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Language and Science Competences of Nigerian and South African High School Learners in Test on Processing Variant Terminology

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Abstract: It has been widely reported that high school learners in Sub-Saharan Africa perform poorly in science subjects in public examinations. From the stand-point of linguistics, research has shown that, complexity arising from dense and varied terminology load and textual flaws in school textbooks impede the optimal processing of scientific texts by learners. There is also the issue of poor understanding of the linguistic features of the language of science. However, the use of variant terminology which may obfuscate the meaning of words in science textbooks has not been adequately studied. This study, therefore, examined term variation in the context of learners' engagement with written science in order to determine the relationship between achievement in tasks on identifying and resolving term variation and learners' language and science competences. Data for the study was derived from the aggregate scores of learners in an achievement test administered to Nigerian and South African high school learners. Results of the analysis indicated that language proficiency of learners was not a correlate of achievement with a coefficient of (p-= -0.7603) but that a weak positive correlation exist between the science competence of learners and achievement in tasks on processing variant terminology with a correlation coefficient of (p value = 0.2056). The study therefore concluded that, language proficiency is not a correlate of achievement in test on processing variant terminology but that achievement of learners in the test administered can be predicted by learners' competence in science. To this effect, the study recommends the broadening of the scope of language proficiency to include a range of meta-linguistic skills, e.g. Thematic Pattern Analysis; Transitivity and Clause Relational Analysis and knowledge of scientific texts as self-organizing systems.

Keywords: Processing Variant Terminology, Language Proficiency, Science Competence, Nigerian and South African Learners

1. Introduction

Research findings from national and international assessments reported that high school learners in Sub-Saharan and South Africa perform poorly in science subjects in public examinations [41]. A number of factors have been attributed to this phenomenon. Research in text-linguistics (also referred to as Discourse Analysis) have shown that complexity arising from dense terminology load [14] and textual flaws in the way information is being packaged in school textbooks [38] impede the optimal processing of scientific texts by learners. There is also the issue of poor understanding of the linguistic features of science textbooks [36]. On one hand, studies conducted from the standpoint of applied linguistics (in the area of language education) in Nigeria attribute underachievement in science among learners to limited proficiency in English language [3, 1, 11]. In South Africa, on the other hand, underachievement in science (especially among black high school learners) is associated with the non-use of home language in teaching and learning science subjects [31, 22] or poor scientific literacy skills [29, 21, 37]. From the above synthesis, it can be seen that in both Nigeria and South Africa, a similar challenge is viewed from differing standpoints. Previous models of achievement in science as proposed in research on language in education identify language proficiency as a framework for learner achievement in science. Research conducted by science educationists on the other hand attribute underachievement in science to poor scientific literacy or the non-use of home language in the teaching and learning science. The mixed nature of findings on the determinant of learner achievement in science leaves educators in a dilemma on which of the variables need to be given prominence in the science classroom. Significant progress awaits studies that will be conducted to address this challenge.

This study investigated the phenomenon of term variation in the context of learners' engagement with written science in order to determine whether there will be a correlation in the achievement of learners with different language and science competencies. It also sought to propose meta-linguistic strategies that learners can use to respond to the challenge posed by term variation in science textbooks. The following research questions would guide the study: 1. Is there a significant correlation between perceived competence of learners in the English language and achievement in tasks on processing variant terminology? 2. Is there a significant correlation between perceived competence of learners in science and achievement in tasks on processing variant terminology? Two null hypotheses (H0) were used to determine the inter-relationship between language proficiency and science competence of learners in test on processing variant terminology. They include: $H0_1$: Perceived competence of learners in the English language cannot predict achievement in tasks involving identifying and resolving terminology variation.

$H0_2$: Perceived competence of learners in science cannot predict achievement in tasks involving identifying and resolving terminology variation.

