THE MATHEMATICS-LANGUAGE SYMBIOSIS: THE LEARNERS' BENEFITS

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Abstract
It has seemingly existed unnoticed that students admitted to read language in the higher institutions often wonder about the place of mathematics in their course of study, that they are compelled to take basic mathematics in their General Studies. On their own part, those whose course of study is mathematics are curious concerning why they are expected to partake in language studies. The effect of this has been unwilling attendance, disinterestedness, low attendance to the lectures, plus poor results or total failure in the examinations. This state of affairs has occasioned this topic of study: "The Mathematics-Language Symbiosis: The Learners' Benefits". The objective is to look into the relationship between mathematics and language to find out whether there is a symbiotic relationship between both of them, the nature of the relationship and the advantages that will accrue to the students or learners. A descriptive approach is adopted in the investigation. The Theory of Applied Linguistics propounded by Leonard Bloomfield in 1941 guides the study. The study finds out that there exists a give-and-take relationship between mathematics and language. Among other things, the investigation finds out that, in reality, mathematical reasoning and problem-solving are closely linked to language, and depend upon a firm understanding of basic mathematics vocabulary. Also established is that language provides students with the foundation they need not only to comprehend mathematical concepts, but to successfully interact within a mathematics classroom so as to continue learning advanced concepts. The findings include the fact that syntactic relations necessitate philosophical statements on logical probability. In other words, some syntactic principles determine logic and mathematical assumptions.

1.0 Introduction

The Oxford Advanced Learner's Dictionary defines Mathematics as the science of numbers and shapes; the process of calculating using numbers. The same book defines Language as the system of communication in speech and writing that is used by people of a particular country or area. From the definitions, Mathematics is a science but Language is not, but belongs to the arts. In both definition and as subjects, the two are poles apart. Even as courses of study in the higher institutions, they do not share some compatibility. The seeming impression people have for them is like that of two straight lines that can never meet at any point.

Besides, in JAMB application, any person offering English as a course is easily presumed not to be so good in mathematics or calculations. The same line of perception is held by some people concerning JAMB applicants who offer Mathematics. They are normally assumed, most times the majority, to be hot in calculative mental and logical reasoning, but obviously very less so in arts, especially in matters of language. The Mathematics-Language regard does not end here. Higher institution students of language and other non-science students are most times astonished, at times with consternation, surprise and wonder to see that they have to go through the rigors of basic calculations or mathematics in their courses of study. The feelings of language students turn bad most times on knowing that their courses will involve some basic concepts in mathematics. The same goes for mathematics students on knowing that some of their courses will touch some basic concepts in grammar or language.

The consequence is that such students are worried, scared and disturbed in their feelings. As they wonder about the relevance of such opposed courses to their fields of study, disgust and despondence will take a better part of them. Unwillingness and disinterest will reside in their feelings. The effect of it all is low attendance to lectures, lack of zeal to study, a fall in morale and a good quantum of nonchalance. These will culminate in poor results or total failure in the examinations. Even the University's wisdom and foresight in including such courses in their curriculum will appear to have not been realized.

It is on account of these observations that this paper is poised to look into the possibility of a relationship between mathematics and language. The objective is to find out whether there exist some relationship between mathematics and language. Another objective is to find out the kinds of advantages that are symbiotically shared between mathematics and language. Another drive of this study is to consequently device some remedy that will help to eliminate the fears that are nursed by mathematics students against language and language students against mathematics.

The paper is organized in such a way that the introduction in section one, will draw the mind of the reader to the motivations for the study. The second section will be literature review where the views of experts in the areas of the relationship of language and mathematics will be thoroughly examined. The third section will concentrate on the assemblage of data and the analysis. The fourth section will bother on the summary of findings and conclusion.

2. Literature Review

In this section, we are focusing on the discussion of the opinions of some experts as they pertain to our area of study.

2.1 Definition and Explanation of Mathematics

According to Oxford English Dictionary published by Oxford University Press in 2012, Mathematics is defined as the science of space, number, quantity, and arrangement, whose methods involve logical reasoning and usually the use of symbolic notation and which includes geometry, arithmetic, algebra and analysis. The word, Mathematics, is from the Greek word "mathema" which means "knowledge, study, learning". This is interpreted to also mean "that which is learnt" or "what one gets to know". It is the study of topics such as quantity (numbers), structure, space, and change. There is a range of views among mathematicians and philosophers as to the exact scope and definition of mathematics.

From Wikipedia, the free encyclopedia, we learnt that mathematics seeks out patterns and use them to formulate new conjectures. Mathematicians resolve the truth or falsity of conjectures by mathematical proof. When mathematical structures are good models of real phenomena, then mathematical reasoning can provide insight or predictions about nature. Through the use of abstraction and logic, mathematics developed from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects. Practical mathematics has been human activities for as far back as written records exist. The research required to solve mathematical problems can take years or even centuries of sustained inquiry.

Drawing our attention to what notable mathematicians said about the discipline of mathematics, Wikipedia, the free encyclopedia, cites Carl Friedrich Gauss (1777-1855) as referring to mathematics as "the Queen of the Sciences"; Benjamin Peirce (1809-1880) called mathematics "the science that draws necessary conclusions"; David Hilbert said of mathematics: "We are not speaking here of arbitrariness in any sense. Mathematics is not like a game whose tasks are determined by arbitrarily stipulated rules. Rather, it is a conceptual system possessing internal necessity that can only be so and by no means otherwise"; Albert Einstein (1879-1955) stated that "as far as the laws of mathematics refer to reality, they are not certain; and as far as they are not certain, they do not refer to reality". All they are saying can be summarized to be talking about the exactitude and unquestionability of the facts provided through mathematics.

