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A Case of Unmarked Register in Mathematical Linguistics

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ABSTRACT

The linguistic and non-linguistic features of the language which is being used in mathematical communication are unique and demarcate the mathematical register from other registers. Mathematical register is not limited in use to classroom teaching and learning but is utilized in other areas by members belonging to the same speech community in the sense of persons using a particular language or register in a definite context. In this paper, we highlight the core markers of the code used in mathematics as a register. We critique the link between linguistic competence and mathematical performance against competence in mathematical register. This analysis is expected to spur more debate in theoretical, psycholinguistics and mathematical linguistics about the interplay between the brain, mathematics and language.

Introduction

Mathematical instruction and learning primarily rely on language (Schleppegrell, 2007). This paper argues that there is a language register which is demonstrated in mathematical classroom. This register is marked by the use of focused vocabulary such as volume, area, ruler, division, squares, phi and product. This paper notes that the way in which morphological forms which are used in mathematical classes have different meanings with those they are given in other contexts of language use (Adams, 2003; Halliday, 1978). The argument of this paper is that performance of a user of a mathematical register is based on his or her competence.

Theoretical Foundations

Functionalist-Generative theory (Sawe, 2015) has shown that knowledge of mathematics is embedded within linguistic competence. It explains that mathematical skills which are applied in mathematical problems are not understood by all native speakers but by a section of users who form the mathematical speech community. For example, speakers of English as a native or a second language who will not attend mathematics class will not understand the techniques and the terminologies which are used in the mathematics register. This is because in the register, words like ‘factors’, ‘borrow’, ‘bracket’ and many other have special meanings. In addition, there are words which are specific to this register such as integers, algebra, sets, arithmetic, mean and least common multiple. These are some of the cursors of mathematics as a distinctive scientific register.

Converging from Chomsky’s (1993; 1995) minimalist framework, the Functionalist-Generative model put forward by Sawe (2015) suggests that arithmetic knowledge forms just a section of the general knowledge of language which is acquired developmentally. For instance, knowledge on how to add, subtract and divide often come earlier than how to work out the square root of a figure. Sawe’s argument is that we learn just a few rules of how to divide, how to add and how to multiply alongside other mathematical rules which we apply in mathematical syntax to arrive at answers that are acceptable to others who know how to calculate as correct. This implies that, as it is in language, we do not store up all answers of all calculations in our brains but just a few formulas which will guide us to solve infinite mathematical problems. Functionalist-Generative theory emphasizes that syntactic generation in mathematics is not only guided by formulas (rules) but is also functionally motivated.

Our study established that choice of vocabulary and the sentence structure to be used greatly affect the way learners comprehend and solve the mathematical problems. Upon varying the words used in one question several times and on different occasions, it proved that learners can either solve or fail to solve a mathematical problem as a result of word choice. In addition, we experimented on the use of simple, complex, compound, grammatical and ungrammatical sentences and the outcome revealed that syntactic reasons can add up the drawbacks in mathematics performance.

Linguistic Markers of Mathematical Register

Semantically, lexemes which are used in the mathematical register often has an aspect of polysemy. This is because they initially had one meaning but in the process of time, they are given another meaning in mathematics. For example, the lexemes ‘problems’ and ‘solutions’ are given register meaning in mathematics relating to the ‘mathematical question’ and ‘its answer’ respectively. Other elements that are unique to this register are the semantic symbols utilized in the expression of specialized meanings as shown below:

a) + is a positive or a plus sign used which whenever it is used, it **semantically** means ‘to add’.

b) – is a negative sign which is used **denotatively** in mathematics to mean ‘subtract’

c) ÷ in mathematical syntax denote that some units should be ‘divided by’ others. In mathematical semantics, this symbol is a **synonym** of ‘/’ as it can be used to convey the same meaning whereby one unit will be made the numerator while the other will be the denominator.

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d) $<$ is a sign used in mathematics register as a substitute to a phrase 'is less than'.
e) $>$ is a sign used in mathematics register as a substitute to a phrase 'is greater than'.
f) = mathematicians use this sign semantically to denote the element of **synonymy** in terms of similarity in quantity.
g) $\neq$ is another sign which is used uniquely in the register as an **antonym** of the verb phrase 'is equal to'.
h) Ɵ this a used in mathematical morphology to denote a semantic aspect of a null integer. It is also used in linguistically to mark the absence of a morpheme.

