Influence of Difficulty with Language of Mathematics on Perceived Self-efficacy in Learning Mathematics among Upper Primary Students of Kerala

Sarabi M K

&

Abdul Gafoor K.

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Abstract

There is increasing realization that mathematics-related self-efficacy expectations are a strong predictor of an array of significant mathematics outcomes. It is also evident that the curricular practice in schools largely neglects development of a student understanding in the unique language of mathematics. Consequently, this study probes how much influence difficulties with different forms of Terms, Symbols, Morphology, Syntax, Semantics and Pragmatics of Mathematics language exert on Self-efficacy belief in learning mathematics of upper primary Malayalam medium students. Mathematical language test administered on 200 standard VII students in Kozhikode and Malappuram districts of Kerala provided 21 categories of language related difficulties. Learner report on self-efficacy in learning Mathematics was summarised as "can learn" or "cannot learn" mathematics. Chi square analyses revealed that difficulty with every components of Mathematics language other than semantics increases the risk of low self-efficacy in learning Mathematics. In general, the risk of low self-efficacy belief in mathematics is observed in nearly 50% to 25% more students with difficulty in Terms, Symbols, Morphology, Syntax, and Pragmatics of Mathematics language than among those without difficulty in these elements of mathematics. This study reiterated the significance of language of mathematics and its various components in achievement and performance of mathematics principles and skills as well as for affective factors, especially self-efficacy beliefs, which in turn impact student motivation to learn mathematics further. Along with suggestions to strengthen language of mathematics among the students, the study indicate to the importance of further exploring and analysing the difficulties arising while teaching mathematics in diverse language settings including Malayalam.

***Keywords*:** Language of mathematics, Mathematics vocabulary, Mathematics difficulty, Self-efficacy in Mathematics.

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Introduction

In spite of the unique language being used in teaching, learning and constructing knowledge of mathematics (Patkin, 2011), learners and to some extent even primary school teachers remain unaware of even existence of a language for mathematics. Students have to use this language effectively in technical and academic ways fit for disciplinary learning (Schleppegrell, 2007). An understanding of language of math is necessary for students to have skills they need to think about, talk about, and assimilate new math concepts (Chard, 2003). Hence, language of mathematics not being explicitly taught or given due implicit emphasis in instructional practice causes students to fail to understand important aspects of mathematics learning. This make mathematics learning progressively difficult from primary school upwards. This in turn affects student belief and confidence in their ability to learn, understand and apply principles and procedures of mathematics, not only at that particular time and stage but also for the related learning contexts in future.

Self-efficacy in mathematics, the extent of student belief in own ability to solve specific mathematics tasks (PISA, 2013) with whatever skills and abilities they may possess (Bong & Skaalvik, 2003) has strong correlation with test performance (Schulz, 2005). This effect on test performance manifests in total effect on performance also (Pajares & Miller, 1994); including through its influence on achievement motivation and self-learning strategies (Yusuf, 2011). Self-efficacy is crucial as students' self-beliefs about academic capabilities do play an essential role in their motivation to achieve and in improving their learning methods (Zimmerman, 2000) as well. Self-efficacy being influential on performance on even stressful tasks (Bandura, 1977) is especially important for mathematics which is commonly considered a difficult subject in schools and beyond. Mathematics-related self-efficacy expectations are stronger predictors, even better than present or past mathematics performance, of tertiary entrance ranks and university entry (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014) as well as mathematics-related educational and career choices (Hackett & Betz, 1989).

Academic language of mathematics include pronunciation, intonation, words, particular meanings of words, preferred sentence structures, accepted discourse patterns, common ways of accomplishing functions of language, and pragmatic rules (Irujo, 2007). Previous analyses of the data on difficulty with various elements of language of mathematics have revealed them to be associated with student perception of difficulty in mathematics (Sarabi & Gafoor, 2017a), perception of relevance of elementary school mathematics to learners' daily life and future utility (Gafoor & Sarabi, 2017) as well as to student attitude towards mathematics learning (Sarabi & Gafoor, 2017b).

Research Questions

Do students' levels of difficulty in language of mathematics significantly associate to their perceived Self-efficacy in learning mathematics? If so, how much influence various elements of Mathematics language do exert on Self-efficacy belief in learning mathematics of upper primary Malayalam medium students in Kerala?

