Linguistics challenges and its influence on perceived difficulty in Mathematics Learning of elementary school students of Kerala

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Abstract

Difficulties in mathematics learning are a multi-faceted issue and the role of language in it is crucial. Language of mathematics includes mathematics text, discourse in classroom and language used in evaluation situations with its specific verbal, symbolic expressions, structure and function. Ambiguity arising from the difference between formal language of mathematics and the multiplicity of meanings in everyday language aggravates concerns related to the linguistic factors in mathematics learning. A distinction between difficulty from lack of knowledge of concepts and processes of mathematics and difficulty arising from fluency of expressing such skills in appropriate language is often vague. Hence, difficulties faced by students in relation to language of mathematics in different vernacular contexts is to be thoroughly studied for helping teachers to successfully impart the process of mathematization. This paper reports a preliminary diagnostic investigation through descriptive survey, with a mathematical language test to identify difficulty arising from language related aspects of mathematics learning in Malayalam language at elementary level. The sample consisted of 200 students in 7^{th} standard (age 11-12) of Kozhikode and Malappuram districts of Kerala. Association between perceived difficulty in learning Mathematics and difficulties in mathematics language is also analysed. Excluding semantics, all others components of language of Mathematics are highly difficult. Furthermore, difficulties generated by all the components of Mathematical vocabulary, Morphology and pragmatics are contributing to perception of maths as a difficult subject. Unquestionably, the challenges in learning mathematics go beyond the language issues, but the linguistic challenges need to be addressed for students to be successful in attaining aims of mathematics learning.

***Key words*:** Difficulty in mathematics, Mathematics vocabulary, Language of mathematics, Student beliefs, Mathematics Instruction

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Introduction

Students' difficulties in learning mathematics are a concern worldwide and studies found out a number of reasons for the same. However, linguistic challenges that students face in mathematics learning remains a less attended reason of difficulty. Every subject has its own way of using language to construct knowledge, and in order to effectively participate in the ways of knowing the subject, students need to be able to use the subject specific language. Learning the language of a discipline is a part of learning that discipline and hence they cannot be separated (Schleppegrell, 2007). The pedagogical challenges students face in mathematics classroom cannot be overcome without giving due attention to language of mathematics through which they enter the domain of mathematics and through which they are assessed. Mathematics processes and skills is to and is being mastered through language which is specific to Mathematics. Students may excel in computation, but their ability to apply their skills will suffer if they do not understand the math vocabulary used in instructions and story problems (Bruun, Diaz & Dykes, 2015). Obviously, vocabulary related difficulties will vary according to the medium of instruction. Chard (2003) suggests that understanding the language of math gives students the skills they need to think about, talk about, and assimilate new math concepts as they are introduced and vocabulary knowledge provides young learners with a mathematics foundation.

This study considers language of mathematics as parallel to natural language and the components of language of mathematics as corresponding to those of a natural language. Mathematics, though, is technically not a natural or informal human language, but is a formal and artificially constructed language (Gough, 2007). Researches have tried to explain the content and structure of mathematics language. Mathematical language is a system of communication with its own set of symbols, conventions or special words (Mbugua, 2012). Vocabulary of mathematics include technical terms specific to mathematics, specialist use of more general terms, and mathematical terms that use everyday words used for unrelated ideas (Barwell, 2005). Mathematics is system of rules or conventions for communication of mathematical ideas, processes and skills in a specialized way, and includes its own Content, Structure and Function; vocabulary and symbols; morphology, Syntax, semantics and pragmatics (Gafoor & Sarabi, 2015). Obviously, not vocabulary only of mathematics but morphology, the syntactic expression and pragmatics also vary according to medium of instruction.