Chapman (1993) gave a quite elaborate description of the various features of mathematical register. She however limited her analysis to school mathematics. In her view, the linguistic field of school mathematics register is easy to identify. Our findings confirmed her view that this register has an array of vocabulary which is unique to it. An assortment of words that are used in this register have specialized meaning as seen in the use of lexemes such as improper, plane, prove, operation, negative and result. This means that these words are semantically assigned register specific senses. Whenever a word is taken from its everyday use it transform into a terminology whose use is only relevant whenever language is used in mathematics or by mathematicians and not necessarily within mathematics' classrooms as some researchers such as Chapman have claimed.

Our study established that there is a difference in the nature of mathematical representation in the brains of speakers of a language who have formal education and those who have no formal education. This is because the formal education introduces mathematical codes which can only be known by reading such as '1' for 'one', '2' for 'two' and '4' four'. Images of these codes called 'figures' such as '1', '2', '3' … do not exist in the brains of speakers who have no formal education. These codes are acquired as part of mathematical knowledge stored up in the brain as we learn mathematics together with other codes such as $\wedge$, $\vee$, x, $\surd$, $\cap$ and % plus many others. It is in this vein that this paper suggests that mathematics is a register which can lock out other speakers of language from communication which is done using these codes just like the register of language can lock out others who are not lawyers. Whereas all speakers can narrate the numbers, not all speakers can speak about or calculate the Chi-square, standard deviation or the circumference in their native languages. This suggests that people can have competence in particular registers.

The authors of this paper argue that performance of language users in the register of mathematics is correlated to their competence in the register (Chomsky, 1965). However, other factors such as drunkenness and sickness come into play in determining how a user of such a register will apply his competence. An interview of 100 respondents indicates that mathematical competence was neither related to the nature of competence that the parents had nor the gender of the speaker. It emerged that the environment can influence attitudes of learners towards mathematics. Surprisingly though, we found that there are learners who were poor in languages yet they loved mathematics and were performing well in it. This suggests attitude too has a greater weight in affecting process of teaching and learning.

Language Acquisition and Learning Mathematics

Our study of first language acquisition and second language learning has revealed that both first and second language learners acquire the vocabulary relating to mathematics before acquiring the skills which are relevant in mathematical calculation. Our study confirmed the findings of other studies that linguistically incompetent learners in mathematical classes experience learning challenges (Le Fevre et al., 2010; Vukovic, 2012). This finding hints that that there is a link between linguistic knowledge and performance in mathematics at various levels of development, acquisition and learning.

Our study found that almost 70% of our study sample had difficulty in solving mathematical problems which had more language descriptions than those which had just equations and numbers. In the study, English was used as the language of instruction and the sampled learners were speakers of English as a second language. The problem, as MacSwan (1997; 2006) explains, could have also been aggravated by semilingualism.

Conclusion

The findings from this study suggest that knowledge of mathematical numerals is inconceivable independent of linguistic knowledge. This implies that numerical knowledge is a subset of linguistic repertoire whereby words are used as referents or signs while the numbers are the referents. All interlocutors must understand a particular system of signs such as language so as to be taught, to learn, to express and solve mathematical aspects. In this vein, we conclude that teachers can only instruct leaners who share with them the same linguistic system (langue).

This paper confirms the claim of the Functionalist-Generative theory (Sawe, 2015) that a there is a great interplay between linguistic competence, communication skills and mathematical performance. It is challenging for a learner to acquire, understand or apply mathematical skills if he or she is linguistically challenged. Listening, speaking, reading and writing aptitudes are linguistic skills which are fundamental in mathematical communication. In this vein, this paper concludes that language should not be disregarded in the attempts to improve mathematical cognition in various levels.

Our conclusion from the results of this study is that general knowledge of language may not directly impact on a learner's mathematical appreciation but can be influenced by the nature of exposure to the mathematical register. From the research findings which were showing many learners performing incredibly well in English while performing dismally in mathematics and vice versa, we arrived at the conclusion that the language associated with learning mathematics is a mathematical register. A learner who will develop a mastery of this register will tend to perform well in its use than other speakers in the respective language who could just be competent in the general language knowledge. Consequently, this paper is accentuating that whereas general language knowledge may not dictate mathematical thinking, mathematical register will always have a bearing on it.

We hypothesize that man cannot think without using a system of signs. As a result, utilize both their internalized language and numerical language in the process of mathematical thinking. This hypothesis suggests that there must be an input of mathematical terms, signs, numerals and formulae into the brain before the brain can afford to think, generate and understand mathematical grammar.

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