Methodology

Descriptive survey on 200 (90 boys and 110 girls), standard VII students randomly selected from upper primary schools of Kozhikode and Malappuram districts of Kerala with Test of Difficulties in Language of Mathematics identified difficulty arising from language related aspects of mathematics learning at elementary level in Malayalam medium schools. 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 from Standard I-VII. 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) of Mathematics language. On each linguistic category, students who scored less than median (up to first quartile score depending on the range of distribution) were identified as facing challenge on that element of language of mathematics. Students also indicated their self-efficacy in learning mathematics as agreement or disagreement to the statement, "I can learn mathematics very well".

Results and Discussion

Influence of six components of mathematics language on Self-efficacy in learning Mathematics is discussed separately. Out of 21 identified language elements in elementary school mathematics, difficulty with 7 elements did not influence students' Self-efficacy in learning Mathematics.

Self-efficacy in learning Mathematics by Difficulties in Mathematics Terms

Table 1 summarises results of Chi-square Tests showing significant association of Self-efficacy in learning Mathematics with Difficulty in Mathematics Terms.

Table 1

Chi-square Tests on Self-efficacy in Mathematics by Difficulties in Mathematics Terms

Language of Mathematics		Self-efficacy in Mathematics		Total (N)	Chi-Square
Math Terminology	Difficulty status	Can Learn (N_1=59)	Can't learn (N_2=141)		
General Terms	Difficulty	21(20.8%)	80(79.2%)	101(50.5%)	7.44 p<.01
	No Difficulty	33(38.4%)	61(61.6%)	99(49.5%)	
Mathematics Terms	Difficulty	19(20.2%)	75(79.8%)	94(47%)	7.36 p<.01
	No Difficulty	40(37.7%)	66(62.3%)	106(53%)	
Specialized use of General Terms	Difficulty	20(21.3%)	74(78.7%)	94(47%)	5.09 p<.05
	No Difficulty	39(36.8%)	67(63.2%)	106(53%)	
Geometric Terms	Difficulty	21(22.6%)	72(77.4%)	93(46.5%)	5.77 p<.05
	No Difficulty	38(35.5%)	69(64.5%)	107(53.5%)	

Learner perceived self-efficacy in learning mathematics is significantly associated to students' difficulty with terminology in mathematics like 'general terms in mathematics', Mathematics terms', and 'Specialized use of General Terms' and 'Geometric Terms'.

However students' self-efficacy in learning mathematics is not influenced by having difficulty in attaining 'Types of Numbers' [$\chi 2$ (1, N=200) =1.41, p >.05] and 'Writing numbers in word names & words to numerals' [$\chi 2$ (1, N=200) =1.51, p >.05].

Students' low self-efficacy belief is significantly more among those with difficulty in 'General Terms' (79.2%) than among those without the difficulty (61.6%) [$\chi 2$ (1, N=200) =7.44, p<.01]. Significantly more students with difficulty in 'Mathematics Terms' have low self-efficacy beliefs (79.8%) than those without such difficulty (62.3%) [$\chi 2$ (1, N=200) =7.36, p<.01]. Significantly more students with difficulty in 'Specialized use of General Terms' have low self-efficacy beliefs (78.7%) than those without such difficulty (63.2%) [$\chi 2$ (1, N=200) =5.09, p<.05]. Students with low self-efficacy is significantly more among those with difficulty in 'Geometric Terms' (77.4%) than among those without such difficulty (64.5%) [$\chi 2$ (1, N=200) =5.77, p<.05].

The risk of low self-efficacy in learning mathematics is observed to increase 1.29 times (RR=1.29, 95% CI [1.07, 1.55]) with difficulty in 'general terms', 1.28 times (RR=1.28, 95% CI [1.07, 1.53]) with difficulty in 'Mathematics terms', 1.25 times (RR=1.25, 95% CI [1.04, 1.49]) with difficulty in 'Specialized use of General Terms' and 1.20 times (RR=1.20, 95% CI [1.00, 1.44]) with difficulty in 'Geometric Terms'.

