ENGAGING VIETNAMESE YOUNG LEARNERS IN MATHEMATICS IN ENGLISH: A MULTISEMIOTIC APPROACH

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ABSTRACT

Of the multiple discourses where the Vietnamese young learners are increasingly engaged to develop their English proficiency, the English mathematical discourse – online and printed – has proved to be more and more popular. This has become especially the case ever since the introduction of the Maths contest via Internet (ViOlympic) as the National contest organized by the Ministry of Education and Training since the 2008-2009 academic year. This presentation explores the extent to which doing mathematics in English can benefit the Vietnamese young learners in learning maths per se as well as in improving their overall English proficiency. Data for illustrations and discussions are withdrawn from the printed resources currently accessible in the Vietnamese context, namely the series "ViOlympic Math", published by Giao Duc Publisher, and "Learning Maths", published by Singapore Asia Publishers. The theoretical background for the study is the systemic framework for intersemiosis across the three resources of language, mathematical symbolism, visual images in mathematic discourse by O'Halloran (2004). The results from a multisemiotic approach yields significant pedagogical implications as it offers insights into the functions of other resources in constructing meanings apart from the well-established role of language in contemporary communication in general and science discourses in particular.

INTRODUCTION

Mathematic Discourse (MD) is referred to as multisemiotic as it is constructed from more than one semiotic resource - language, visual images and mathematical symbolism (O'Halloran 2004, p.21). The view of mathematics as a multisemiotic discourse is significant in a pedagogical context as a better understanding of the functions of mathematical symbolism and visual images permits a re-evaluation of the role of language in the construction of meaning in this naturalized domain. Such an understanding proves to be even more essential in the case of content and language integrated learning in a foreign context, where the learners have to cope with both mathematic problems per se and a foreign language.

This study is an attempt to investigate MD written in English for the primary school learners. Specifically the present study examines the following research questions: (1) To what extent is each of the three semiotic resources is represented in the materials of learning mathematics in English (ME) developed for young learners; and (2) How many words do the young learners need to know to understand the vocabulary in ME and to what extent these materials can enhance incidental vocabulary learning. Two major areas of interest are the lexis specific to the field of Mathematics and that to children's everyday world.

MATHEMATICAL DISCOURSE

O'Halloran (2004) can be best viewed as a first step towards a comprehensive Systemic-functional Grammar for MD. The major concern of this study is to investigate the multisemiotic nature of MD. She developed theoretical frameworks for mathematical symbolism and visual display. As reviewed in O'Halloran's (2004, pp. 13-15) the multisemiotic approach, where language, visual images and mathematical symbolism are considered as semiotic resources, originally stems from O'Toole's (1994, 1995, 1999) extensions of Halliday's (1978, 1994) Systemic-funtional approach to displayed art, and Lemke's (1998, 2000, 2003) early work in mathematical and scientific discourse. Following are the central tenets which are relevant to the present study.

(1) MD is considered as 'multisemiotic' construction; that is, discourses formed through choices from the functional sign systems of language, mathematical symbolism and visual display.

(2) MD involves language, mathematical symbolism and visual images. The functions of each semiotic resource may be summarized as follows. Patterns of relations are encoded and rearranged symbolically for the solution to the problem. Due to the limited functionality of the symbolism, language functions as the meta-discourse to contextualize the problem, to explain the activity sequence which is undertaken for the solution to the mathematics problem. Visual images in the form of abstract and statistical graphs, geometrical diagrams, and other types of diagrams and forms of visual display, mirror our perceptual understanding of the world, showing the relations in a multi-dimensional spatio-temporal format. They thus connect and extend common-sense experience to the mathematical symbolic descriptions.