Achievement in mathematics is highly related to students' understanding of mathematical language (Mbugua, 2012). Learning mathematics in a language far beyond their daily life makes it difficult for the students. Students not only prefers for items that were linguistically simpler (Abedi & Lord, 2001) but their performance was poorer for word problems written in more complex language compared to the same problems in easier text, and the weakest performance was observed for problems that were both linguistically and mathematically challenging (Barbu & Beal, 2010). Students make mistakes when solving mathematics problems due to lack of understanding of mathematical language. General verbal ability is involved in how children reason numerically whereas phonological skills are involved in executing arithmetic problems (Vukovic & Lesaux, 2013). Difficulty in understanding the language by which mathematics is taught will influence their perception about mathematics learning. Student's perception about mathematics is noteworthy as

perceived difficulty is an important reasons for students not continuing with mathematics (Brown, Brown & Bibby, 2008) and Students' self-perceptions strongly predicted subsequent achievement (Skaalvik, & Skaalvik, 2006). In this context, this paper approaches difficulties in learning mathematics from a language of mathematics perspective. It is premises that identifying the area and type of difficulty in mathematics language for students of Malayalam medium schools will help to make mathematics learning more meaningful for them.

Research questions

To what extent students feel difficulty in select components of language of mathematics if taught through Malayalam medium? And, do difficulties in language of mathematics contribute significantly to student perceived difficulty in upper primary school mathematics?

Methodology

Preliminary diagnostic investigation through descriptive survey, with a mathematical language test was done. Percentage analysis and chi-square test of independence were employed for statistical analysis.

Participants

Participants were 200 (with 90 boys and 110 girls), 7th standard students randomly selected from upper primary schools of Kozhikode and Malappuram districts of Kerala.

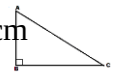
Research Instruments

Test of Difficulties in Language of Mathematics diagnose difficulty arising from language related aspects of mathematics learning at elementary level. The test contained items related to verbal and symbolic expressions, structural and functional aspects of mathematical language identified after the analysis of contents of mathematics textbooks and achievement tests for elementary grades (Standard I-VII) and the items were on pre-requisites for grade 8 mathematics. All the 72 items were scored 1 each. Based on their linguistic feature items were grouped into 21 categories under Terms (6), Symbols (3), Morphology (1), Syntax (5), Semantics (3) and Pragmatics (3). Since the test was based on prerequisites for learning mathematics concepts in Grade 8 low score in this test implies that students feel difficulty in basic mathematical concepts in its linguistic aspect. The students also rated their perceived difficulty of Mathematics on a 3 point scale –Easy, Moderately difficult & highly difficult- and which were later converted into two- easy and difficult by merging last two categories as difficult.

Table 1

Description of Test of Difficulties in Language of Mathematics

Mathematical Language Category	Components	No. of Items	Example
Terms	General Terms	8	Peculiarities
	Mathematics Terms	8	Second order
	Specialized use of General Terms	6	Similarity
	Geometric Terms	3	Area

	Types of Numbers	3	13 is a Prime number
	Writing numbers in word names & words to numerals	4	Two hundred and nineteen
Symbols	Fractional form of General terms	2	Choose the correct fractional expression for 'Half'
	Arithmetic Symbols	4	4 Point 5
	Geometrical Symbols	1	Perpendicular symbol
Morphology	Parts of words	6	deci (one tenth)
Syntax	Translating Phrases into Algebraic Expressions	1	*'subtract one form two consecutive natural numbers*
	Arithmetic Principles in Numerals	2	(150 – 50) – 40 = 150 + (50 + 40)
	Arithmetic Principles with variables	2	(X – Y) – Z = X – (Y + Z)
	Conventions	1	$\frac{m}{3} =$
	Translating Algebraic Expressions to Phrases	1	X + 2X Translate Algebraic Expressions to Phrase
Semantics	Word meaning in specific context	4	What is 4 times $1\frac{1}{2}$?
	Statements of Geometric Principles	4	Sum of pair of supplementary angles is 180^0– Right or wrong
	Arithmetic Principles in Common Language	3	Instead of adding the same number a fixed number of time, it is enough to multiply the number with the number of times.- Right or wrong
Pragmatics	Word Problems	2	It requires $1\frac{1}{2}$ meter of cloth for a dress. How much cloth is required to stitch 4 such dresses?
	Reading Geometric Diagrams	3	3 cm  4 cm Area of given right triangle =

Identifying Operations	4	Which operation is to be performed to see by how much is 15 less than 45?
Total	72	

Statistical analyses

Percentage analysis and Chi square analysis were followed up by comparison of proportions, and calculation of Risk Ratio, and Odds value.