Stressing about the application of mathematics, our source makes it clear that mathematics is essential in many fields, including natural science, engineering, medicine, finance and the social sciences. It maintains that applied mathematics has given rise to entirely new mathematical disciplines, such as statistics and game theory.

Further insight into what mathematics is comes from Courant and Robbins (1996). They let us know that the three leading types of definition of mathematics are called logicist, intuitionist, and formalist, each of which reflects a divergent philosophical school of thought. Intuitionist definitions identify mathematics with certain phenomenal. An example of an intuitionist definition is "Mathematics is the mental activity which consists in carrying out constructs one after the other". Intuitionism allows only mathematical objects that one can actually construct, no more no less. So, if it cannot be constructed, then it falls outside the coverage of intuitionism. The definition of mathematics in terms of logic sees mathematics as "the science that draws necessary conclusions". Here, one can say that in logic, presented statements or facts form the basis of the drawing of inferences or making finality statements. As per the Formalist definitions, it is the one in which mathematics is identified with its symbols and the rules for operating on them. That is why it is often defined as "the science of formal systems". A formal system is set of symbols, or tokens, and some rules telling how the tokens may be combined into formulas. In formal system, the word, axiom, has a special meaning, different from the ordinary meaning of " a self-evident truth". In formal systems, an axiom is a combination of tokens that is included in a given formal system without needing to be derived using the rules of the system.

2.2 Definition and Explanation of Language

In Okolo and Ezikeojiaku (1999:14), Ladd's (1957:32) view "Language is primarily an instrument of communication among human beings in a community". This is different from Chomsky's (1957:13) view which says that language is "a set (finite or infinite) of sentences each finite in length and constructed out of a finite set of elements". Sapir's (1921:8) definition is that language is a purely human and non-instinctive method of communicating ideas, emotions, and desires by means of voluntarily produced symbols". The definition Hall (1968:158) gives about language is that it is "the institution whereby humans communicate and interact with each other by means of habitually used oral-auditory symbols".

The observation that is made in the above definitions is that it is a tool which human beings use, and the purpose of usage is to exchange message with other people. The method of communication is by symbols. It becomes established from all these that language is for man to use in some cases for passing ideas, emotions and desires across to people. That is, making human beings to be aware of what they did not know before.

The modern use of the word, language, is not restricted to natural languages such as Igbo, Yoruba, Hausa, Edo, English or French. What is happening is that the idea of language is being extended to other varieties of communication, notation or calculation. Along this line, there is computer language and other artificial languages that are constructed to respond to specific needs (Okolo and Ezikeojiaku, 1999).

Further still, Okolo and Ezikeojiaku (1999) give us an overwhelming insight into the over-spreading role language plays in human life. According to them, from birth to death, language enters into the fabrics of our lives. It is the tool with which we carry out most mundane transactions of our everyday-life. It is the pillar that holds all scientific work, including mathematics. Even when we are alone, our thoughts are conducted and made to come into awareness as words and sentences. We hardly recognize the relevance of language until we experience communication breakdown. It is the ability to talk that marks human beings out from other animals. For this reason, the study of this ability should constitute a central aspect of any study of human life. Human understanding and cooperation are made possible by language. Okolo and Ezikeojiaku (1999) cite Samuel Johnson's words in his Lives of the English Poets, Vol. 1, where he says that "language is the dress of thought". What this means is that we rely on language for many purposes. Language can change opinions and beliefs as well as exert control over people's thoughts and actions. They also tell us that language and abstract thoughts are closely linked. Another lesson we are given through these expositions of the uses of language is that it is this wide range of application of language to human life that has intensified the investigations into the nature of language by linguists. On this account, also, it is not surprising that, in recent years, one of the fastest-expanding branches of knowledge has been linguistics, scientific study of language.

Finch (2000) takes us to the knowledge of what linguistics does with language. First of all, linguists approach language in a scientific manner, adopting an objective method. Secondly, they apply an empirical method by which means they do some observation, description and then an explanation. Observation, description and explanation are the three stages of linguistic enquiry. Their job takes off with the observation of how people use language, on the platform of which they supply a description of language use, and ultimately, once the data has been analysed, they will provide an explanation. It is at this stage of explanation that linguists endeavour to establish the underlying rules which the speakers are following.

Finch (2000) makes us to understand that before the emergence of linguistics, language in the western world had been the interest largely of philosophers and prescriptive grammarians. According to him, it was the era of Ferdinan de Saussure, a Swiss linguist, that structural linguistics developed; language began to be seen as a self-enclosed system. In this system, words are related to each other as signs and can be strung together in various combinations to form sentences. He maintains that the extent of word's capacity to form sentences is seen as the sum of its potential to combine with, or substitute for, others. In Finch's (2000) view, Saussure imagined sentences as having two axes-paradigmatic and syntagmatic. He termed the axis of substitution paradigmatic, that of combination, he termed syntagmatic. The work of Saussure combined with the works of Noam Chomsky have finally achieved for linguistics the respect it deserves as a major humanistic discipline.

As a humanistic discipline, linguistics has developed a branch known as Applied Linguistics. According to Crystal (1991), applied linguistics is a branch whose primary concern is the application of linguistic theories, methods and findings in order to explain language problems which have arisen in those experience areas. In his view, learning and teaching of foreign languages is the most developed aspect of applied linguistics. According to Wilkins (1999:7), applied linguistics is a study that:

> "…concerned with increasing understanding of the role of language in human affairs and thereby with providing the knowledge necessary for those who are responsible for taking language-related decisions whether the need for these arises in the classroom, the workplace, the law court or laboratory".