(3) MD depends on both intrasemiosis and intersemiosis. As the types of meaning made by each semiotic are fundamentally different (p.16), and thus the three semiotic resources fulfil individual functions, the success of mathematics depends on utilizing and combining the unique meaning potentials of language, symbolism and visual display in such a way that the semantic expansion is greater than the sum of meanings derived from each of the three resources. Intrasemiosis refers to meaning which arises from the relations and shifts across the three semiotic resources; Intersemiosis, meaning within one semiotic resource,. is important because . Royce (1998, p. 26, cited in O'Halloran, 2004, p. 159) refers to intersemiosis as '*intersemiotic complementarity*' where '*visual and verbal modes semantically complement each other to produce a single textual phenomenon*'. As Royce and also Lemke (1998, cited in O'Halloran, *ibid. p. 159*) explain, the product is '*synergistic*' or '*multiplicative*' in that the result is greater than the sum of the parts.

> *Language, symbolism and visual images function together in mathematical discourse to create a semantic circuit which permits semantic expansions beyond that possible through the sum of the three resources. Following this view, the success of mathematics as a discourse stems from the fact that it draws upon the meaning potentials of language, visual images and the symbolism in very specific ways. That is, the discourse, grammar and display systems for each resource have evolved to function as interlocking system networks rather than isolated phenomena. (O'Halloran, ibid. p. 159)*

(4) Mathematical printed texts are typically organized in very specific ways which simultaneously permit segration and integration of the three semiotic resources. (p. 11). The systems of meaning for language, symbolism and visual images are integrated in such a way that the behaviour of physical systems may be described. Choices from the three semiotic resources function integratively. That is, the linguistic text and the graphs contain symbolic elements and the symbolic text contains linguistic elements. The symbolic elements may also be either spatially separated from the main body of the linguistic text or embedded within the linguistic text.

METHODOLOGY

3.1 The books under study: The books which served as a corpus of the present study comprise two sets. The first set consists of two books published by Vietnam Education Publishing House - *Math ViOlympic 4* and *Math ViOlympic 5;* the second is two books published by Singapore Asia Publishers - *Learning Maths 1B* and *Learning Maths 2A. Math ViOlympic 4* and *Math ViOlympic 5* are the only two published in Vietnam so far in this realm. From the series published by the foreign publisher, these two books were chosen for analysis as these two are for the children of the same age groups as those in the first set. The number of problems and of running words of the verbal texts in each book is shown in Table 1.

Table 1. Number of Problems and Words in Individual Books Analysed

Book	No. of Problems	Running words
Learning Maths 1B	381	3434
Learning Maths 2A	393	1570
Math ViOlympic 4	555	5465
Math ViOlympic 5	400	5076
Total	1,729	15,545

3.2 Instruments: The sets of corpus were analysed using *Compleat Lexical Tutor* developed by Tom Cobb (available at http://www.lextutor). *VocabProfile* gives all the information regarding vocabularies frequency of a text - the number of type, token, word families, type token ratio, function and content words and even breaks any English text into its frequency levels according to the thousand-levels scheme, Academic and off-list words, indicated by colours. *Frequency* extracts frequency lists from the corpora. *TextLexCompare* is used to tract the amount of vocabulary repitition across the books within each set and across the sets.

3.3 Procedures: To achieve the aims, the texts were typed and computerized. The corpus was first closely analysed in terms of the distribution of the verbal, visual, and symbolic components. Whereas the statistics of the linguistic and symbolic components were computationally performed, the images were manually calculated. To analyse the vocabulary of the books, the raw data were processed to omit the proper nouns. This is because many researchers have taken the approach that proper nouns may be easily understood by readers (e.g. Nation, 2006; how proper nouns are handled makes a big difference to an output profile. (Cobb, 2010). The symbolic components and numers, which are inherent and pervasive of this genre, were also omitted. The data were then submitted to the vocabulary profile after being converted to TXT.

FINDINGS AND DISCUSSION

Distribution of the Three Semiotic Resources

As explicated above, the organisation of mathematical printed texts, typically involving three semiotic resources, simultaneously permit segration and integration of the these componential elements. An in-depth analysis of the data, both computationally and manually, yielded insightful findings on the distribution of the resources, shown in Table 2.

