Understanding the Language and Literacy Challenges for Students Learning Mathematics and Science in a Caribbean Creole Language Context

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Abstract

Students' levels of academic achievement in mathematics and science can be affected when they are instructed in a language that is not their first language or vernacular. This paper examines the language and literacy challenges of school mathematics and science when the language of instruction is Standard English (SE), but students' first language or vernacular is an English-related Creole. The report is based on teacher and student discourse in three classrooms at different levels of one primary school in the Caribbean country of Trinidad and Tobago. Qualitative content analysis of transcripts was used to identify areas of challenges for students. Using Halliday's systemic-functional theoretical framework, the challenges of negotiating the registers of the disciplines are analysed and described. The study concludes with a discussion of the pedagogical implications of the findings. Suggestions are also offered for teachers who wish to help their students "cross language borders" to gain access to curriculum content in second language/dialect situations.

1. Introduction

The first language of many children who enter primary schools in the Caribbean island of Trinidad and Tobago is a Creole language, Trinidad/Tobago English Creole (TEC). This language variety is lexically related to, but otherwise linguistically different from, Standard English (SE), the official language of instruction (LoI). The use of a second language or dialect as the LoI across the curriculum raises concerns about the possible impact on student achievement throughout their school career. In addition, since language can empower or exclude students from the learning process, valid questions arise with respect to equity and access for students who have limited competence in the language in which they are instructed in every area of the school curriculum.

In a linguistic environment in which a Creole language exists alongside a lexically-related Standard language, differences between language varieties can lead to miscommunication between speakers [1]. Furthermore, where significant differences in phonology, morphology and syntax between the two language systems exist, the use of Standard English as the official LoI may create challenges for students who are not proficient in this variety. Research into language across the curriculum suggests that school disciplines use varieties of language that are specific to content areas [2,] and that different disciplines require students to use specialized language styles, technical vocabulary, genres and text types and graphic representations [3]. In a Creole language context, as in any other educational context, educators need to consider how the language of the discipline affects the ease with which students acquire concepts in subjects such as mathematics and science. This is because language is the medium through which teaching and learning are accomplished in schools. Students' level of literacy in the content areas would determine the extent to which they understand oral and written discourse in content area classrooms. It follows that it may not be reasonable to expect students to easily comprehend mathematics and science texts if they are being educated in a variety that is not their vernacular or everyday language. Apart from oral and written texts, and particularly in mathematics and science, students must negotiate meaning in other semiotic codes or communication systems such as diagrams, charts, pictures and graphs [4].

This paper reports on a study of the nature of the language and literacy challenges that students might be experiencing when they learn mathematics and science in a Creole language situation. The main research question which guided the investigation was: "What language and literacy challenges do the registers of mathematics and science create for students in a situation in which the official language of instruction is Standard English and their first language or vernacular is a Creole variety of English?" Based on the findings, the paper offers suggestions for teacher pedagogy in this context and in similar situations.

The study connects to the wider debate on multicultural education and the ways in which schools can acknowledge and respond to the language of different communities. Language is closely tied to the culture of learners and influences their world-view. The consequences for students' learning must be considered when the form and the use of their language differ from the one used as the official language of instruction in schools.

2. Language in the school curriculum

Different terms are used in the literature to refer to the type of language that students are required to use in order to learn in schools. This variety is most frequently referred to as "academic language" [5] though some researchers use alternative terms. For example, Gee [6] considered the language of school a "social language" which students must acquire to develop "school literacy" (p. 76). Zwiers [5] defined "academic language" as "the set of words and phrases that describe content-area knowledge and procedures, express complex thinking processes and abstract concepts, and create cohesion and clarity in written and oral discourse" (p. 1). He argued that for English language learners, it is almost a third language, the acquisition of which is limited to the classroom. It might perhaps be more accurate to extend this observation to include classroom related activities since proficiency in academic language can also be developed through engagement in projects and activities outside of classrooms.

Research suggests that academic language specific to content areas across the curriculum is a critical factor in the disparity in achievement levels between high-performing and low-performing students in schools. This is due to the fact that academic language is characterized by subject-specific vocabulary, grammatical forms and structures, figurative expressions, and prescribed ways of communicating [2, 7]. This situation may affect the ease with which students who speak a Creole variety of English acquire concepts in subject disciplines in the primary school curriculum. Since language is the medium by which teaching and learning are conducted, students must negotiate diverse academic texts in order to learn. Classroom texts require language proficiency, so it may not be reasonable to expect students to easily comprehend mathematics and science texts if they are taught in a variety that, for them, is a second language or dialect. The fact that students have to negotiate meaning in different semiotic codes [2] creates additional challenges for their comprehension of classroom discourse in content areas, with possible effects on their ability to grasp concepts, understand information, and express themselves in oral, written and graphic modes.