Self-efficacy in learning Mathematics by Difficulties in Mathematics symbols

Table 2 summarises results of Chi-square Tests showing significant association of Self-efficacy in learning Mathematics with Difficulty in Mathematics .Symbols.

Table 2

Chi-square Tests on Self-efficacy in Mathematics by Difficulties in Mathematics Symbols

Language of Mathematics		Self-efficacy in Mathematics			
Symbol	Difficulty status	Can Learn (N_1=59)	Can't learn (N_2=141)	Total (N)	Chi-Square
Fraction form (of common terms)	Difficulty	29(22.3%)	101(77.7%)	130(65%)	9.24 p<.01
	No Difficulty	30(42.9%)	40(57.1%)	70(35%)	
Arithmetic Symbols	Difficulty	14(16.5%)	71(83.5%)	85(42.5%)	12.07 p<.01
	No Difficulty	45(39.1%)	70(60.9%)	115(57.5)	

Learner perceived self-efficacy in learning mathematics is significantly associated to their difficulty with symbols like 'Fraction form (of common terms) and arithmetic symbols. However, Learner perceived self-efficacy in learning mathematics is not associated with difficulty in 'Geometrical Symbols' [$\chi 2$ (1, N=200) =2.24, p >.05].

Students with low self-efficacy belief are significantly more among those with difficulty in 'Fraction form of common terms' (77.7%) than among those without such difficulty (57.1%) [$\chi 2$ (1, N=200) =9.24, p<.01]; the risk of low self-efficacy with difficulty being 1.36 times that without difficulty (RR=1.36, 95% CI [1.09, 1.69]). Students with low self-efficacy belief are significantly more among those with difficulty in 'Arithmetic Symbols' (83.5%) than among those without such difficulty (60.9%) [$\chi 2$ (1, N=200) =12.07, p<.01]; the risk of low self-efficacy with difficulty being 1.37 times that without difficulty (RR=1.37, 95% CI [1.15, 1.63]).

Self-efficacy in learning Mathematics by Difficulties in Morphology of Mathematics Words

Table 3 summarises results of Chi-square Tests showing significant association of Self-efficacy in learning Mathematics with Difficulty in Morphology of Mathematics Language.

Table 3

Chi-square Tests on Self-efficacy in Mathematics by Difficulties in Morphology of Mathematics

Language of Mathematics		Self-efficacy in Mathematics		Total (N)	Chi-Square
Morphology Element	Difficulty status	Can Learn (N_1=59)	Can't learn (N_2=141)		
Parts of words	Difficulty	26(21.3%)	96(78.7%)	122(61%)	10.09 p<.01
	No Difficulty	33(42.3%)	45(57.7%)	78(39%)	

Learner perceived self-efficacy in learning mathematics is significantly associated to their difficulty with 'Parts of words' in mathematics. Students with low self-efficacy belief are significantly more among those with difficulty (78.7%) than among those without difficulty (57.7%) [χ^2 (1, N=200) =10.09, p<.01]; the risk of low self-efficacy for students with difficulty in 'Parts of words' in mathematics being 1.36 times that without difficulty (RR=1.36, 95% CI [1.10, 1.69]).

Self-efficacy in learning Mathematics by Difficulties in Syntax of Mathematics Language

Table 4 summarises results of Chi-square Tests showing significant association of Self-efficacy in learning Mathematics with Difficulty in Syntax of Mathematics Language.

Table 4

Chi-square Tests on Self-efficacy in Mathematics by Difficulties in Syntax of Mathematics Language

Language of Mathematics		Self-efficacy in Mathematics		Total (N)	Chi-Square
Syntax element	Difficulty status	Can Learn (N_1=59)	Can't learn (N_2=141)		
Arithmetic Principles in Numerals	Difficulty	22(18.8%)	95(81.2%)	117(58.5%)	15.51 p<.01
	No Difficulty	37(44.6%)	46(55.4%)	83(41.5%)	
Arithmetic Principles with variables	Difficulty	26(22.8%)	88(77.2%)	114(57%)	5.71 p<.05
	No Difficulty	33(38.4%)	53(61.6%)	86(43%)	
Conventions	Difficulty	26(23%)	87(77%)	113(56.5%)	5.26 p<.05
	No Difficulty	33(37.9%)	54(62.1%)	87(43.5%)	
Translating Algebraic Expressions to Phrases	Difficulty	24(22%)	85(78%)	109(54.5%)	6.45 p<.05
	No Difficulty	35(38.5%)	56(61.5%)	91(45.5%)	