Table 2. Distribution of Three Semiotic Resources

	Language	*Symbolic elements*	*Images*		*Total of Problems*
			Illustrative	*Integral*	
	No. (%)	*No. (%)*	*No. (%)*	*No. (%)*	
Learning Maths 1B	30 (7.87%)	20 (5.24%)	4 (1.04%)	351 (92.12%)	381
Learning Maths 2A	158 (40.20%)	301 (76.59%)	2 (0.50%)	31 (7.88%)	393
Math ViOlympic 4	555 (100%)	241 (43.42%)	26 (4.68%)	33 (5.94%)	555
Math ViOlympic 5	400 (100%)	214 (53.5%)	5 (1.25%)	37 (9.25%)	400

The most noticeable feature is the presence of all the resources in all the books analysed. However, whereas the *Learning Maths* series tends to favour symbolic and imageries, the *Math ViOlympic* series displays an overwhelming predominance of language. All the problems in the *Math ViOlympic series* are reprsented via language (100%); by contrast, images account for less than 10 percent, of which approximately a half are just for the illutrative purpose rather than functioning as an integral component of the proplems in question. In other words, these images can be omitted without any inhibition to understanding on the part of the learner.

Table 3. Tokens, Types, and Families at Each Level in *Math ViOlympic 4* and *5*

	Math ViOlympic 4			*Math ViOlympic 5*		
Word list (1,000)	**Tokens (%)**	**Types (%)**	**Families**	**Tokens (%)**	**Types (%)**	**Families**
1	4539 (83.06)	417 (67.69)	300 (70.09)	4068 (80.14)	290 (64.59)	225 (65.60)
2	478 (8.75)	91 (14.77)	71 (16.59)	533 (10.50)	78 (17.37)	65 (18.95)
3	108 (1.98)	22 (3.57)	21 (4.91)	108 (2.13)	18 (4.01)	16 (4.66)
4	50 (0.91)	17 (2.76)	11 (2.57)	120 (2.36)	16 (3.56)	11 (3.21)
5	78 (1.43)	11 (1.79)	8 (1.87)	51 (1.00)	11 (2.45)	9 (2.62)
6	86 (1.57)	6 (0.97)	4 (0.93)	72 (1.42)	6 (1.34)	5 (1.46)
7	2 (0.04)	2 (0.32)	1 (0.23)			
8				1 (0.02)	1 (0.22)	1 (0.29)
9	11 (0.20)	5 (0.81)	5 (1.17)	62 (1.22)	4 (0.89)	3 (0.87)
10	3 (0.05)	1 (0.16)	1 (0.23)	5 (0.10)	3 (0.67)	3 (0.87)
11	43 (0.79)	3 (0.49)	3 (0.70)	8 (0.16)	2 (0.45)	2 (0.58)
12						
13						
14						
15	1 (0.02)	1 (0.16)	1 (0.23)	8 (0.16)		1 (0.29)
16				7 (0.14)		2 (0.58)
17	1 (0.02)	1 (0.16)	1 (0.23)			
18	1 (0.02)	1 (0.16)	1 (0.23)			
19						
20						
Off-List	64 (1.17)	38 (6.17)	??	33 (0.65)	17 (3.79)	??
Total	5465 (100)	616 (100)	428+?	5076 (100)	449 (100)	343+?