Mekiliuwa (2008) sees applied linguistics to be about the application of what we know about language, how we learn it and how we use it to solve problems in the real world. Umaru (2005) is of the view that applied linguistics makes use of the findings and techniques of other areas of linguistic study. She maintains that the findings and techniques are used to render helps in many different practical ways, especially in language teaching. The implication of all these views about applied linguistics is that it is a branch of linguistics that puts the discoveries of the theories of linguistics into practical gainful advantages for mankind. It means also that through applied linguistics, the theories of linguistics are not wasted; they are converted to practical uses for mankind. It also means that any field, such as mathematics, to which the findings of linguistics are applied, is an indication of the works of applied linguistics.

2.3 Existence of Mathematical Linguistics

As obtained from www.encyclopediaofmath.org/index.php, Mathematical linguistics is a discipline whose objective is the development and study of ideas forming the basis of a formal apparatus for the description of the structure of natural languages (that is, the metalanguage). The discipline came into being out of the internal needs of theoretical linguistics and problems in the automatic processing of linguistic information. Mathematical linguistics uses such methods as the theories of algorithms, automata and algebra. It is a branch of mathematical logic. In structural linguistics, language is presented as a "system of pure relations. This, in a way, brings language near to the abstract systems studied in mathematics. Mathematical linguistics helps in the understanding of the logical processes necessary to establish the truth of propositions, and ability to think logically and analytically. It gives the competence and confidence in the use of appropriate mathematical tools, techniques and methodologies for solving a wide range of problems. It gives the preparedness for a career requiring a high level of numeracy, or further mathematics-related study.

Chomsky (1962) makes it clear that Mathematical linguistics is a branch of mathematical logic. The methods used in mathematical linguistics have found application in the theory of programming. The concept of the function of language is seen as a transformation of certain abstract objects, that is, meanings, into objects of another type, and from there, it is changed into "text", and conversely. Chomsky (1962) presents mathematical linguistics as a discipline that uses syntactic structures to describe the structure of parts of speech. In doing that, the syntactic structures are represented by a graph or di-graph of a special form, usually with labeled vertices and/or edges. According to him, this is the best developed theory of description for the "surface" levels (that is, those most remote from the "meaning"). At these levels, the structures are usually trees.

Chomsky (1962) expresses the importance of the analytic models of language. The reason of their importance is because they permit the logical nature of many ideas and categories of traditional linguistics to be made more precise. In a number of models, the initial data are represented as finite sets and finitary relations.

From Reghizzi (2009), we get facts about formal language theory which developed from linguistics. He states that in mathematics, computer science and linguistics, a formal language is a set of strings of symbols that may be constrained by rules that are specific to it. The alphabet of formal language, he maintains, is the set of symbols, letters, or tokens from which the strings of the language may be formed; frequently, it is required to be finite. The strings formed from this alphabet are called words, and the words that belong to a particular formal language are sometimes known as well-formed words or well-formed formulas. There are many names by which a formal language may be referred, such as formal grammar, regular grammar or context-free grammar or formation rule.

Mbah (2011) delves into some basic assumptions that are made in syntax. According to him, in the course of addressing some issues in language, it is found out that some syntactic rules are described as coincident with some logical and mathematical principles. As philosophy sees itself as the fountain of human knowledge, it is language that is the conveyer of the philosophy itself. It is for this reason that linguistic, logical and mathematical rules tend to have their source in these general principles that obviously direct human reason in its intellectual operation. In his view, there exists some discrete mathematics whose application can only be explained by the syntactic principles of contemporary syntactic theory. Also, set theory and formal logic can be described on the basis of syntax. He maintains that it is not easy to appreciate the interface between algebraic and syntactic formalizations. And that there tends to be some influence of some linguistic principles on mathematical logic and discrete mathematics. It may be necessary to look into how syntactic principles determine logic and mathematical assumptions. From Mbah (2011), it is discovered also that syntactic statements necessitate philosophical statements on logical probability. That is to say, some syntactic principles determine logic and mathematical assumption. He reminds us that language consists of symbols, and that it is good we look into how these symbols relate and find relevance in mathematics. Again, Mbah (2011) discloses that grammar's syntax is known to be guided by principles no matter the language involved. The formation of lexical items and their projections are directed or guided by these principles.

The fact remains, he maintains, that language consists of symbols made up of letters and digits. The letters are made use of in writing language whereas letters and digits are used in logic e.g. in mathematics. According to him, each digit has its reflexes in letters. Letters are concatenated to produce lexical items or juxtaposed to generate strings of words or figure. Mbah (2011) exemplifies his idea thus:

1 /wΔn/
2 /tu/
10 /ten/

He says that in the presentation, the figures are digits whereas their phonological reflexes are made up of letters. Their difference is easily seen in the fact that the digits have discrete values not minding the social context. And it is a whole number with a singular value. /wΔn/ on the other hand can mean a non-negative integer with a singular value (1) or it can be the past tense of "win". This shows that context may attribute other meanings to the word. We can understand from here that context is the variable operator that determines the meaning which linguistic items are said to have. What this means is that linguistic items have a wider application than mathematical or logical words. The claim being made by this analysis is that when symbols are concatenated, they are united to each other and together form a meaningful unit.

Mbah (2011) is of the view that the principles of union, intersection and complementation, which, according to Mendelson (1970), Partee Meulen and Wall (1990) and Mbah (1998), are all elements in the phenomenon of field of sets, also apply in language. He maintains that it is possible for morphemes, whether free or bound, to constitute isomorphic entities, which get concatenated to each other under the principle of the union of isomorphic sets, where $A \cap B = \{x: x \in A \text{ or } x \in B\}$. In his illustrated presentation, Mbah (2011) sells the view that different contexts assign different semantic values to lexical items within a syntactic component. From this, he goes ahead to say that it is arguable that mathematical values are but a strand of syntactic values. He then goes on to conclude that if we replace any grammatical class with X, then its phrasal projection XP is both equivalent to and a mere extension of X; and that this equivalence explains why the head of a phrasal category replaces it within a syntactic slot, e.g.

