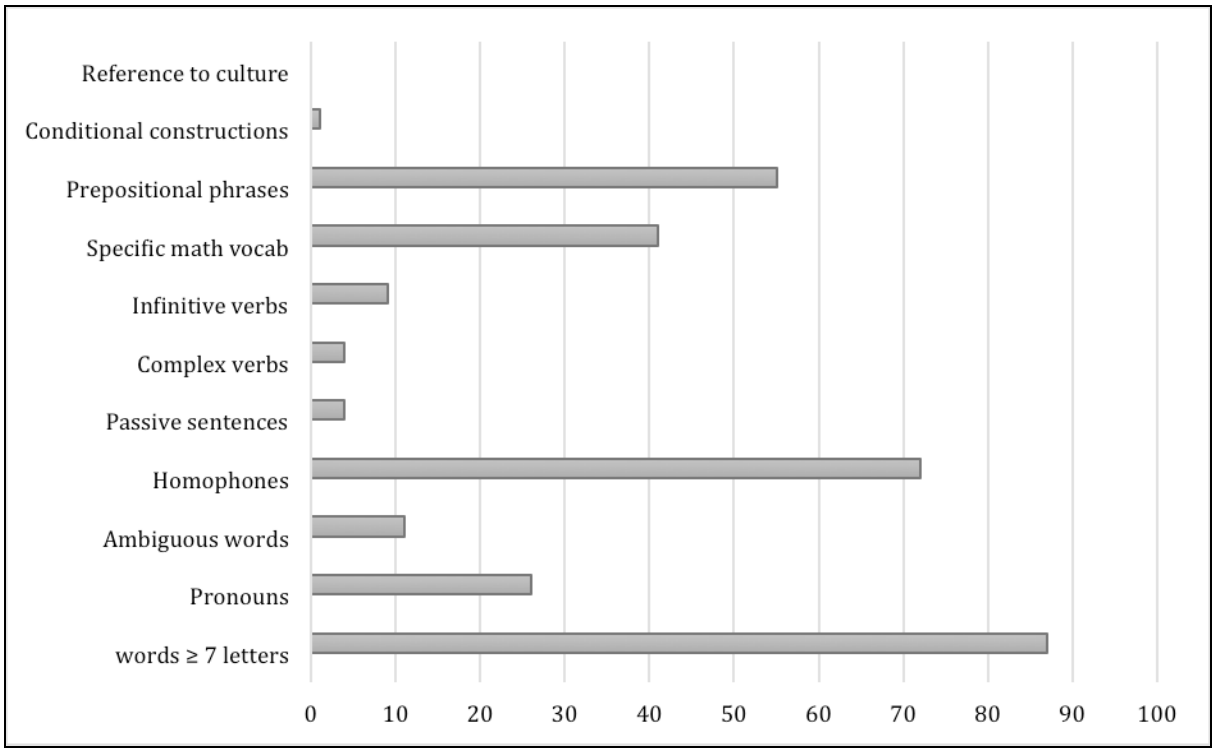


Figure 12. Frequencies of the use of different linguistic features in the 2013 ANA questions

Looking at the language use in the 2013 ANAs, the analysis of the linguistic features revealed that for each question analysed, a number of language features occurred and some appeared more frequently than others. When the language features that occurred in the items are arranged, starting from the most frequently used to the least frequently used, the features are as follows: words with seven or more letters (88), homophones (72), prepositional phrases (55), specific mathematical vocabulary (41), pronouns (26), ambiguous words (11), infinitive

phrases (9), complex verbs/passive voice (3), conditional constructions (1) and references to cultural events (0). As noted before, the greater the total number of linguistic features, the more difficult the question. In this case, question 16.1 may be considered the most difficult of all the questions because it has the greatest number of linguistic features: 'Hexagon/Pentagon/ Quadrilateral/ Triangle/ From the above frame choose the word to name each of the 2-D shapes'.

Table 2 below presents a summary of the indicators of question complexity derived from Table 1. The questions are in their descending order, from the highest challenging linguistic complex question to the lowest challenging linguistic complex question. The summary is in terms of the 11 word and syntactic level features that were the focus of analysis and the formula for the Linguistic Complexity Index (LCI) which is (Number of words + Sum B + Sum C + Sum D) ÷ Number of sentences is applied. For the questions that had one sentence, the total number of the linguistic features was the same as the LCI. Therefore, for single sentence questions, the more the linguistic features the higher the LCI. For those questions that had two sentences, the LCI was half the total linguistic features. There was only one question with three sentences and so its LCI was one third of the total of its linguistic complexity features.