Results and Discussion

Results are discussed under two major categories viz. Linguistic Challenges in Mathematics Learning and Influence of Difficulties in Mathematics Language on Perceived difficulty.

Linguistic Challenges in Mathematics Learning

Twenty one categories of mathematical language related difficulty were grouped as areas of high difficulty (Mean% score < 50%), Areas of Moderate Difficulty (Mean% score is in the range 50% -60%) and Areas of Low Difficulty (Mean% score > 60%).

A. Areas of high difficulty in language of Mathematics

Mean percent scores of High difficulty components in Mathematics Language are given in Table 2.

Table 2

Mean Percent Score of High Difficulty Language Components in Mathematics

Sl. No.	Mathematical Language Category	Components	Mean (% score)
1	Syntax	Translating Phrases into Algebraic Expressions	25
2	Symbol	Fractional form of general terms	35
3	Morphology	Parts of words	39
4	Pragmatics	Word Problems	41
5	Syntax	Arithmetic Principles in Numerals	41
6	Syntax	Arithmetic Principles with variables	43
7	Syntax	Conventions	43
8	Syntax	Translating Algebraic Expressions to Phrases	45
9	Terms	General Terms	49

The high difficulty language components in Mathematics appears in the order: Translating Phrases into Algebraic Expressions, Fractional form of general terms, Parts of

words, Word Problems, Arithmetic Principles in Numerals, Arithmetic Principles with variables, Conventions, Translating Algebraic Expressions to Phrases and General Terms. Only 25 percent of students correctly translated Phrase into Algebraic Expression. More than 50% fails on conventions and translating algebraic expressions to phrases.

B. **Areas of Moderate Difficulty in Language of Mathematics**

Mean percent scores of moderate difficulty Language components in Mathematics are given in Table 3.

Table 3

Mean Percent Score of Moderate Difficulty Language Components in Mathematics

Sl. No.	Mathematical Language Category	Components	Mean (% score)
1	Semantics	Word meaning in specific context	51
2	Semantics	Geometric Principles	53
3	Terms	Mathematics Terms	53
4	Terms	Specialized use of general Terms	53
5	Terms	Geometric Terms	54
6	Pragmatics	Reading Geometric Diagrams	55
7	Pragmatics	Identifying Operations	56
8	Symbols	Arithmetic symbols	58
9	Terms	Types of Numbers	58

The Moderate difficulty language components in Mathematics appears in the order: Word meaning in specific context, Geometric Principles, Mathematics Terms, Specialized use of general Terms, Geometric Terms, Reading Geometric Diagrams, Identifying Operations, Identifying arithmetic symbols and Types of Numbers.

C. **Areas of Low Difficulty in Language of Mathematics**

Mean percent scores of low difficulty Language components in Mathematics is given in Table 4.

Table 4

Mean Percent Score of Low Difficulty Language Components in Mathematics

Sl. No.	Mathematical Language Category	Components	Mean (% score)
1	Semantics	Arithmetic Principles in Common Language	63
2	Terms	Writing numbers in words & words to numerals	63
3	Symbols	Geometrical Symbols	70

The Low difficulty components in Mathematics language appears in the order Arithmetic Principles in Common Language, Writing numbers in words and words to numerals and Geometrical Symbols.

Influence of Difficulties in Mathematics Language on Perceived difficulty

Influence of 6 components of mathematics language on perceived difficulty was studies using 2x2 cross tabulation. The components are Terms, Symbols, Morphology, Syntax, Semantics and Pragmatics. Students were categorised as those with and without difficulty in each Language component of Mathematics based on their median score in the test and based on their perceived difficulty [Easy (N=43) or Difficult (N=157)]. Chi square test was used to determine whether these factors influence perceived difficulty of upper primary students as most of the upper primary students consider Mathematics as a difficult subject (78.5%). The data and the result of this section in detail are not attempted here for want of space. The overall results are indicated in findings below.