Obi nwere ego di ocha biara

(Obi who is fair and rich came)

What he implies here is that the above sentence has approximately the same meaning with this: Obi biara (Obi came).

\subsection{Mathematics as a Language}

2.4 Mathematics as a Language

In *www.ascd.org/ASCDpdf/Building*, we are given some explanation on the value of directly teaching language skills in various disciplines, including mathematics. Here, it is made clear that writing was developed by the Sumerians approximately 5,000 years ago. At the same time, the Sumerians developed some written notation for mathematics. Writing and mathematics are brain tools-they are powerful aids to the human mind. The abilities to use both written language and mathematics are also so useful to people that these are basics in our formal educational system. Mathematics education system pays some attention to the idea that mathematics is a language.

As obtained from http://www.mathematicallycorrect.com, in a speech delivered at the annual meeting in Chicago of the National Conference of Teachers of Mathematics (NCTM), April, 1988, by Frank B. Allen, Emeritus Professor of Mathematics, Elmhurst College, he is quoted from the paper as saying: "This brings me to my major thesis that natural language, gradually expanded to include symbolism and logic, is the key to both the learning of mathematics and its effective application to problem situations. And above all, the use of appropriate language is the key to making mathematics intelligible. Indeed, in a very real sense, mathematics is a language. Proficiency in this language can be acquired only by long and carefully supervised experience in using it in situations involving argument and proof".

From the same source, it is made clear that mathematics and writing are not far-removed from each other. Professional mathematicians spend most of their time writing: communicating with colleagues, applying for grants, publishing papers, writing memos and syllabi. Writing well is extremely important to mathematicians, since poor writers have a hard time getting published and obtaining funding. It is ironic but true that most mathematicians spend more time writing than they spend doing mathematics.

According to the source, one of the simplest reasons for writing in a mathematics class is that writing helps you to learn mathematics better. By explaining a difficult concept to other people, you end up explaining it to yourself. It is also made clear that the language of mathematics does not consist of formulas alone. The definitions and terms are verbalized often acquiring a meaning different from the customary one. One may wonder whether 0 is a number. As the argument goes, it is not, because when one says, "I watched a number of movies", one does not mean 0 as a possibility (since 0 is not a natural number). 1 is an unlikely candidate either (since we are talking of *number of movies*).

Our internet source reveals that Warren Esty published an article in the Mathematics Teacher (Nov. 19992, 616-618) entitled "Grade assignment based on progressive improvement" which was reprinted in the NCTM's Emphasis on Assessment and posted on the web by the Eisenhower National Clearinghouse for Mathematics and Science Education. Esty, in that book, writes as follows: Mathematical results are expressed in a foreign language. Like other languages, it has its own grammar, syntax, vocabulary, word order, synonyms, negations, conventions, idioms, abbreviations, sentence structure and paragraph structure. It has certain language features unparalleled in other languages, such as representation (for example, when "x" is a dummy variable it may represent any real number or any numerical expression). The language also includes a large component of logic. The language of mathematics emphasizes all these features of the language (Esty, 1992).

It is also revealed that when students do a description of the attributes and relationships in mathematics in their own oral language terms, the teacher can, through questioning guide the students to increasingly precise language of mathematics. Once the language is clearly understood, as are the definitions of the concepts and principles, the symbolic translation to equations (numerals and operational symbols) are relatively easy. It gulps time to assist students acquire concepts and definitions.

2.5. Computational Linguistics

Oettinger (1968) exposes the relationship of computer and its implied calculations with language. He is of the view that computers for languages and languages for computers are two points of a modern synthesis of mathematics and linguistics with the computer sciences. To him, computational linguistics is a subset of mathematical linguistics which deals with the application of computers to linguistic problems and with the application of linguistics to computer problems. He reveals the existence or the first practical realization of large scale automatically sequenced digital calculators, capable of manipulating not only numerals in accordance with the laws of arithmetic, but also any symbol system based on a discrete alphabet and obeying combination laws of the greatest generality. He maintains that mathematical linguistics from which computational linguistics springs up is also concerned with specialized technical jargons, mathematical or chemical notations, the formal symbol systems of logic, or the various systems for instructing computers which, as products of more self-conscious and deliberate human creation, are called artificial languages.

Hutchins (1999) argues that computational linguistics came into being with the efforts in the United States in the 1950s to use computers to automatically translate texts from foreign languages, particularly Russian scientific journals, into English. Sharing his own view about the work of computational linguistics, Barach (1975) says that since computers can make arithmetic calculations much faster and more accurately than humans, it was thought to be only a short matter of time before the technical details could be taken care of that would allow them the same remarkable capacity to process language. On his part, Crowley (1992) adds the view that aside from automatic translation, computational and quantitative methods are also used in historical linguistics in reconstruction of earlier forms of modern languages and sub-grouping modern languages into language families. This is because the earlier methods like lexicostatistics and glottochronology have been proved to be premature and inaccurate. With computational linguistics, automated processing of human languages is presently being carried out. According to Salvi, Montesano, Benardino and Santos-Victor (2012), the ability of infants to develop language has been modeled using robots in order to test linguistic theories. Through computational linguistics, therefore, the linguistic development of an individual within a lifetime is continually improved using neural networks and learning robot systems. Researchers have created a system which not only predicts future linguistic evolution, but also gives insight into the evolutionary history of modern-day languages. Computational approaches help in giving a better understanding of how language works on a structural level (Marcus and Marciniewicz, 1993).

From Jurafsky and Martin (2009), it is argued that computational linguistics is making human-computer interaction much more natural. Many of the earliest and simplest models of human-computer interaction, such as ELIZA for example, involve a text-based input from the user to generate a response from the computer. In computational linguistics, speech recognition and speech synthesis deal with how spoken language can be understood or created using computers. Parsing and generation are sub-divisions of computational linguistics dealing respectively with taking language apart and putting it together. Machine translation remains the sub-division of computational linguistics dealing with having computers translate between languages (Oettinger, 1965).