Contrary to the univocity principle in terminology theory which states that terms in specialized texts are precise and not prune to variation, Gerzymisch-Arbogast [13] context-specific term model shows that the meaning of terms as represented at the system level (e.g. in dictionaries and glossaries) sometimes vary from what one encounters at the parole or individual level of the text. She further provides an account of the relationship between language system and language use as a means of framing variation in the use of terminology in specialised language texts. Based on textual analysis of data from Monetary Economics, Gerzymisch-Arbogast develops an elaborate conceptual framework to support her claim and refers to lexical variation as term contamination. Term contamination can manifest both at the level of designation or term and at the level of concept [13]. At the level of designation, which is the focus of this study, contamination of similarity manifests if two terms, e.g. 'money' and 'cash' are used interchangeably so as to represent the same or similar concepts at system level. If the use of superordinate term, e.g. 'assets' and a subordinate term 'funds' are used interchangeably so as to represent the 'other' concept at system level, it exemplifies contamination of inclusion. Contamination of intersection manifests when two terms, e.g. 'wealth' and 'money' are used interchangeably so as to represent intersecting concepts at system level. The phenomenon of terminology variation can be illustrated using two text configurations from Nigerian and South African life sciences textbooks. The texts describe the functions of sensory neuron (e) s.

Table 1. *A Transitivity Analysis in Two Text Configurations on the Functions of Neuron (e) s.*

Function Class	**Actor Nominal group**	**Process: Mat Verb**	**Goal Noun**	**Circumstances: Place**	
				Place α (Source)	**Place β (Destination)**
Text 1	SENSORY NEURONS	CARRY	IMPULSES	FROM THE RECEPTORS	TO THE BRAIN AND SPINAL CORD
Text 2	SENSORY NEURONS	TRANSMIT	INFORMATION	FROM THE RECEPTORS	TO THE (CNS) CENTRAL NERVOUS SYSTEM

To illustrate, we see from Text 1 that, the term used for the Actor or that which initiates the action [10] is 'sensory neurons' across the two text sources. The Process also has a verb referred to as 'carry' in Text 1 and is realized as 'transmit' in Text 2. The Goal is described as 'impulses' in Text 1 and as 'information' in Text 2. Like in the case of the Actor slot, the Place alpha slot is consistently realized as 'receptor' in both text configurations. Term variation can also be observed in the Place beta constituent of the clause (i.e. destination) by the use of 'central nervous system' in Text 2 and 'brain and spinal cord' in Text 1. Based on the categories of term variants outlined in the context specific term model, the relation between the terms used in the Actor slot is ideal relation [13]. The use of terms in the Process slot exemplifies contamination of similarity while that involving the use of terms in the Circumstances slot is contamination of inclusion. For reason of space, we shall illustrate the nature of ideal relation and contamination of inclusion (See. Figure 1).

Figure 1, at the system level, has the ideal relationship where term TN1 (CNS) refers to a concept TB1 (CNS), and term TN2 (sensory neuron) refers to a concept TB2 (sensory neuron). The solid lines from TN2 to TN2 and TN1 to TN1 exemplify what is referred to as ideal relation [13]. The broken lines from TN1 to TN 2 and from TN2 to TB1 illustrate contamination of inclusion; where the term for a superordinate concept (CNS) is used for a subordinate concept (brain and spinal cord). It has been argued in a related study that a student who understands both text configuration should be able to draw this inference and that a student who is unable to do that is unlikely to have understood both configurations [20]. This and other forms of terminological variation (contaminations) identified earlier represent a hypothesis of one major challenge that students face in learning the terms and concepts of written science.