Findings

Excluding semantics of mathematics, all other elements of language of Mathematics contribute to high difficulty

The high difficulty components in Mathematics language - Translating Phrases into Algebraic Expressions, Fractional form of general terms, Parts of words, Word Problems, Arithmetic Principles in Numerals, Arithmetic Principles with variables, Conventions, Translating Algebraic Expressions to Phrases and General Terms- are contributed by syntax, pragmatics, morphology and vocabulary of mathematics language.

'Translating phrases into algebraic expression' is the most difficult component whereas the reverse operation is far easier

Only Twenty-five percent of students correctly translated Phrase into Algebraic Expression whereas around 50% students can translate algebraic expressions to phrases correctly.

Terms- both general and discipline specific – generate significant difficulty for the students.

Mean percent score for Mathematical terms and general terms are nearly 50%. Specialized use of general Terms (53%) and Geometric Terms (54%) are also source of difficulty in relation with mathematics vocabulary.

Arithmetic principles stated in numerals and variables are much difficult than those stated in common language.

Mean percent score for arithmetic principle stated in common language is much better than arithmetic principles in Numerals and variables; also these two components were equally difficult.

Difficulties generated by all the components of Mathematical vocabulary, Morphology and pragmatics are contributing to perception of Mathematics as a hard subject.

Difficulties in components of mathematical terms- General Terms, Mathematics Terms, Specialized use of General Terms, Geometric Terms, Types of Numbers, Writing numbers in word names & words to numerals; Symbols- Fractional form of General terms, Arithmetic Symbols, Geometrical Symbols; Morphology- Parts of words; and Pragmatics- Word Problems, Reading Geometric Diagrams, Identifying Operations; are contributing significantly to perception of Mathematics as a difficult subject.

Out of five components in syntax, three are causative factors of perceiving maths as difficult

Difficulties in translating phrases into algebraic expressions and arithmetic principles with variables does not differentiate students perceived difficulty whereas arithmetic principles in numerals, conventions and translating algebraic expressions to phrases are causative factors of perceiving maths as difficult subject.

In semantics, 'word meaning in specific context' is the only component contributing to perceived difficulty in Mathematics.

Other two components of semantics- Statements of geometric principles and arithmetic principles in common language is not much difficult for the students and they are not associated with the perception of students about mathematics as a difficult subject.

Conclusion and Implications

Students come to school with conversational language which is far beyond academic language used in teaching mathematics. Language cannot be detached from what is taught and learned in schools. Teachers need to help students to cope with any language new to them. Thus, one of the major steps required to make mathematics attractive to students is helping them master the language of mathematics. However, mathematics teachers focus usually on teaching – learning the competencies like the process of mathematics and its operations (Gafoor & Sarabi, 2015). Most Mathematics teachers lack in required preparation for providing support that learners require to meaningfully learn mathematics.

Language of Mathematics is not very easy to learn for the young learners. It demands continuous effort from the learner and support from the teacher. Proper identification of difficulties sourcing from language of mathematics is needed at early stages of school. The National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (NCTM, 2000) states that, "Students who have opportunities, encouragement, and support for speaking, writing, reading and listening in mathematics classes reap dual benefits: they communicate to learn mathematics, and they learn to communicate mathematically." McCartney (2009) Suggests that using a variety of pedagogical techniques and tools such as the word wall and small-group problem-solving days are ways to strengthen student attitude toward problem solving, pay closer attention to precise math vocabulary, and complete math assignments. Teachers can use variety of methods in order to improve mathematical language proficiency, in view of the significance of mastering it. To prepare students fluent with the vocabulary of Mathematics language teachers can use strategies for vocabulary development developed by Marzano (2005) in 6 stages -Provide a description, explanation, or example of new term, Students restate explanation of new term in own words, Students create a non-linguistic representation of term, Students periodically do activities that help add to knowledge of vocabulary terms, Periodically students are asked to discuss terms with one another, Periodically students are involved in games that allow them to play with terms. Finally, even as the challenges in learning mathematics go beyond the language issues is unquestionable, the linguistic challenges too need to be addressed for students to be successful in attaining aims of mathematics learning.

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