Table 4. Tokens, Types, and Families at Each Level in Learning Maths 1B and 2A

	Learning Maths 1B			*Learning Maths 2A*		
Word list (1,000)	**Tokens (%)**	**Types (%)**	**Families**	**Tokens (%)**	**Types (%)**	**Families**
1	2541 (74.00)	300 (54.84)	229 (55.99)	1310 (83.44)	220 (74.83)	170 (75.56)
2	411 (11.97)	98 (17.92)	77 (18.83)	146 (9.30)	35 (11.90)	29 (12.89)
3	33 (0.96)	18 (3.29)	15 (3.67)	25 (1.59)	6 (2.04)	5 (2.22)
4	161 (4.69)	32 (5.85)	27 (6.60)	16 (1.02)	7 (2.38)	6 (2.67)
5	75 (2.18)	20 (3.66)	18 (4.40)	8 (0.51)	5 (1.70)	5 (2.22)
6	59 (1.72)	14 (2.56)	12 (2.93)	33 (2.10)	3 (1.02)	2 (0.89)

7	40 (1.16)	14 (2.56)	14 (3.42)	6 (0.38)	3 (1.02)	2 (0.89)
8	4 (0.12)	4 (0.73)	4 (0.98)			
9	4 (0.12)	2 (0.37)	2 (0.49)	4 (0.25)	2 (0.68)	2 (0.89)
10	5 (0.15)	2 (0.37)	2 (0.49)			
11	6 (0.17)	3 (0.55)	3 (0.73)	5 (0.32)	4 (1.36)	4 (1.78)
12	1 (0.03)	1 (0.18)	1 (0.24)			
13	1 (0.03)	1 (0.18)	1 (0.24)			
14	2 (0.06)	1 (0.18)	1 (0.24)			
15						
16						
17	4 (0.12)	1(0.18)	1 (0.24)			
18						
19	4 (0.12)	2. (0.37)	2 (0.49)			
20						
Off-List	83 (2.42)	38. (6.95)	??	17 (1.08)	9 (3.06)	??
Total	3434 (100)	547 (100)	409+?	1570 (100)	294 (100)	225+?

Table 5. Cumulative Coverage (%) for Each Book

Word list	*Math ViOlympic 4*	*Math ViOlympic 5*	*Learning Maths 1B*	*Learning Maths 2A*
1,000	83.06	80.14	74.00	83.44
2,000	91.81	90.64	85.97	92.74
3,000	93.79	92.77	86.93	94.33
4,000	94.70	95.13	91.62	95.35
5,000	96.13	96.13	93.80	95.86
6,000	97.70	97.55	95.52	97.96
7,000	97.74		96.68	98.34
8,000		97.57	96.80	
9,000	97.94	98.79	96.92	98.59
10,000	97.99	98.89	97.07	
11,000	98.78	99.05	97.24	98.91
12,000			97.27	
13,000			97.30	
14,000			97.36	
15,000	98.80	99.21		
16,000		99.35		

17,000	98.82		97.48	
18,000	98.84			
19,000			97.60	
20,000				
Off-List	100.00	100.00	100.00	99.99
Tokens	≈100.00	≈100.00	≈100.00	≈100.00

In the meantime, visuals are always contextualized in relation to the linguistic text and/or the symbolic component in the *Learning Maths* series. Another significant finding from the data is the particularly high proportion of images in *Learning Math 1B*, which is likely to result from an awareness of the meanigful function of this means in MD in general and its motivating role to young learners of language in particular. Accordingly, in this book, the two other resources make up a mere 7.87% and 5.24%. Finally, the symbolic component is moderately high in all the three other books (76.59%, 53.5%, and 43.42%). This result is obviously due to the function of this semiotic resource in MD, as described in the third section.

Features of the Linguistic Text

To answer the second research question – to what extent doing mathematics in English can be beneficial to the young learners' vocabulary growth, the verbal data were submitted to *VocabProfile Frequency*, and *TextLexCompare*. Table 3 and 4 summarize the data in terms of tokens, types, and families of sets of *Math ViOlympic* and *Learning Maths*, respectively; the culmulative coverage for each book is shown in Table 5.