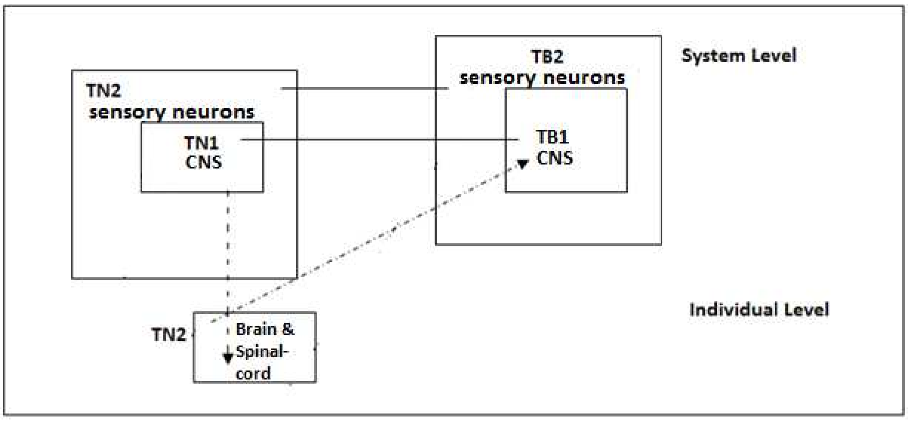

Figure 1. *Example of Contamination of inclusion.*

2. Method

The study was conducted in Adamawa state, North Eastern Nigeria and Cape Town in the Western Cape of South Africa. A quantitative method research design was used to test two null hypotheses on whether language proficiency and science competence of learners are correlates of achievement in tasks on processing variant terminology. Data for the study derived from the performance scores of learners in a written task that was meant to ascertain their ability to cope with terminology variation. The study sample comprised two hundred (200) participants from four schools (two each from Nigeria and South Africa). Participants in each country were given text excerpts on a topic as exemplified in Texts 1 and 2. In the excerpt and the question, although the wording was in parts dissimilar, the thematic pattern was identical. The idea here was to find out whether students can establish a relationship between, for instance, a subordinate term (e.g. brain and spinal cord) in the test question and a superordinate term (e.g. central nervous system) in the text excerpt. Whereas the question and the text both use 'sensory neurons' and ' receptors' in the Actor and Place alpha slots, differences in wording can be seen in the following pairs: transmit (question) and carry (text); impulses (question) and information (text); brain and spinal cord (question) and central nervous system (text).

A ten-item test on Identification and Resolution of Term Variation (TIRTV) was developed by the researcher and verified by a life science teacher to ensure that the questions had content validity. The test is a Multiple Choice Question on the topics cell, diffusion, osmosis, nervous coordination and nitrogen cycle. After the test questions have been validated by teachers, a pilot study was conducted by the researcher to test logistics and reliability of the test questions. The test questions had a Cronbach alpha reliability measure of (10 item test α =.70). Permissions to conduct the research were then sought from the Western Cape Education Department and the management of selected Nigerian schools where the study was conducted. When the permissions were granted to conduct the research, the researcher and teachers from the participating schools selected learners randomly across streams in SSS3/Grade 12 in Nigeria and South Africa respectively based on their cumulative performance in English language and science.

The participants selected were then categorized according their language and science competences. They were then briefed on the nature of the research after which consent forms were issued requesting them to indicate their willingness to participate in the research. The test was then administered to learners in both Nigeria and South Africa at different intervals. Data obtained after the test was administered were analysed using the Pearson Product-Moment Correlation Coefficient and Chi-Square Test Inferential Statistical tests. Results from the computation of the inferential statistical tests are presented in the next section.

3. Results

Two null hypotheses were formulated in the study conducted. The first was set to determine whether achievement scores of learners in the test administered can be associated with their profiles (assessed in terms of strength or weakness) in English language and science. The hypotheses were tested using the Pearson Moment Correlation Coefficient Test. Before presenting results on the two hypotheses proposed; an overview of the performance of Nigerian and South African participants in the test administered would suffice. Table 2 presents results on the performance of Nigerian learners per question in a ten–item test on processing variant terminology while Table 3 presents that of the South African participants.

