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Learning Mathematics in English at Basic Schools in Ghana: A Benefit or Hindrance?

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Abstract: Facilitating effective mathematics learning and higher mathematics achievement have long been recognized as a key to the scientific and technological advancement of the African continent. While the central role that language proficiency plays in mathematics teaching and learning has received an overwhelming research attention in the literature over the past two decades, this is not the case among African policy-makers and political leaders. Drawing mainly from our professional experiences as mathematics educators and from the international research literature, our primary intent in this paper is to answer this question: How does the learning of mathematics in English at the basic school level help or hinder students' mathematical proficiency? To answer this question, the paper is organized as follows. The first part, the introduction, gives a brief overview of the language of learning and teaching in Africa. The second part describes the method and conceptual framework undergirding the research. In the third section, we have analyzed the effects of mathematics learning and teaching through English for basic students whose mother tongue is a Ghanaian language. The conclusion offers four recommendations for developing and improving the mathematics proficiency of students in basic schools.

Keywords: *Mathematics proficiency, English language, student culture, language of learning and teaching (LOLT).*

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Introduction

Language plays a central role in mathematics teaching and learning, yet it has not received much attention among many educators, researchers and policy-makers in Africa. The language factor is hardly blamed for Africa's poor educational outcomes such as low matriculation rates, mass failure of students in mathematics exit examination and international assessments, secondary school dropout rates, dismal early reading scores, and low standards of literacy of university entrance students (Bamgbose, 2000; Gove and Cvelich, 2010; Rollnick and Manyatsi, 1997). Certainly, Africa's dismal educational outcomes have other causes such as poverty, lack of resources, political instability, ineffective government bureaucracy, and poor teacher quality. Nevertheless, since the language medium of teaching and learning question has been left uncritically analyzed, discussed or debated, the linguistic causes of Africa's poor educational outcomes have been ignored (Dutcher, 2001). Unearthing African poor schooling outcomes necessitates a critical interrogation and thorough investigation of the language used for teaching, learning and assessment of mathematics in its school system.

Purpose, Rationale and Organization of Paper

In this paper, we draw mainly from our narrative experiences as mathematics educators and from the research literature with the primary intent to answer this question: How does the learning of mathematics in a colonial language (English, French, Portuguese, etc.) at the basic school level help or hinder students' development of mathematical proficiency? To answer this question, we based our analysis on the realities encountered by Ghanaian basic students learning mathematics as our case study. A case study is an intensive scholarly inquiry that deals with a unit of phenomenon and it allows us to understand the phenomenon much better rather than studying all basic students in African countries learning mathematics through different colonial languages (Merriam, 2001; Yin, 2003). With this unit of the phenomenon thoroughly analyzed, it is then possible to make generalization to the entire phenomenon to which the unit is a member (Cohen and Manion, 1994).

In Ghana English is the language of government and administration, the learned professions and much of the media. English is also the language of learning and

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teaching[1] (LOLT) in Ghanaian schools from primary 4 (Ampiah, 2010), though later policy had sanctioned English-only as the LOLT throughout the school system (Owu-Ewie, 2006). Like many other policies in African countries, the use of Ghanaian languages as LOLT from pre-school to class three is hardly monitored, leaving teachers to use their own discretion to adopt any LOLT they find appropriate. According to Ampiah (2008), observational studies indicate that in rural, urban and private elementary schools (k-6) in Ghana English language only is used as the LOLT for mathematics teaching and learning due to the limited mathematics register in Ghanaian languages. A similar observation is made in junior high schools (1-3), though the use of Ghanaian language is dominant in teacher-student classroom interactions in rural schools (68%) and 37% in urban schools but almost 100% in private schools. The same author reports that in private elementary schools, teachers and students use only English for classroom interactions compared to 6%-13% for rural schools and 11%-60% for urban public schools.

Many reports and scholarly articles have been written about poor mathematics achievement of Ghanaian basic school students. The common proxies normally used to determine student mathematics achievement are the results of public examinations such as the Basic Examination Certificate Examination (BECE) and international assessments like Trends in International Mathematics and Science (TIMSS) (Adetunde, 2007; Anamuah-Mensah and Mereku, 2005; Ministry of Education, Youth &Sports, 2004; Mullis et al, 2008; West African Examination Council, 2006). For example, Anamuah-Mensah and Mereku (2005) attribute the poor performance of Ghanaian junior high school students (JHS 2) in the TIMSS 2003 to the inability of teachers to fully cover the mathematics curriculum content domains of number concepts, algebra, measurement, geometry, and data management. They also argue that the national mathematics curriculum puts an undue emphasis on number concepts or computational skills, knowledge of facts and procedures to the neglect of problem-solving. Lastly, they contend that Ghana national mathematics syllabus, textbooks and teacher handbooks for JHS are out-of-date and do not meet international standards.

Nevertheless, none of these researchers and scholars has included English as language of learning and teaching mathematics in the catalogue of probable causes for basic student dismal mathematics achievement. We wonder why, knowing very well that almost all the teachers and students in basic schools in Ghana are incompetent users of the English language. The absence of English language proficiency from the core analysis of poor mathematics achievement of Ghanaian basic students in those examinations motivated us to write to undertake this research. As a matter of fact, the act of speaking, listening, thinking and writing through English are not constantly thought of among Ghanaian scholars, researchers and policy-makers as part of learning mathematics. Though in the mathematics classroom language is the dominant means through which students express the knowledge they have acquired as well as their understanding of mathematical ideas, concepts, procedures, principles and formulas (Yushau, 2004), language is often trivialized or ignored as insignificant.