Tables 3 and 4 show that the tokens are spread over the 20 most frequent 1,000 word families of the BNC. The importance of knowing the most frequent word families is clearly demonstrated in the first rows of these three tables. The first 1,000 word families from the BNC account for up to approximately four-fifths of tokens in the problems in all these books – 83.06%, 80.14%, 74.00%, and 83.44%. For example, regarding *Math ViOlympic 4*, the first row indicates that 417 different word forms (types) are the source of these 4539 tokens. These 417 types reduce to 300 word-families. Similarly, as for *Learning Maths 2A*, the first 1,000 word families account for 1310 of the tokens, 220 of the types, and 170 of the families. It is useful to consider the output in terms of word families because similarity in forms and meanings for tokens from the same family may facilitate understanding and retention. It is also clear that after the second 1,000 word-families, the decreasing rate of the tokens tend to be approximately the same across the four books. From the seventh-1,000 onwards, a large number of types occur only once or twice, which means that the number of difficult words is few and far between.

As shown in Table 6, it is also important to note that of these huge coverages of the first 1,000 word-families, the number of the function words tends to double that of the content words throughout the data.

Table 6. K-1 sub-analysis in terms of content and function words for individual books

K1 Words	***Math ViOlympic 4***	***Math ViOlympic 5***	***Learning Maths 1B***	***Learning Maths 2A***
Function words	59.26%	52.41%	45.78%	50.22%
Content words	27.20%	31.08%	30.86%	33.90%

Assuming that proper nouns and mathematical symbolysm are repeatedly present, the findings suggest that only a small vocabulary is needed for young learners to comprehend these mathematic problems. The number of word-families a learner would meet when s/he finished Math ViOlympic 4, Math ViOlympic 5, Learning Math 1B, and Learning Math 2A is 428^{+}, 343^{+}, 409^{+}, and 225^{+}, respectively. The corpus was shown to contain not only a small number of word-families but also a high frequency rate of encounter of each word, which is strikingly similar similar across the two series. A small number of these word families are met from as high as 592 to six times (64.32%, 86.94%, , 76.28%, and 70.35%). The overall and unexpected finding from a close analysis of the lists of frequency indicates that these soaring high percentage are typically represented by function words and technical words. By contrast, a substantial majority occur merely once or twice in each book (Table 7). It should also be noticed tokens from this low-frequency group typically lie with everyday common vocabulary for young learners's world, namely family, school, animals, and fruits.

Incidental learning theory indicates that if unknown words are repeatedly encountered in meaningful contexts, their meaning will gradually be acquired (Nagy et al. 1985). Research into L2 reading suggests that if unknown words are encountered six more times, there is the potential for incidental learning (Rott 1999). However, acquisition of word meaning is also dependent on the contexts of encounters (Webb 2008). If words repeatedly occur in highly informative contexts, their meanings may be learned after a small number of encounters. However, in less informative and/or misleading contexts, it could take as many as 20 encounters for unknown words to be learned. (Webb 2010). Therefore, it is possible to deduce from the findings that the the chance for vocabulary growth via doing ME is minimal.

Table 7. Number and Percentage of Encounters with Word Families in Each Book

	Math ViOlympic 4		**Math ViOlympic 5**		**Learning Math 1B**		**Learning Math 2A**	
	%	No. of WF	%	No. of WF	%	No. of WF	%	No. of WF
6 times & >	64.32	165	86.94	153	76.28	146	70.35	64
5-3 times	26.75	111	7.9	108	12.44	121	14.95	67
2-1 times	8.93	370	5.15	214	11.28	299	14.7	167

(WF: Word family)

Table 8. Recyclying index over each set

	Math ViOlympic 4 & Math ViOlympic 5	*Learning Maths 1B &Learning Maths 2A*
Token	84.84%	74.94 %
Types	55.46%	49.47%

A further analysis by means of TextLexCompare yields the percentage of recycled vocabulary in each set of corpus, summarised in Table 8. The output shows that the recyclying index does not go above 90% for either set. This means that many or most words throughout the two successive books of each set are being met in density environments of around 2 words in 10, which doubles the density that learners can handle. Research indicates that for learners to be able to guess words in context and gain adequate comprehension of written text it is necessary to know at least 95% of the words (Lauger 1989). Moreover, comprehension and incidental vocabulary learning through reading are likely to increase if the percentage of known words in a text is 98% (Nation, 2001). This result significantly supports the finding that there may be very little incidental vocabulary learning from doing ME for primary school children.