The specialized vocabulary of content areas such as mathematics can be more obvious to the teacher than to the students, who may come to class with the knowledge of terms used in one way, and must learn the mathematical concept called by the same name [7]. There are additional complications for the second language learner because mathematics terms do not translate well and although teachers may explicitly teach new technical vocabulary, some crucial items may be overlooked. Teachers at times also assume that students either know technical terms already or will pick up the meanings elsewhere in the curriculum [7].

As it does in mathematics, language plays an important role in the acquisition of science knowledge and concepts. It is the main means through which students understand, construct and express scientific concepts. For both primary and secondary school science, students use language to interpret and create ways of representing science activity and knowledge in subject-specific ways [8]. This includes science vocabulary since many words that are used in everyday speech, such as "force" and "energy" have different, precise meanings in school science. It therefore means that science teaching must help children to distinguish between scientific language and everyday speech, and provide them with suitable experiences to develop science concepts.

Carolan, Prain and Waldrip [8] further argued that students must understand and conceptually link different modes of representation. Such representations include verbal, graphic and numerical forms which are often linked to produce multi-modal representations in science texts. Their study of learners trying to negotiate the challenge of engaging with, and interpreting different representations of the same science concepts revealed that students experienced difficulties when they had to integrate concepts across modes. The process is made more difficult if they have to do so in a language that is not their first language.

3. The social dimension of language and literacy

The systemic-functional approach adopted by researchers such as Fang and Schleppegrell [2] differs in emphasis from the socio-cultural approach adopted by other researchers and New Literacy scholars such as Gee and Street [6, 9] who describe language use in terms of the social context and the culture in which students are schooled. The two perspectives are, however, compatible. From a socio-cultural perspective, in any community, the ways in which schools require students to use language, "school literacy" [6], reflects the social practices and world views of particular social groups. Whichever term one uses, "academic language" or "school literacy", the fact is that the variety used in school is the language of privileged mainstream culture that reflects different ways of knowing and making sense of human world experiences. It is not a neutral, value-free language variety that is better suited for use in schools. However, its use can be explained by prevailing social, cultural, and political dynamics which constrain teachers and students to act and speak in specific ways.

Ethnographic studies conducted by researchers such as Brice Heath [10] revealed important

differences in the discourse patterns of social groups; that is, the ways different groups use language to communicate in speech and in writing. Schools tend to favour an essayist prose style which requires the use of grammatical and lexical information to make important relationships between sentences quite explicit. For some social groups, the way they are required to use language in school conflicts with their everyday, out-of-school language use. This situation can privilege one social group over others in schools.

Thus, from a socio-cultural perspective, the analysis of language use in schools cannot only focus on the linguistic and the textual, but must include the social and historical context in which language is used to produce discourse, and the value placed on the language that children bring to school. This is even more significant in post-colonial societies such as Trinidad and Tobago, where negative attitudes to the Creole vernacular persist. Despite the arguments of linguists and researchers in education over several decades who have shown that Creole languages are viable linguistic systems, many people, including speakers of Creole, still view these languages as imperfect, "broken" versions of lexically related standard varieties such as Standard English [1].

Both international [11] and Caribbean researchers [12, 13] in science education suggest that traditional practices and beliefs of social groups can differ from conventional science, and influence students' learning. Herbert [13] extended this strand of research and devised curriculum to help Caribbean students "cross borders" between traditional and conventional ways of knowing, and enable them to have greater access to school science. Language played an important role in teacher pedagogy.

This line of research suggests that cultural and linguistic diversity can create challenges for the ways in which mathematics and science content is taught, learnt, and assessed. This is partly due to the fact that these disciplines are registers [14] or unique varieties of language which express knowledge of the world in specific ways. Where students have limited competence in the language in which they are instructed, it follows that their learning must be supported by strategies that help them to "cross language borders" to access content, as well as to express their knowledge.

4. Theoretical framework

This investigation used Halliday's systemic-functional linguistic theory [14, 15] which explains language variation in terms of the diversity in structures and processes in the social system. Halliday, and researchers writing from this perspective consider language use in speech communities as functional, communicative events that create meaning in a specific social and cultural context. It is a semiotic process of making meaning through the use of specific linguistic choices.