Table 2. *Performance of Nigerian Learners per Question in Ten–item Test on Processing Variant Terminology.*

Topic	Special Science School		Special Arts School	
	(√ %)	(X %)	(√ %)	(X %)
1 Nervous coordination	31 (86)	14 (14)	21 (60)	14 (40)
2 Nervous coordination	11 (31)	24 (69)	22 (62)	13 (387)

Topic	Special Science School		Special Arts School	
	(√ %)	(X %)	(√ %)	(X %)
3 The cell	05 (14)	30 (76)	11 (31)	24 (69)
4 The cell	30 (85)	05 (15)	22 (62)	13 (38)
5 Plant nutrition	31 (86)	04 (14)	26 (74)	09 (26)
6 Plant nutrition	30 (85)	05 (15)	24 (68)	11 (32)
7 Nitrogen cycle	28 (80)	07 (20)	12 (34)	23 (66)
8 Nitrogen cycle	24 (68)	11 (32)	17 (48)	18 (52)
9 Respiration	15 (42)	20 (58)	22 (62)	13 (38)
10 Respiration	17 (48)	18 (52)	11 (31)	24 (69)

It can be seen from Table 2 that while learners scored between 68% - 80% in six out of the ten test questions in both schools where participants were pooled, the performance of learners in the other four test questions was low, with a range between 14% - 40%. Table 3 presents the aggregate scores of the performance of South African learners in tasks on processing variant terminology.

Table 3. *Performance of South African Learners per Question in a Ten-item Test on Processing Variant Terminology.*

Topic	Science School (Dinaledi) Special Arts School			
	(√ %)	(X %)	(√ %)	(X %)
1 Nervous coordination	29 (83)	06 (17)	27 (77)	08 (23)
2 Nervous coordination	28 (80)	07 (20)	20 (57)	15 (43)
3 The cell	20 (57)	15 (43)	21 (60)	14 (40)
4 The cell	27 (77)	08 (23)	12 (34)	23 (66)
5 Nitrogen cycle	11 (31)	24 (69)	13 (37)	22 (63)
6 Nitrogen cycle	09 (25)	26 (75)	06 (17)	29 (83)
7 Blood circulation	20 (57)	15 (43)	20 (58)	15 (42)
8 Blood circulation	21 (60)	14 (40)	23 (66)	12 (34)
9 Water transport in plants	29 (83)	06 (17)	15 (42)	20 (58)
10 Water transport in plants	25 (71)	10 (29)	13 (37)	22 (63)

As indicated in Table 3, more than half of the participants from the special science school (Dinaledi) scored 90% in eight questions from the ten–item test but recorded very low marks in the remaining; in question 4 and 5 with a range between 31% - 27%. For learners from the special arts school, results presented in Table 3 indicated that, participants got correct answers to five of the ten questions in the test administered with a percentage between 58% - 83%. The table also indicated that, participants got wrong answers to the other five questions with a range between 57% -77%. Even though results presented on the aggregate scores of Nigerian and South African learners are suggestive of the fact that participants find the processing of term variants challenging, relationship between performance in the various test questions and the language and science competences of learners cannot be determined. Results presented in Tables 2 and 3 do not also indicate whether there is a correlation between the performance of Nigerian and South African learners. The next section presents results of two hypotheses proposed to determine the correlation between: a) performance in test on processing variant terminology and language proficiency of learners, b) performance in test on processing variant terminology and science competence of learners.

Correlation between language proficiency and achievement in test on identification and resolution of term variation

A null hypothesis was formulated to assess the relationship between learners' proficiency in English and performance in tasks on processing variant terminology. The hypothesis stated that:

$H0_1$: Perceived competence of learners in the English language cannot predict achievement in scientific tasks involving identifying and resolving variation in terminology usage.

Results from the Pearson Product-moment correlational analysis is presented in Table 4.