2.6. Mathematics and Language Learners

Pimm (1987) argues that nothing should be allowed to obscure the complex role of language in mathematics. Supporting the idea in a rather different way, DfES (1999) is of the opinion that children's English can be used as a framework for teaching mathematics. He maintains that English provides the means for children to think about mathematics, as well as to express that thinking. In his view, if children are not supported to develop mathematical English, they are less likely to be able to participate fully in mathematics lessons, and so will have fewer opportunities to make progress in mathematics.

Barwell (2002) is of the view that mathematical discourse has specialist syntax, particularly to the expression of logical relationships. He makes it clear that the use of "of", "or", "a), "if" and "then" to define mathematical relationships are all significant. He goes further to stress that mathematical discourse involves the use of mathematical symbols. The kind of symbols involved range from numerals to more specialized notation. These symbols have a syntax of their own. That is why 2X and 2x mean different things. Also, matching tasks could support the connection of symbols with the related words. He argues that there are specialized ways of talking in mathematical discourse. That way of talking includes written and spoken forms of mathematical explanation, proof or definition, as well as text types like word problems. Besides, he is of the view that mathematical discourse also includes a social dimension. There are ways that teachers and students talk, but their talking is associated with mathematics. Instructions, for example, might include expressions like "simplify", or "complete the following". Teachers often use 'we' to refer to 'people who do mathematics' (e.g. we use x to represent an unknown). Mathematics, in his opinion, helps one to find patterns and make reliable predictions. It is also a good training for the mind since it makes one a more vigorous thinker. It is said to be a good push-up for the minds of human beings. Mathematical models are fast becoming the best way to understand a complex phenomenon. That is why biologists, economists, sociologists, neuroscientists are busy developing mathematical models to understand their chosen phenomenon. Once a phenomenon reaches a certain level of complexity, the human mind is simply not able to understand it as a whole.

Raiker (2002) is of the view that spoken language is in large part responsible for problems in the teaching and learning of mathematics. He is of the opinion that teachers should be aware of the language they use when teaching mathematics and that the recommended vocabulary should be used with caution. If the language being used is cryptic, it can impede meaningful problem solving. Mathematics and literacy are deeply connected in reality. Literacy does not exist only in language arts classes.

The techniques used to hone language skills should reach beyond the classrooms of English language and be extended to mathematics. According to him, scientists have discovered that the same genes in our DNA determine our aptitude in both mathematics and language arts. This suggests that humans are born with an innate disposition to comprehend and construct meaning of words, symbols, and abstract concepts found in algebra, for example. The biological base of learning mathematics and language is a single symbolic processing system-the fundamental procedure by which we learn to decode letters, numbers, and signs, and to derive meaning from these symbols. What this goes to show is that the essence of mathematics has much to do with reading comprehension than memorizing rules.

Raiker (2002) goes on to say that while there is a strong genetic connection between literacy and developing maths skills, stronger still are the environmental influences, which is why so many people consider themselves unable and unwilling to learn mathematics. Mathematics can be learned just like soccer and language, but it must be learned and taught appropriately. Scientists acknowledge that the aptitude for developing maths skills is directly connected to literacy. The conclusion is reached that if students applied reading comprehension tools like translating abstract concepts into their own words, defining difficult vocabulary, and finding concrete and semi-concrete examples in order to make real world connections to what they are learning, these students would ultimately be far more successful in mathematics than they might be otherwise. Language encompasses more than grammar and literature; it is how we communicate and solve problems by expressing ourselves in the best language possible, be it English, image, or even algorithm. Therefore, it is clear that the best practices in literacy educations should be applied in all subjects, and from there we can build a culture that lessens the mysticism of mathematics, making all of us "maths people", simply people …well-rounded and well-educated.

2.7. Application of Mathematics Learning to Other Areas

In the internet, from *http://www.edweek.org/ew/article/2015/06/03,* some research facts about the transfer of knowledge, especially that of mathematics, are shared by Holly A. Taylor, a psychology professor at Tufts University, in Medford, Mass, in the Association of Psychological Science conference. According to him, "looking at the longer history of transfer of knowledge, the research shows that if you have students pull a general concept out of a combination of specific examples and give multiple different examples, it increases transfer of that concept to new examples". In that also, David J. Purpura, an assistant professor in clinical psychology at Purdue University, in West Lafayette, gave the suggestion that young students' ability to apply early mathematics skills can be hampered or propelled by their language development, not minding their knowledge in mathematics. He also said that in order to be able to do any mathematics, the student must have these basic language abilities of words like 'plus' or 'take away'; and that the way a concept is presented can also affect how easily students understand when and how to apply it in other situations.

Dale and Cuevas (1992) and Jarret (1999) share their views from their researches on why mathematics instruction is needful for English language learners. They reveal that making sure that students understand mathematics vocabulary and have ample opportunities to use it is very important. They point out the following mathematics skills as the ones that require serious proficiency in language: solving word problems, following instructions, understanding and using mathematical vocabulary correctly. They reveal that initially, they did not know that mathematical problems solving are closely related to language. They share the idea that English language learners' (ELL) teachers who are to teach content areas are being asked to lead or support instructions in the mathematics classroom. They express how surprised they are to realize how big a role language plays in mathematics instruction.

Some of their lessons about using language in mathematics instruction include the importance of language acquisition, building background knowledge, increasing student language production, and explicitly teaching academic language. Through the use of language, the students are being provided with the foundation they need not only to understand the mathematical concepts, but also to successfully interact within a mathematics classroom so as to continue learning more advanced concepts.