Context is an important concept in Halliday's theory. He suggests that there are three dimensions to any context: the social activity taking place, which Halliday [14] calls the "field"; the relationship between the participants or the "tenor"; and the rhetorical channel which participants use to communicate, called the "mode". A "text'' is functional; and is produced in the course of an event which occurs in a specific social ''context''. Halliday introduced the term 'register' to refer to a "set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings" [14, p.175]. The variety of language is appropriate to a particular type of social situation, serves a specific function and is characterized by domain-specific vocabulary, appropriate styles of meaning and modes of argument. Registers link texts (oral, written, or visual) to their context.

Eggins [16] summarized the four main theoretical claims that systemic-functional linguistics makes about language. The first is that language use is functional; that is, it serves a specific purpose. The second claim highlights the semantic property of language in that it is used to create meaning. Thirdly, the social and cultural context in which language is used influences the meaning that is created. The final claim is that the entire process of language use in a specific context is a semiotic one; that is, language users choose the means by which meaning is created, and the modes they select to communicate can vary from oral speech, to written text, to icons and pictures. Schools attempt to teach students to use this way of using language or "register" to participate effectively in mathematical ways of knowing. Applied to educational contexts, the classroom can be viewed as one of a diversity of structures in the social system, with the language use of teachers and students considered aspects of the communication process taking place in that particular context. The environment of the classroom is embedded in the larger context of the institution of the school, which in turn operates within a larger unit of the society.

With specific reference to mathematics, the "register" of this discipline can be said to be characterized by the use of language in ways that are different from other disciplines, and from everyday language. For example, in baking at home, children may use or hear their parents use a measurement of "a pinch of salt", but this is not a unit that is a conventional unit of measurement in school mathematics. Halliday's [14] theory also focuses on the internal structure of texts and the elements that work to promote cohesion and coherence. Lexical and grammatical features that are internal to the text

function to make the text a unified whole, rather than a series of random sentences.

5. Method

This paper is based on data from a more extensive investigation that I conducted to analyse the language challenges that students face when their vernacular is an English-related Creole the official language used to instruct them in schools is Standard English. In order to research the issue, I adopted a qualitative case study design and used purposeful sampling to select one case. The site was an urban primary school in Trinidad and Tobago, Rose Hall Government Primary School, which served three communities. For the purpose of lesson observation, three classes were selected. These comprised the three sub-cases: Infants Year 1 (ages 5-6), Standard 1 (ages 7-8) and Standard 4 (ages 10-11). Qualitative content analysis was used to analyse the lesson transcriptions and field-notes recorded from field observation over a period of six months. A constant comparative method was used to compare pieces of data. Linguistic differences were identified and occasions when students experienced challenges understanding content were noted. The categories, sub-categories, and descriptors used in this study were adapted from existing literature [17, 18]. Others were added on the basis of my investigation. All illustrative examples were taken from spoken or written data gathered during classroom observation for the study.

6. Findings

The challenges of the registers of mathematics and science were evident at every class level. However, the demands differed in nature and complexity, depending on the class level. The major categories of language challenges observed in mathematics and science were those in reading comprehension and vocabulary; spelling; grammatical patterns and structures; textual features; figurative expressions; and the use of multiple semiotic systems. These are discussed below.

6.1. Reading and vocabulary

The ability to read was a factor in students' ability to participate in mathematics and science lessons. In one mathematics lesson observed at the Infant class level, students had difficulty identifying and spelling words such as "strawberry", "chocolate" and in another lesson, the number "four". This limited the extent to which students could make sense of the mathematical teaching points that were developed in the lessons. Reading in the content areas required students to interpret information in different directions: from left to right, right to left, top to bottom, bottom to top, and even diagonally when they were required to read graphs. For example, infant students had to move in different directions when they used the "number line" in a mathematics lesson. Older students were required to interpret segments of a pie chart. In Language Arts, reading is usually limited to reading the printed word. In mathematics and science, students had to read symbols, as well as words. In addition, students' comprehension and expression depended on their command of vocabulary. Some of these lexical items were used in both everyday English and students' vernacular, but the meanings were different in the school registers. These included terms such as "set" and "times". In some instances, the meaning of a word was shared by the language varieties, however, there was more precision in meaning in the academic register. Students also faced greater challenges when a word had different technical meanings in mathematics and science. Sometimes even within the same register, the meanings of related words, such as "radius" and "diameter" in mathematics, challenged students' comprehension.