Learner perceived self-efficacy in learning mathematics is significantly associated to their difficulty with Syntactic principles in Mathematics Language, like 'Arithmetic Principles in Numerals' [as in 23 + 23 + 23 + 23 + 23 = 5 x 23], 'Arithmetic Principles with variables'[as in A x A x A = 3A], 'Conventions' [as in lb=l*b] and in 'Translating Algebraic Expressions to Phrases' (for example, 6X - 3X = "subtract three times of one number from 6 times of that number"). But, students' self-efficacy in learning mathematics is not influenced by difficulty in 'Translating Phrases into Algebraic Expressions' [$\chi 2$ (1, N=200) =0.65, p >.05].

Students with low self-efficacy in learning mathematics are significantly more among those with difficulty in 'Arithmetic Principles in Numerals' (81.2%) than among those without such difficulty (55.4%) [$\chi 2$ (1, N=200) =15.51, p<.01]. Significantly more students with difficulty in 'Arithmetic Principles with variables' have low self-efficacy in learning mathematics (77.2%) than those without such difficulty (61.6%) [$\chi 2$ (1, N=200) =5.71, p<.05]. Significantly more students with difficulty in 'Conventions' have low self-efficacy in learning mathematics (77%) than those without such difficulty (62.1%) [$\chi 2$ (1, N=200) =5.26, p<.05]. Students with low self-efficacy in learning mathematics are significantly more among those with difficulty in 'Translating Algebraic Expressions to Phrases' (78%) than those without such difficulty (61.5%) [$\chi 2$ (1, N=200) =6.45, p<.05].

The risk of low self-efficacy in learning mathematics occurs in 24% to 47% more students among those with difficulty in Syntactic principles in Mathematics Language, than in students without such difficulty. Specifically, the risk of low self-efficacy in learning mathematics is observed to increase, 1.47 times (RR=1.47, 95% CI [1.19, 1.81]) with difficulty in 'Arithmetic Principles in Numerals', 1.27 times (RR=1.27, 95% CI [1.05, 1.53]) with difficulty in 'Translating Algebraic Expressions to Phrases' , 1.25 times (RR=1.25, 95% CI [1.03, 1.52]) with difficulty in 'Arithmetic Principles with variables' and 1.24 times (RR=1.24, 95% CI [1.02, 1.50]) with difficulty in 'Conventions'.

Self-efficacy in learning Mathematics by Difficulties in Semantics of Mathematics Language

Learner perceived self-efficacy in learning mathematics is not significantly associated to their difficulty in attaining 'Word meaning in specific context' in mathematics [$\chi 2$ (1, N=200) =3.71, p>.05] , 'Statements of Geometric Principles' [$\chi 2$ (1, N=200) =1.56, p >.05] and 'Arithmetic Principles in Common Language' [$\chi 2$ (1, N=200) =2.41, p >.05].

Self-efficacy in learning Mathematics by Difficulties in Pragmatics of Mathematics Language

Table 5 summarises results of Chi-square Tests showing significant association of Self-efficacy in learning Mathematics with Difficulty in Pragmatics of Mathematics Language.

Table 5
Chi-square Tests on Self-efficacy in learning Mathematics by Difficulties in Pragmatics of Mathematics Language

Language of Mathematics		Self-efficacy in Mathematics		Total (N)	Chi-Square
Pragmatic Element	Difficulty status	Can Learn (N_1=59)	Can't learn (N_2=141)		
Word Problems	Difficulty	27(22.7%)	92(77.3%)	119(59.5%)	6.56 p<.05
	No Difficulty	32(39.5%)	49(60.5%)	81(40.5%)	
Reading Geometric Diagrams	Difficulty	17(18.9%)	73(81.1%)	90(45%)	8.86 p<.01
	No Difficulty	42(38.2%)	68(61.8%)	110(55%)	
Identifying Operations	Difficulty	18(20.5%)	70(79.5%)	88(44%)	6.18 p<.05
	No Difficulty	41(36.6%)	71(63.4%)	112(56%)	

Learner perceived self-efficacy in learning mathematics is significantly associated to their difficulty with Pragmatics of Mathematics Language used in Word Problems, Reading Geometric Diagrams and Identifying Operations to solve a problem.