From Dale and Cuevas (1992) and Jarret (1999), the importance of teaching academic vocabulary is brought to our knowledge. It helps in teaching mathematics -specific terms like percent or decimal. Also, it helps in understanding the difference between the mathematical definition of a word and other definitions of that word.

Moschkovich (2008) gives some example that underscores why vocabulary must be introduced within the context of the content. He exemplifies this with a sketch of a triangle whose two dimensions are given as 3cm and 4cm and the student is required to find the third dimension designated as "x". The student clearly knew the meaning of the word "find" because he/she "found "it on the page and circled it. The student even put a note on the page to enable the teacher locate the lost "x". Here signaled it with "Here it is", using an arrow to point at "x" in the sketch of the triangle on the book page. The fact is that the student understood the meaning of "find" in one context, but not in the appropriate mathematical context. What this goes to teach us is that lack of familiarity with a vocabulary can hinder one's ability to solve the mathematical problem. Bernardo (2005) counsels that teachers should demonstrate that vocabulary can have multiple meanings, encourage students to offer bilingual support to each other, provide visual cues, graphic representations, gestures and pictures, identify key phrases or new vocabulary to pre-teach. All these will help the students to read and understand written maths problems. At times the student's background knowledge of mathematics can be used as a stepping stone for other language learning.

2.7. The Theoretical Framework

The theory that guides this work is that of Applied Linguistics propounded by Leonard Bloomfield in 1941. Giving the thrust of the subject, Agbedo (2015:264) asserts that, "in applied linguistics, the findings of linguistic theories and descriptions are taken over and applied directly to language teaching, translation and other relevant fields". Anagbogu, Mbah and Eme (2010:33) see applied linguistics as "the application of the theories, methods and findings in linguistics for practical uses and to non-linguistic fields". The claim of the theory is that after linguists have researched into language and made their findings available for use, then other interested professionals will come and use the knowledge the linguist has won and use it to improve their performance in their own field.

Applied linguistics is currently being used to improve language teaching. It is also being used in grammar construction, translation studies, formulating actual techniques in teaching and production of textbooks, solving practical problems of automatic or machine translation and exploitation of statistical techniques related with the use of language. It is used in developing computer programmes or computer-assisted language learning. In fact, any area problems of language can be solved in the real world, applied linguistics goes there.

That accounts for its use in this work to see how language helps in solving the problems of mathematics and vice versa. At the end of the exercise, it will be established how learners of both language and mathematics will be the gainers in the symbiosis.

1. **Data Presentation and Analysis**

Here, we are set to assemble the facts of our investigation so as to ascertain if there is a symbiotic relationship between mathematics and language and the nature of the relationship.

3.1 Data Presentation

Having defined language and mathematics as the key words of our topic, it necessary we highlight the outcome of the definitions.

The definitions we made about language show that language has the following components:

a. A vocabulary made up of symbols or words. Symbols like α, β are used in language.
b. A grammar that has the rules of how these symbols may be put into use
c. A syntax which places the symbols in linear structures
d. A discourse or narrative made up of strings of syntactic propositions
e. A community of people who use and understand these symbols
f. A range of meanings that can be communicated with these symbols

It should be noted that each of these symbols has its place and usefulness in the language of mathematics.

3.2. The Nature of the Relationship between Mathematics and Language

We have to look into the relationship between mathematics and language through the elements of mathematics in language and the elements of language in mathematics. This will also take into consideration what language offers to mathematics and what mathematics offers to language.

3.2.1 The Elements of Mathematics in Language

In terms of definition, the language of mathematics can be described as the system used by mathematicians to communicate mathematical ideas among themselves. That is, the symbolized or coded rule by which those who do mathematics pass ideas across to one another.

The language of mathematics is made up of such components as technical terms and grammatical conventions (peculiar to a discourse on mathematics) for example $\forall n \in N \exists m \in Z \ni m + n = 0$. This is just saying that any whole number has an additive inverse (additive inverse of x is y if x + y = 0).e}

A. The Vocabulary of Mathematics.

The under-mentioned points are true about the vocabulary of mathematics:

a. Mathematical notation has assimilated symbols from many different alphabets and type faces. These symbols seem specific to mathematics, for example $\$\beta, \alpha, \varepsilon, \mu, \sigma, \exists, \varphi, \sum$, e.t.c.

b. The symbolic notations can be multiple variables simply called x, y, z, etc.

c. Sometimes it is not easy to understand the formulas without a written or spoken explanation; in some cases, the formulas are difficult to read aloud. Information is lost if not well translated to words. For example, $\$P(X\backslash Y) = \frac{P(X \cap \quad Y)}{P(Y)}$, this says that the conditional probability of X given Y is the probability of X intersection Y divided by probability of Y. The learner needs spoken or written explanations of concept involve.

d. Mathematics has its own brand of technical terminology. In some instances, a word in general usage possesses a different or specific meaning in mathematical situations. Examples of such words are, group, ring, field, category, term and factor. For example in general usage, group is number of people or things that are connected in some ways. In Mathematics, group is set with a binary operation such that properties like closure, existence of: identity element, inverse of any element of the set, with respect to the binary operation are satisfied. It should be noted that these descriptions are virtually saying the same thing "Things with rule that brought them together".

e. There are special terms like tensor, fractal, functor, etc. These special terms needs to be explained with common or familiar language for comprehension.

f. Mathematical statements are known to have complex taxonomy. Examples include axioms, conjectures, theorems, lemmas and corollaries.

g. Mathematics has stock phrases (mathematical jargons) that seem have specific meanings. The examples are as follows: "if and only if", "necessary and sufficient", "without loss of generality", "complete the following", "simplify the following", etc. Observe that their meanings are not far from their facial meanings when analyse, eg 'if and only if' is used for phenomena that is 'doubled barred' 'A $A \Leftrightarrow B$, says A implies B and B implies A.