In a TEC language environment, the number of homophones created by the phonological system required students to decide on the appropriate interpretation of sounds based on the contexts in which they were uttered. For example, a word such as "width" spoken by both teachers and students had the same sound as "with" and "wit" if pronounced in Creole. This is because the final "th" sound used in SE for words such as "width" is not used in Creole in this phonological environment. In addition, some words like "sum" are homophones in both language varieties. Interpreting the intended meaning of words and expressions was usually easier when students had to process written rather than oral text.

6.2. Defining terms and processes

Some of the challenges were similar across class levels. For example, students in all three classes generally experienced difficulties defining terms and processes. From the Infant Year 1 level to Standard 4, students often defined terms or processes by referring to concrete examples. They usually began with a statement such as: "(term/process) is when ….", or "(term/process) is like…" It appeared easier for them to offer an example of an object, idea, or phenomenon when asked to characterise or explain what it was. Defining entails generalizing and abstracting to frame a statement structured in a way that is conventional for mathematics or science discourse. The ability entails more than knowledge of word meaning; it involves the selection and categorisation of relevant features, understood in meaningful and appropriate contexts. Even at the highest class level, students experienced difficulties

producing definitions using academic language considered appropriate for mathematics and science.

Not unexpectedly, at the highest class level, Standard 4, students faced the largest number of subject-specific terms in both mathematics and science. There was high lexical and conceptual density in oral and written texts used in the classroom, especially in mathematics, to such an extent that students seemed to be overwhelmed at times. This situation was not merely due to the presence of unknown or partially known terms, but also because of irregularities in English spelling, and syntactic and morphological features of academic language. When faced with challenges understanding and interpreting meaning in context, students tended to be silent and non-responsive to teacher questioning, or marginally participated in classroom discourse.

6.3. Grammatical patterns and structures

Another major category of challenges included variations in grammatical patterns and structures. Both in speech and writing, students had to correctly interpret long, dense noun phrases, particularly in mathematics. There were also pre-numerative phrases which referred to quantifiable, but abstract, qualities of head nouns as identified in Schleppegrell [18]. This was especially so at the Standard 4 level when the teacher explained or questioned students and used phrases such as: "… a quarter of a circle divided in two is one-eighth …." Spoken and written discourse commonly exhibited a high density of information, and students had to understand the meaning of structures that were linguistically complex. For example, the data included phrases with adjectives and quantifiers preceding or coming after nouns, and the mixing of cardinal and ordinal numbers, as in the phrase "…four 90 degrees angles". These occurred in both oral and written texts. When listening, students had to quickly make connections between segments of texts in order to understand mathematics and science content. They also had to navigate grammatical differences between SE and TEC to understand basic concepts. Two examples of such instances were the use of the superlative grammatical structures "most liked" and "least liked" in mathematics at the Infant level; and the passive construction expressed by the phrase "is eaten by" in science lessons in the Standard 4 class. In the second instance, morpho-syntactic differences between SE and TEC at time created challenges for students. For example, in a science lesson, some students had difficulty understanding and reproducing the diagram showing a food web. Part of the difficulty stemmed from the use of the phrases "eats" and "is eaten by" to describe the relationship between different animals and matter in the food web. At the start of the lesson, their teacher asked students to describe what they were seeing on a page in their textbook where a picture of a food web was illustrated. She questioned them on several aspects of the diagram to elicit their understanding, then specifically focused on the direction of the arrow and invited comparison of the shape of the arrow in a food web to its shape in a food chain. She asked students to describe what was happening in the diagram they were viewing. Students therefore had to indicate which animal was eating and which one was being eaten by other animals. Through questioning, the teacher sought to elicit what the arrow represented. Although there was much discussion and explanation about the diagram, at the end of the lesson, most of the students were unsure or incorrectly responded to teacher questioning on the relationship between organisms in the food web Another term that the teacher at the Infant level introduced in a mathematics lesson and which posed some difficulty for students' comprehension in the mathematics context was ''as many as''. This term is not commonly used in the vernacular of the students in the class.

6.4. Textual discourse features

Students also had to understand and use a range of textual features common to mathematics and science discourse. These included words such as "all together" which signal the kind of mathematical procedures that are relevant to the solution of problems. Furthermore, students were expected to make connection between words used synonymously, retrieve associations of deictic words such as "this" and "that"; and decipher elliptical phrases in which words were omitted. Teachers' use of figurative expressions also required students to apply analytic skills to determine literal and figurative meaning in oral communication. All these factors are relevant to students' perception of cohesion and coherence in the oral and written texts. The sense they made of what they were hearing and reading, in oral, written, or graphic mode, depended on the level of their language competence in the language of instruction, and their ability to connect segments of the discipline specific texts that their teachers presented or generated.