Those with low self-efficacy in learning mathematics are significantly more among students with difficulty in 'Word Problems' (77.3%) than among students without such difficulty (60.5%) [$\chi 2$ (1, N=200) =6.56, p<.05]; among students with difficulty in 'Reading Geometric Diagrams' (81.1%) than among students without such difficulty (61.8%) [$\chi 2$ (1, N=200) =8.86, p<.01]; among students with difficulty in 'Identifying Operations' (79.5%) than among students without such difficulty (63.4%) [$\chi 2$ (1, N=200) =6.18, p<.05].

Specifically, the risk of low self-efficacy in learning mathematics is observed to increase, 1.31 times (RR=1.31, 95% CI [1.09, 1.57]) with difficulty in 'Reading Geometric Diagrams', 1.28 times (RR=1.28, 95% CI [1.05, 1.56]) with difficulty in 'Word Problems' and , 1.26 times (RR=1.26, 95% CI [1.05, 1.49]) with difficulty in 'Identifying Operations', compared to students without these specific difficulties in pragmatics of language of mathematics.

Conclusion and Implications

The risk of low self-efficacy occurs in 20% to 29% more students if with difficulty in various types of terminology in mathematics, than if without such difficulty. Various types of mathematics terminology (in Malayalam) in the order of their impact on low self-efficacy are general terms (like Peculiarities, and Simplify), mathematics terms (like Add, Subtract and Second order), specialized use of General Terms (like Difference, Sign, and Volume) and geometric terms (like Parallelogram, radius, perimeter). Low self-efficacy in learning mathematics also associates with low attainment of mathematics symbols or morphology of mathematics terms. The risk of low self-efficacy increase by 1/3rd with learner difficulties in Fraction form or Arithmetic Symbols, and with difficulty in 'Parts of words'. Incidence of low self-efficacy belief in mathematics is nearly 50% to 25% more if elementary school students have difficulty with syntax of Mathematics such as those involved in stating Arithmetic Principles in Numerals, Translating Algebraic Expressions to Phrases, and

Arithmetic Principles with variables and Conventions. Compared to students without such difficulty, the risk of low self-efficacy in learning mathematics is observed to increase by more than ¼th, with difficulties in Word Problems, Identifying Operations in such problems, and Reading Geometric Diagrams.

This study has reiterated the critical importance of language of mathematics and its various components in attainment of principles and performance on related mathematics skills; as well as for affective factors especially self-efficacy beliefs which in turn impact student motivation to learn mathematics further. Hence, language should not be separated from what is taught and learned in school (Lucas, Villegas & Gonzalez, 2008). Instruction should provide opportunities for students to actively use mathematical language (Moschkovich, 2012). Teachers need to plan to explicitly teach specific and general academic terms in mathematics as well as to facilitate the development of other aspects of academic language (Echevarria, Vogt, & Short, 2010). Vocabulary instruction is crucial and requires mathematics teachers also to intentionally provide many rich, robust opportunities for students to learn mathematics words and terms, related concepts, and their meanings. Such instruction should cover maths words chosen to reduce vocabulary gaps and improve students' abilities to apply language of mathematics to the task of solving mathematics problems (Butler, Urrutia, Buenger, Gonzalez, Hunt & Eisenhart, 2010). Conversations develop reasoning and problem-solving abilities as well as they build self-confidence (Wenger, 2011As cited in Webb & Webb, 2013). On teachers part, facilitating inculcation of language of mathematics demand familiarity with the students' linguistic and academic backgrounds, an understanding of the language demands inherent in the learning tasks and skills for using appropriate scaffolding (Lucas,Villegas & Gonzalez,2008). Development of this understanding in different language settings, including Malayalam, necessitates further exploration and analyses of difficulties in teaching of mathematics through those languages.

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