B. The Grammar of Mathematics

a. The grammar employed for mathematical discourse is essentially the grammar of the natural language used as a substrate, but with several mathematics-specific peculiarities.

b. The mathematical grammar used for formulas has its own grammar, which does not depend on a specific natural language, but shared internationally by mathematicians regardless of their mother tongues.

c. A mathematical formula can be a part of speech in a natural language, phrase, or sentential phrase, or a full-fledged sentence.

d. An equation can be given the status of a sentence or sentential phrase in which the "greater than or equal to" symbol has the role of a verb, eg 2x = 6 .

e. Mathematical formulas can be vocalized (spoken aloud). The vocalization has to be learned and is dependent on the underlying natural language. Some examples of the vocalization are: "f(x)" is pronounced "eff of eks", "$\frac{dy}{dx}$" is vocalized like "dee-why-dee-eks". The fraction bar is omitted.

f. There is the use of "inclusive first person plural "We". What it means is "the audience (or reader) together with the speaker (or author).

g. There is a language community of mathematics. What this implies is that mathematics is used by mathematicians who form a global community made up of speakers of many languages. It is also used by students of mathematics. Nearly all educated people have some exposure to pure mathematics.

3.2.2. The Elements of Language in Mathematics

The following are the aspects of language that are existent in mathematics:

a. Capital Letters used in Denoting Sets and Specification of Sets is done with Natural Language. For example, let A be the set whole numbers less than 9 but greater than 1, i.e $A = \{x : x \in \ Z \ and \ 1 < x < 9\}$.

One way of describing sets is to use a natural language to specify all the requirements imposed on the set. Even the enumeration of all the elements of the set is put in a comma-separated list enclosed in curly brackets. This means that commas and brackets that are characteristic of language are used. For example, A = {2,3,4,5,6,7,8}.

b. Use of Ellipsis

In the abbreviations of definition of sets that have clear (already known) meanings, ellipsis is used.

c. Use of Definitions and Involvement of Writing.

In general, to introduce a new construct into a mathematical system, the notion of "formal definition" is used. A definition is just a piece of text exactly and unambiguously describing the behaviour of our new construct. Also, writing that is characteristic of language is used so much in mathematics. This implies the incorporation of symbols for which language is known. Writing and mathematics are brain tools. They are powerful aids to the human mind. Writing and mathematics are linked. The abilities to use both written language and mathematics are so useful to people that these are basics in our formal educational system. Mathematicians write a lot. Writing helps one to learn mathematics better. By explaining a difficult concept to other people, one is explaining it to himself.

d. Mathematical Results are expressed in a Foreign Language. Mathematics is universal and results need to go out from the local to others.

e. Use of Symbols and notations

The symbols mathematics uses are obtained from many different alphabets, and they seem specific to mathematics. Mathematics also uses notations that are in multiple variables like x, y, z, etc.

f. Formula Vocalization\\

Mathematics formulas are vocalized just as words are pronounced in language.

g. Use of "inclusive first person plural "We"

Mathematicians use "we" to make reference to the audience (or reader) together with the speaker (or author).

f. There is a Language Community of Mathematics.

Like a language that must have a community that uses it, mathematics is a property of mathematicians who form a global community composed of speakers of many languages.

3.2.3 What Mathematics Offers to Language (A Part of the Symbiosis)

a. Finding patterns and making predictions.

Mathematics helps human beings or students to find patterns and make reliable predictions. With it, a linguist can get his hands on any and all the tools he can find that will help him to study whatever sub-field he wants to specialize in. The principle of mathematical induction which says that if a proposition 'P(n)' is true for n = 1 and true for n = k implies true for n = k + 1, then P(n) is true for every natural number, is very a powerful tool for making reliable predictions.

b. A good training for the mind.

In being a good training for the mind, mathematics makes a language person a very vigorous thinker in whatever field one finds himself. It is a good push-up for the mind. For example, A $\rightarrow B$ does not imply $B \rightarrow A$ but implies $\sim B \rightarrow \sim A$. If A then B, has not given us information on 'if B', but it tells us that if there is no 'B' then there is no 'A'.

c. Guarantee of future relevance.

In the present fast-lane of world development, mathematical models are fast becoming the best way to understand and cope with complex phenomenon. That is why biologists, economists, sociologists, neuro-scientists and linguists are developing mathematical models to understand their chosen phenomenon. Once a phenomenon reaches a certain level of complexity, the human mind is simply not able to understand it as a whole. Language involves the interaction of thousands of variables. With mathematical models and statistical analysis, mathematics is not only a tool, but also the right tool.

d. Without mathematics, language learners will be behind the times.

Any 21st century linguist will be required to read about and understand mathematical models as well as understand the statistical methods of analysis. Whether we like it or not, the use of mathematics as a tool of analysis is already here with us and its prevalence will grow over the next few decades. We can only join the train so that we remain updated and sophisticated.

e . Learning mathematics will make us better linguists.

Nobody will like not to belong to the group of linguists that successfully tackle challenging language problems. Any linguist worth his salt will surely like to be a part of the community of scholars who work to unfold the mysteries of language. Mathematics is a tool that will help an aspiring language learner to enter that community and contribute to it in a highly productive way.

3.2.4. What Language Offers to Mathematics (A Part of the Symbiosis)

What language offers mathematics can be examined under the following headings:

a. Some mathematics skills require language proficiency

   There are some skills in mathematics that require expertise in language. Such skills are as follows: solving word problems, following instructions, understanding mathematics vocabularies and using mathematical vocabularies correctly.

When there is lack of familiarity with mathematical words, it tends to hinder the ability of the student to do mathematics problem. This can lead to empathy for those who struggle to understand mathematics assignments.