A significant aspect of students' learning in mathematics and science in all three classes that participated in the study relates to the ability to communicate information graphically. Means of communication included working with diagrams, charts, pictures and graphs encountered in textbooks, notes and boards in the observed classroom. These are disciplinary modes of communication that students are taught to read and interpret and produce as conventional ways of communicating in school mathematics and science.

At the Standard 4 class level, one lesson on *Graphs* in mathematics clearly demonstrated the skills students needed to develop to successfully read and interpret information in graphic form. At the beginning of the lesson, the teacher asked how many students lived in the school community of Rose Hall and when nine students raised their hands, she drew nine icons to represent people on the board and wrote: "one [icon] represents one". She then questioned to find out where other students lived and constructed a graph to represent the population of surrounding villages. Having agreed on numbers of 7500, 3000, and 1000, she engaged students in a discussion of how these numbers could be represented on a graph. Some aspects of the graphic representation that students found challenging included choosing an appropriate scale given the high numbers they were using; converting the actual numbers to the icons used to symbolise people, and relating numerical representation to the symbolic representation; and comparing the figures using the symbolic representations. Additional language challenges which students encountered in learning mathematics and science included acquiring the ability to use physical, pictorial, graphic, symbolic, verbal and mental representations of ideas. The process of learning involved the acquisition of ways of thinking, speaking, writing and representing phenomena in ways that were typical of the disciplines. Students therefore had to understand and use different semiotic systems when their teacher asked them to explain, and then to draw the relationship between organisms in a food web.

7. Implications for teaching and learning

When students are schooled, they are expected develop the academic language and show understanding of the way each school discipline uses language to communicate knowledge of the world. Similar to findings in Nagy and Townsend [19], aspects of the registers evident in the teaching and learning interactions in this study included subject-specific vocabulary, associated grammatical forms and structures, and all other prescribed ways of communicating in the disciplines. Shanahan and Shanahan [20] contend that language and literacy are embedded within disciplines and are connected to specific learning situations. Thus, if students are to develop ways of thinking, speaking, reading, writing, and representing used by mathematicians and scientists [6], educators would need to immerse them in the discourse of the disciplines. In this way, students can overcome the language challenges posed by the academic language of school disciplines and would be better positioned to participate meaningfully in the community. Fang and Schleppegrell [2] argue for the need to make discipline specific ways of using language explicit, and they suggest that this would help learners to engage more fully with content and develop their subject literacies. It is therefore important for teachers to become aware of the labels that students have in their vernacular, in this case Trinidad/Tobago English Creole, to express key ideas or concepts in school disciplines. The classroom interactions observed suggest that teachers need to pay greater attention to students' acquisition of the registers that are typically used by school disciplines. In other words, teacher pedagogy must support student acquisition of content area literacy. In a situation where there is overlap in vocabulary and grammatical structure of language varieties in use, the borders are blurred. For example, Trinidad/Tobago English Creole (TEC) and Standard English share many lexical items. However, the meaning of the same word might be different in the two varieties. This heightens the complexity of teaching, and the challenges of student learning across the school curriculum. Teachers should therefore be knowledgeable about the specific ways in which disciplines such as mathematics and science use language. Further, the register of the discipline should be examined against the vernacular of students to discover the crucial ways in which the two language varieties differ, not only in their linguistic form, but also in their functions. This is particularly important at the early levels of children's schooling when their language awareness may not be well developed.

Aspects of the registers evident in the teaching and learning interactions reported here included subject-specific vocabulary, associated grammatical forms and structures, and other prescribed ways of communicating in the disciplines, as well as important differences in linguistic features between SE and TEC. In the literature, these are extended to include the use of language for reasoning and argumentation, as well as the ability to reason with inscriptions [2]. Such a convenient categorization of facets of language separates the language from the content. However, language and literacy are embedded within disciplines and are connected to specific learning situations. Thus, if students are to develop ways of thinking, speaking, reading, writing, and representing used by mathematicians and scientists [6], educators would need to find ways to immerse them in the discourse of content areas. Teachers would also need to use pedagogical strategies to raise students' language awareness throughout the school curriculum.