CONCLUSIONS

The study is inspired by an appreciation of the multisemiotic nature of MD. This is essentially a new approach to mathematics for teachers and students of mathematics, offering penetrating insights into the functions of the semiotic resources, individually and integrally.

Overall, although all the three semiotic resources are manipukated in the whole corpus, the distribution tends to be unequal between the two series analysed. The visual component fails to be paid due attention in the *Math ViOlympic* series, which displays an overwhelming predominance of the linguistic text. An opposite extreme can be found in the *Learning Math* series. As indispensable as symbolism in MD, this resource is represented by a moderately high percentage in most of the books.

Lexical profile analysis shows that learners who finish both these books are likely to encounter frequent words (at the 1000 level) enough to make significant gains in vocabulary knowledge, with particular reference to technical mathematic-specific terms; however, Frequency analysis indicates that around one half of the word-families will not be met sufficiently for incidental learning of vocabulary to occur. Text comparison analysis further shows that the rate of new word introduction in the higher-level book in each set is more than most L2 learners will be able to cope with.

Pedagogical Implications:

The results of the close analysis from a multisemiotic perspective have immediate pedagogical implications as follows.

First, these test-orientated books are claimed "to help students to familiarize with the fascinating test format, thinking stimulation and computer practice before competition. […] to get the best competition score" (Dang & Nguyen, 2016, p.3). The market-driven practices have also resulted in materials with a predominance of the linguistic and symbolic components. The findings therefore indicate an urgent need for producing research-informed graded materials beyond those presently available in which we should not lose sight of the multi-semiotic nature of MD. Mathematical symbolism and visual images have evolved to function in co-operation with language. As "*the visual image plays an increasingly important role in different branches of mathematics*" (O'Halloran 2004, p.148), with the impact of increased computational ability, colourful computer-generated visual images can now be generated with minimal effort. Captivatingly presented, these materials for primary-school children may be of greatest importance to get learners accustomed to MD in English as a foreign language and to help them meet the initial challenge in content - language integrated learning (CLIL) that ME may at first present.

Second, although incidental vocabulary learning may occur through finishing the two books, the number of words outside this specific domain learned is likely to be limited. Thus, teachers and learners should not consider vocabulary learning as the primary goal of doing ME. Learners may undoubtedly benefit from other explicit ways to learn vocabulary than through doing ME. To facilitate understanding, it may be necessary for teachers either to encourage guessing from context or to provide glossaries so that learners can check L1 translations quickly when necessary.

Implications for Further Research:

The data we have looked at in this article suggest the following considerations for further studies.

First, given the dearth of graded materials in this area, there should be more research to select and sequence resources, integrating text-based with Internet-based texts, and to provide smooth, principled access to them. In addition to the obviously primary goal of systematically targeting the field-specific needs, efforts can be made to help facilitate vocabulary growth opportunities that these materials can offer. Frequency profiling software can be used to modify and create texts to pre-specified lexical profile and coverage; and text comparison software can be used to ensure degree of lexical recycling over a series of chapters, books, and series.

Second, the results of the present study suggest there may be potential for incidental learning of the first 1,000 word-families through engaging the young learners in doing mathematics in English. However, while this is a useful finding, further research to examine experimentally through a controlled treatment with the learners to provide a more accurate assessment of the extent of transfering new word learning to novel contexts is needed. In addition, the sub-dimensions to the basic learning condition, such as the spacing between encounters should be taken into consider.

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