Table 2. Summary of complexity of individual questions ranked according to LCI

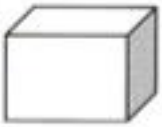
Question	No. of features present out of the 11 types of features	Aggregate No. of features	Linguistic Complexity index	Question	Types of Features in Question	Aggregate No. of features	Linguistic Complexity index
16.1	7	33	33	**18.2**	5	15	15
17	6	30	30	**10**	6	29.5	14.8
9.2	6	30	30	**1.4**	7	14	14
8	8	29	29	**15.1**	7	27	13.5
18.3	7	27	27	**1.6**	6	13	13
13	4	25	25	**7**	5	25	12.5
9.1	7	46.5	23.3	**6.1**	5	12	12
15.2	6	22	22	**5.1**	5	23	11.5
11	6	20	20	**15.4**	6	23	11.5
18.1	5	38	19	**1.5**	3	10	10
5.2	5	18	18	**1.1**	6	19	9.5
1.2	6	18	18	**12.1**	3	7	7
19	6	18	18	**14**	7	20.6	6.9
13	4	17	17	**12.2**	2	6	6
3.1	6	15	15				
4.1	6	15	15				

Column 1 above indicates the number of all possible 11 features present in the questions as this adds to the nature of question complexity. When the complexity of questions is ranked in terms of the number of different features manifest, question 8 is the most complex: 'Draw the hands of the given clock face to show that the time is a quarter past eight.'

However when applying the LCI formulae the three most complex questions are those shown in Figure 3 below.

16.1 'Hexagon/Pentagon/ Quadrilateral/ Triangle/ From the above frame choose the word to name each of the 2-D shapes'

17. Complete the table:

OBJECT	NAME OF OBJECT	SHAPE(S) OF THE FACES
	_____	Rectangles
	Triangular prism	Triangles and _____

9.2 'Write down the flight number of a flight which will depart for its destination after midday.'

Figure 13. Three most complex questions according to the LCI formulae

On the other hand perhaps the poor performance could be explained in terms of the limited 3D experience learners are exposed in the Grade 4 (and earlier), and especially in this case also the difficulty of interpreting a 2D representation as a 3D object. This limited experience would go hand in hand with limited exposure to the vocabulary of naming pictures of three dimensional objects.

Conclusion

Being recently introduced assessments, not much research has been done on the ANAs. In a press article, Henning and Dampier (2012) argue that there is need for this research especially in South Africa where the majority of learners grapple with learning in a second language. The importance of the research will also have implications for other countries where learners write assessments in L2 or L3. A study by Graven & Venkatakrishnan (2013) indicated that while teachers supported the introduction of the ANAs because they are standardized and provide guidance on what is expected, they noted several concerns such as the complexity of language used.

The study was designed to explore the linguistic complexity of the Grade 4 mathematics ANAs posed in English but written by the majority of learners who are not proficient in English. We note, for the majority of learners, English has only been the LoLT of mathematics instruction for approximately 6 months before Gr 4 learners write these ANAs. Given this reality, we argue that especially in the early grades of learning in English, it is essential that test designers work as carefully as possible to minimise language complexity of test items. Failure to do so will inevitably unfairly advantage the minority of mother tongue English learners.

It is hoped that the empirical findings of the linguistic challenges of the ANAs will inform educationists, especially those involved in the design of national assessments, on the nature of language challenges that learners face when writing the mathematics ANAs, and pay greater attention to the language proficiency of the learners. Secondly, it is hoped that the in-depth case study that follows this analysis in the form of learner and teacher experiences of these ANA questions will inform teachers as to ways to support learners in meeting the language demands in the preparation for the ANAs.

References

Abedi, J. (2006). Language issues in item development. In S. M. Downing & T. M. Haladyna (Eds.), *Handbook of test development*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bergqvist, E., & Dyrvold, A. & Osterholm, M. (2012). Relating vocabulary in mathematical tasks to aspects of reading and solving. In C. Bergsten (Ed.), *Proceedings of MADIF-8, The Eighth Swedish Mathematics Education Research Seminar*. Umea, Sweden.

Chall, J. S., Jacobs, V., & Baldwin, L. (1990). *The reading crisis: Why poor children fall behind*. Cambridge, MA: Harvard University Press.

Cummins, J., & Swain, M. (1986). *Bilingualism in Education*. London: Longman.