Word problems pose a challenge because they require that students read and comprehend the text of the problem and identify the question that needs to be answered and finally create and solve a numerical equation. For example 'A committee of 5 is to be selected from six science and four non- science students. How many such committees are possible if at least one non-science students must be included.' The role that is been played by words like 'a', 'such', 'at least', should

be properly understood before one can solve such problem. Language helps in teaching mathematics-specific terms like "percent" or "decimal".
It also helps in understanding the difference between the mathematical definition of a word and other definitions of that word.

b. Communication is a key to mathematics learning.
   Language plays a key role in mathematics classroom. Fluency in language gives learners access to the whole world of mathematics. Greater percentage of attention to mathematical discourse is concentrated on students' ability to communicate by clarifying and justifying their ideas and procedures.

The teachers' role in fostering mathematical discourse in the classroom is very important. This is because the teacher creates the opportunity for students to engage in discussions. And the teacher engages in exploring, negotiating and sharing knowledge. The way the teacher uses language in the classroom serves as a vital instance of effective communication.

c. Articulation of principles and concepts
   In learning mathematics, there is the need to articulate the principles, concepts and rationale behind the steps of a particular problem solution. With language, the students have the opportunity to deepen their understanding of higher-level knowledge structures in mathematics.

d. Removal of mathematics' ambiguities

With the teacher being mindful of his diction or language, the learners or students will benefit by the removal of the ambiguities in mathematics for them. This will strengthen the students' mathematical vocabulary. "Two hundred and three thousandths", for instance, leads to ambiguities, because it could mean either 200.003 or 0.203. Explanation, translation and comprehension of mathematical terms and processes remove ambiguities.
Students have difficulties in making sense of mathematical language. Teachers play a big role in the (harmonious or discordant) translations between formal mathematical language and natural language.

They also use language to describe and explain mathematical ideas. For example, how to use long division to solve a mathematical problem has to be explained. The students have to be conversant with the steps involved in the long division algorithm. Some mathematical terms like algorithm, plus, minus, divide, goes into, take away, subtract, quotive division context and partitive division context have to be explained. The teacher has to know that the use of cryptic language impedes meaningful problem solving in mathematics. The teacher has to distinguish between the symbol and the context.

d. A clue provider for number learning.

Language supplies rich clues to number meaning. It is a well-known fact that early learning about numbers is a critical foundation to subsequent performance in mathematics in the classroom. That is why it is beneficial to expose kids to speech that contains informative cues to number concepts. In the simplest terms, it is vital to teach children to memorise their 1, 2, 3 along with their A, B, and C. For example: 1,2 'buckle my shoe', 3,4 'knock at the door' ...

One-Ofu	O-N-E--one
Two-Abuo	T-W-O--two
Three-Ato	T-H-R-Double E--three

Four-Ano F-O-U-R--four
Five-Ise F-I-V-E-five e.t.c

More still, using numbers in ordinary conversation helps young children learn the meaning of numbers. In the same way, using numbers to talk to toddlers gives the child a better head start in mathematics than teaching him to memorize 1-2-3 counting routines.

e. Discovery of learners' problem areas.

When a mathematics teacher pays attention to specific instances of language commonly used in the mathematics classroom, it helps the teacher identify more clearly what sort of language that can be a source of difficulties and helps them understand why such language must be adapted in order to make it more meaningful. The language a child speaks affects the rate at which they learn number words, and learning number words in natural conversation. In mathematical analysis, some students do not like the frequent use of $\varepsilon > 0, \delta(\varepsilon)$, language comes in to tell them that that ε is a positive number and that $\delta(\varepsilon)$ says that the value of δ depends on the value of ε .

4. **Summary of Findings and Conclusion**

The focus point in this section is to summarise our findings and conclude the study.

4.1. **Summary of Findings**

The study has succeeded in making a lot of findings as they relate to our objectives. The study has discovered that there are some elements of mathematics in language and also some elements of language in mathematics. With this, it becomes clear that there exists some relationship between mathematics and language.

Also, through the uses mathematics makes of some elements of language and the ones language makes of the elements of mathematics, we have been able to find out that the nature of the relationship between mathematics and language is a give-and-take form. That is to say the type of relationship is a symbiotic brand.

A thorough look into the nature of the symbiotic partnership reveals that in order for learners or students of mathematics to acquire the skills to solve word problems, follow instructions, understand mathematical vocabularies and use the mathematical vocabularies correctly, they imperatively require proficiency in language. Also discovered is that communication is a key to mathematics learning, especially for the explanation, translation and comprehension of mathematical terms, concepts and processes. It is found out that language helps teacher discover learners' problem areas, and offers learners the avenue to express mathematical thinking, remove mathematics' ambiguities as well as provide a rich clue for number learning.

On the part of mathematics, it is discovered that it offers learners of language a good training for logical thinking, a guarantee for future relevance and the chance not to be behind the times. It is also established through this study that mathematics helps language learners to be able to identify patterns, make predictions and belong to the enviable community of linguistic scholars who work to unfold the mysteries of language.

4.2. Conclusion

At the onset, this study was motivated by the ill-feelings of mathematics learners in being required to do some courses in language and similar feelings in language majors in being mandated to study mathematics-related courses. The paper moved on to find out if these feelings are justified by investigating if any relationship exists between mathematics and language and the nature of relationship, if any. Another motivation for the study is to indicate how the relationship will be of benefit to learners of both language and mathematics. These investigations have been carried out and the findings have been made that satisfy the objectives of the study.

An overwhelming set of pieces of evidence has been found to prove that there is a symbiotic type of relationship existing between mathematics and language. This prevalent brand of partnership is found out to be of immense benefit to both learners of language and mathematics. The teachers of the two disciplines of human study also have their own plethora of advantages from the two distinct fields of study. And this discovery will go a long way to quench the ill-feelings that erroneously characterize the study of mathematics and language.

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