Table 4. *Correlation between Science Competence and Achievement in Test on Identification and Resolution of Term Variation.*

Variables	Type of hypothesis	Pearson coefficient
Language competence and Achievement in test	(1 Tail) Sig. 0.05	*r = -0.7603*

As indicated in Table 4, the correlation coefficient between language competence of learners and achievement showed a value of ($r = -0.7603 < 0.05$) signifying a strong negative correlation. What this means is that, the proportion of total variance in achievement of learners in the test involving identification and resolution of variation in terminology usage cannot be attributable to language competence of learners. In view of this inference, the hypothesis that competence of learners in English language can predict achievement in test on how to identify and respond to term variation is rejected. We now consider the second hypothesis.

$H0_2$: Perceived competence of students in science cannot predict achievement in tasks involving identification and resolution of terminology variation

Table 5. *Correlation between Science Competence and Achievement in Test on Identification and Resolution of Term Variation.*

Variables	Type of hypothesis	Pearson coefficient
Science competence and Achievement in test	(1 Tail) Sig. 0.05	*r = 0.2050*

Results of the analysis as indicated in Table 5 revealed a correlation coefficient of ($r = 0.2050 > 0.05$) signifying a weak positive correlation. In other words, science competence of learners is a correlate of achievement in test on how to identify and respond to term variation. In this light, the null hypothesis that competence of learners in science can predict performance in test on how to identify and respond to term variation is upheld.

4. Discussion of Results

Language proficiency and achievement in processing variant life sciences terms

The results from the Pearson Product-moment Correlation test indicated a negative correlation between language proficiency of learners and achievement in test on processing variant terminology. This finding corroborates the "Asian Effect" that was observed among Japanese, Chinese and Koreans learners who had poor proficiency in English but performed better than their American pairs in science and mathematics [24, 36]. The findings, however, contradict results of studies conducted by language educationists who identify language proficiency as the sole framework for overcoming barriers to the understanding of science [21, 11].

Science competence and achievement in test on processing variant life sciences terms

Results that science competence (rather than language proficiency) is a correlate of achievement in test on processing term variants as a task in learning science contradicts a large body of literature in language education which justify the claim that limited proficiency in English impedes science achievement especially when instruction and tests are undertaken in English. It is however consistent with results reported in previous studies that scientific literacy rather than language proficiency fosters achievement in science [17, 8]. It also confirms the findings of previous research associating underachievement in science to poor scientific literacy skills [30, 22, 38].

The finding that science competence of learners (rather than language proficiency) is closely correlated with the achievement of learners in test on processing term variants justifies distinction between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) [8]. This is also a perspective which argues that "learning science is not just the mastery of vocabulary […] but rather knowledge of network of relationships [or Thematic Patterns Analysis] among scientific concepts and knowledge of how language is used in a field or context" [19]. Findings from the two hypotheses leave the teacher in a dilemma on which of the two variables need to be given prominence in the science classroom. In view of the mixed results derived from previous findings on the role of language in science education, a synthesis is in order. We therefore elect to take a different tack by combining insights from the outcomes from both hypotheses that were tested. This is also the stance which argues that combined high levels of English language proficiency and reasoning skills enhanced students' ability to learn scientific content knowledge in English [41].

5. Conclusion

Two null hypotheses were proposed and tested in order to determine whether competences of learners in English and science could predict performance in tasks involving processing variant terminology in science textbooks. The results indicated that, science competence of learners (rather than language proficiency) is correlated with the achievement of Nigerian and South African learners in test involving the processing of terminology variation. In the light of this, a need exists for broadening the scope of language proficiency in science and language education research to include wide range of language and text analytical skills. From the standpoint of science education, the scope of language proficiency would comprise among other skills the ability to detach content from contexts [20], and the ability to identify different kinds of knowledge that are linked by functional relations [18, 28]. A broader framework for conceptualising language proficiency would comprise among other variables: knowledge of grammatical relations or thematic patterns [19, 2] as illustrated in Figure 1; Transitivity and Clause Relational Analysis [39]; ability to analyse collocations [2]; knowledge of scientific texts as a self-organising system [9]; knowledge of textual cohesion [31] and the ability to identify perspectives in textual progression [4].

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