8. Conclusion

This paper has raised issues pertinent to the nature of the challenges confronting primary school students whose vernacular is Trinidad/Tobago English

Creole, but who are taught mathematics and science in Standard English. This investigation can be extended to other school disciplines. In addition, the investigation can focus on teaching and learning at the secondary, and the tertiary level where students might face similar challenges in negotiating the language of instruction, and the academic language specific to the disciplines they study. Such a line of inquiry can equip content area teachers with the pedagogical tools to help students cross language borders and overcome the challenges posed by the academic language of school disciplines. This would increase levels of literacy in content areas across the school curriculum and better position students to participate meaningfully in academic communities inside and outside their school.

9. References

[1] H. Simmons-McDonald, "Trends in Teaching Standard Varieties to Creole and Vernacular Speakers", *Annual Review of Applied Linguistics*, Cambridge University Press, Cambridge, 2004, pp. 187-208.

[2] Z. Fang, and M. Schleppegrell, "Disciplinary Literacies across Content Areas: Supporting Secondary Reading through Functional Language Analysis", *Journal of Adolescent and Adult Literacy*, International Reading Association, Newark, Delaware, USA, 2010, pp.587–597.

[3] Australian Capital Territory, Department of Education and Training, "Language for Understanding Across the Curriculum: Strategies Handbook Studies Section", 1997, http://www.det.act.gov.au/_data/assets/pdf_file/0004/17338/LUAChandbook.pdf (24 April 2013)

[4] J. Lemke, "Multimedia Semiotics: Genres for Science Education and Scientific Literacy" in M. J. Schleppegrell & M. C. Colombi (Eds.), *Developing Advanced Literacy in First and Second Languages: Meaning with Power*, Erlbaum, Mahwah, NJ, 2002, pp. 21-44.

[5] J. Zwiers, *Building academic language: Essential practices for content classrooms*, Jossey-Bass, San Francisco, 2008.

[6] J. P. Gee, *Social Linguistics and Literacies: Ideology in Discourses* (4th ed.), National Science Teachers Association, Arlington, VA, 2012.

[7] C. Lager, "Types of mathematics–language reading interactions that unnecessarily hinder algebra learning and assessment", *Reading Psychology*, 27(2-3), 2006, 165–204.

[8] J. Carolan, V. Prain, & B. Waldrip, "Using representations for teaching and learning in science", *Teaching Science*, 91(1), 2008, 18–23.

[9] M. Street, "The Hidden Dimensions of Mathematical Language and Literacy", *Language and Education*, 19(2), pp. 136-141.

[10] S. B. Heath, *Ways with Words: Language, Life, and Work in Communities and Classrooms*, Cambridge University Press, Cambridge, 1983.

[11] O. Lee, "Culture and Language in Science Education: What Do We Know and What Do We Need to Know?" *Journal of Research in Science Teaching*, Wiley and Sons, New Jersey, USA, 2001, pp. 499–501.

[12] J. George, *An Analysis of Traditional Practices and Beliefs in a Trinidadian Village to Assess the Implications for Science Education*, Unpublished doctoral dissertation, The University of the West Indies, St. Augustine, 1995.

[13] S. Herbert, "Collateral Learning in Science: Students' Responses to a Cross-Cultural Unit of Work", *International Journal of Science Education*, Taylor and Francis, London, 2008, pp. 979-993.

[14] M. A. K. Halliday, *Language as a Social Semiotic: The Social Interpretation of Language Meaning*, Edward Arnold, London, U.K., 1978.

[15] M. A. K. Halliday, "Towards a language-based theory of learning", *Linguistics and Education*, 5(2), 1993, 93-116.

[16] S. Eggins, *An introduction to systemic functional linguistics*, (2nd ed.), Continuum, London, UK, 2004.

[17] R. N. Rubenstein, and D. R. Thompson, "Understanding and Supporting Children's Mathematical Vocabulary Development", *Teaching Children Mathematics*, National Council of Teachers of Mathematics, Reston, VA, 2002, pp. 107-112.

[18] M. Schleppegrell, "The Linguistic Challenges of Mathematics Teaching and Learning: A Research Review", *Reading & Writing Quarterly*, International Reading Association, Newark, Delaware, USA, 2007, pp. 139-159.

[19] W. Nagy, & D. Townsend, "Words as Tools: Learning Academic Vocabulary as Language Acquisition", *Reading Research Quarterly*, 47(1), 2012, 91-108.

[20] T. Shanahan, & C. Shanahan, "Teaching disciplinary literacy to adolescents: Rethinking content area literacy", *Harvard Educational Review*, 78(1), 2008, 40–59.