Department of Basic Education. (2011). *Report on Annual National Assessments Grades 1-6 & 9.* Department of Basic Education, Pretoria.

Department of Basic Education. (2012). *Report on Annual National Assessments Grades 1-6 & 9.* Department of Basic Education, Pretoria.

Department of Basic Education. (2013). *Report on Annual National Assessments Grades 1-6 & 9.* Department of Basic Education, Pretoria.

Department of Basic Education (2014) Official Website. http://www.education.gov.za/Curriculum/AnnualNationalAssessment/tabid/424/Default.aspx - downloaded on 21st July 2014

Fleisch, B. (2008). *Primary education in crisis: Why South African schoolchildren underachieve in reading and mathematics*. Cape Town: Juta.

Graven, M., & Venkatakrishnan, H. (2013). ANAs: Possibility and Constraints for Mathematical Learning. *Learning and Teaching Mathematics*, 14, 12-16.

Halliday, M. (1975). Some Aspects of Sociolinguistics. In E. Jacobsen (ed*) Interactions Between Language and Mathematical Education: UNESCO Report No. ED-74/CONF-808*, 64-73, Paris:

Halliday, M. A. K. (1989). Some grammatical problems in scientific English. *Australian Review of Applied Linguistics: Genre and Systemic Functional Studies*, 5(6), 13-37.

Halliday, M. A. K. (1993). Language and the order of nature. In M. A. K. Halliday and J. R. Martin (Eds.), *Writing science: Literacy and discursive power* (pp. 106–123). Pittsburgh: University of Pittsburgh Press.

Henning, E., & Dampier, G. (2012). *Simple language is the answer to "difficult" assessment tests. Mail and Guardian.* Retrieved May 2, 2013, from http://mg.co.za/article/2012-09-08-simple-language-is-the-answer-to-difficult-assessment-tests.

Hinkel, E. (2002). Why English passive is difficult to teach (and learn). In E. Hinkel & S. Fotos (Eds.), New perspectives on grammar teaching (pp. 233- 260). Mahwah, NJ: Lawrence Erlbaum Associates.

Lee, H. (2007). Teaching mathematics vocabulary to diverse groups. Intervention in School & Clinic, 43(2), 121.
Murray, M. (2004). Teaching mathematics vocabulary in context. Portsmouth, NH: Heinemann.
O'Halloran, K. L. (2005). Mathematical discourse: language, symbolism and visual images. Continuum: New York.
Reddy, V. (2006). *Mathematics and science achievement at South African schools in TIMSS 2003*. Cape Town: HSRC Press.
Schleppegrell, M. J. (2007). The linguistic challenges of mathematics teaching and learning. *Reading and Writing Quartely*, 23, 139-159.
Sesati, M., & Adler, J. (2000). Between languages and discourses: Language practices in primary multilingual mathematical classrooms in South Africa. *Educational Studies in Mathematics* 43 (3), 243-269.
Shaftel, J., Belton-Kocher, E., Glasnapp, D., & Poggio, J. (2006). The impact of language characteristics in mathematics test items on the performance of English Learners and students with disabilities. *Educational Assessment*, 11, 105-126
Spaull, N. (2011) *A Preliminary Analysis of SACMEQ III South Africa.* A working paper of the Department of Economics and the Bureau for Economic Research, Stellenbosch University. Stellenbosch: BER University of Stellenbosch.
South Africa. Department of Education. (2008). *National Reading Strategy*. Pretoria: Government.
Tanko, E. (2010). Facing Difficulties in the Acquisition of the English Passive by L1 Speakers of Hungarian Acta Universitatis Sapientiae, Philologica, 2, (2) 312-325.
Taylor, N., Muller, J., & Vinjevold, P. (2003). Getting Schools Working: Research and Systemic School Reform in South Africa. (Cape Town: Pearson Education South Africa.)
Taylor, N. (2009). Standards-based accountability in South Africa. *School Effectiveness and School Improvement*, *20*(3), 341–356.
Vygotsky, L. S. (1976) *Mind in Society. The Development of Higher Psychological Porcesses*. Edited by: M. Cole et al. Harvard University Press: Cambridge.
Wolf, M. K., & Leon, S. (2009). An investigation of the language demands in content assessments for English Language Learners. *Educational Assessment*, 14, 139-15.

Acknowledgements

The work of the SA Numeracy Chair, Rhodes University is supported by the FirstRand Foundation (with the RMB), Anglo American Chairman's fund, the Department of Science and Technology and the National Research Foundation.