This paper is organized as follows. The first part discusses the research method and conceptual framework that anchors the research. In the second portion of the paper, we have analyzed the effects of mathematics learning and teaching through English language for basic school students[2] whose mother tongue is a Ghanaian language rather than English. Our main argument is that learning mathematics through in basic school hinders student development of mathematics proficiency. In the conclusion, the final part, we offer four recommendations for developing and improving the mathematics proficiency of students in basic schools.

Research Approach

We have been mathematics educators for a long time now, with a mix of Ghanaian and Canadian professional experience. The second author has more than three decades of professional experience as a mathematics and science educator; having taught in secondary schools and a university in Ghana before coming to the University of Toronto, Canada, to pursue a doctor of philosophy degree in mathematics and physics. After completion of his doctoral studies, he taught mathematics at the community college level and then later on moved to the University of Toronto. At these levels, he taught mathematics to students from diverse cultures.

The first author started teaching mathematics and science in Toronto inner-city elementary and middle schools for four years after obtaining his undergraduate degrees in mathematics and education from York University, Toronto. He also obtained a master's degree in mathematics education from the same university. Later on, he taught mathematics and science for seven years in a secondary school in Nunavut, Canada's newest territory, where the students were Inuit Aboriginal people. In all, he has more than 15 years of experience teaching elementary, middle and high school mathematics and science. Above all both of us were mathematics and science

[1] In accordance with Setati's (2005) usage of the term, we preferred to use language of learning and teaching (LOLT) rather than medium of instruction or language of instruction. It reflects realistically what goes on in the schools.

[2] Basic school is used here to refer to students in the first 9 years of schooling (primary one to junior high school form three).

students in Ghana and Canada before we became educators. The first author completed secondary school calculus and other mathematics courses in Ontario before enrolling in a university undergraduate mathematics program. The second author studied advanced mathematics courses at the secondary school, undergraduate and master's programs in mathematics at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Our previous status as students of mathematics has enriched our professional experience and understanding as mathematics educators, in terms of teaching, learning and assessment of mathematics through English as a second language.

Consequently, as mathematics educators we have valuable, insightful experiences to share about mathematics teaching, learning and assessment of students whose indigenous language or mother tongue is non European language. Qualitative researchers may regard our professional experiences as stories or narratives. They may also say that we lead storied lives (Connelly and Clandinin, 1990; Creswell, 2008). These authors may characterize our professional narratives or stories as similar in character to interviews, letter writing, journal records, field-notes, autobiography and biography that constitute the major approach to data collection in qualitative research methodology. Using professional education narratives as research data is increasingly acceptable in the field of qualitative research (Gardner, 2001; Stoddart, 2001) and nursing (Eubanks, 1991). It is also an accepted part of qualitative research that requires examination of one's personal practice or experience, like action research(Greenwood & Levin, 1998) and of other research traditions, such as ethnography, where the personal experience of the researcher is considered inseparably bound up with the data collection, analysis and interpretation activities (Ellis, 1995; Hannabuss, 2000).

On our part, we opted to use our professional experiences because they help us to supplement the paucity of literature we found on teaching and learning mathematics in colonial languages by continental Africans. In addition, the use of our professional experiences, we hope, would allow the reader to understand where we are coming from in terms of our mathematics teaching and learning experiences, values and the practical nature of this research for improving mathematics education in the African continent. As well, this genre of researchers as participants will assist mathematics educators to learn from their accumulated experiences and use such learning to improve their mathematics instruction and facilitate student mathematics proficiency. Not only that, it also offers opportunities to mathematics teachers develop critical perspectives about mathematics teaching, learning and assessment.

As our research approach is qualitative or interpretative (Denzin and Lincoln, 1994) it enables us to critique or corroborate with the literature in the field using our combined practical teaching experiences. Teachers' practical experiences have an empirical merit as Fenstermacher (1994) has asserted:

> *The concept of practical knowledge is a legitimate epistemological category so long as we attach to it demands for justification or warrant in the same way that demands are attached to formal knowledge (p.47).*

In this quote, Fenstermacher (1994) is suggesting that knowledge gained from experience is of value, relevance and meaning in qualitative research provided we are able to demonstrate that such claims are practical and fairly logical within the context of such experiences. We have provided substantial evidence for our assertions rather than merely narrating our accumulated experiences as mathematics educators.

Those narratives (or professional experiences) have shaped and continue to shape our professional lives as we interact with students, prepare lesson plans, design mathematics activities, assess student mathematics performance or engage in any professional development activities. However, those narratives are not merely incidents, events, or observations of what happened in our professional lives. We produced our narratives through critical reflection on our accumulated professional experiences over the years in teaching students whose primary language is non-English. As we reflected on our experiences we met face-to-face in our offices or engaged in phone discussion once a week from October 10, 2012 to January 25, 20013 to discuss and critique those reflections. Our research question, conceptual framework and the following sub-questions guided our individual as well as our collective reflections: (1) How is it like teaching or learning mathematics through English? (2) What problems do English-learners encounter in the mathematics classroom and how do teachers respond to those learning problems? (3) Do teachers actually know that English-learners have linguistic problems learning mathematics in English? (4) How do you assess English-learners' knowledge of mathematics? (5) What are the learning effects of using both the indigenous language of the student and English to teach mathematics? (6) What are the practical benefits of using students' indigenous language to teach them mathematics?

A face-to-face meeting for the research could last between one and half hours but each of our phone conservations exceeded 2 hours most of the time. In the meetings we shared our reflections and provided opportunities for each to ask questions of the other's reflections. Sometimes our reflections led us to more questions than answers as we focused on the sub-question we were trying to answer. In all, we had a total of five meetings, seven sessions of phone conversation and ten electronic exchange of correspondences (emails).We took notes of all those final reflections, used the themes identified in the reflections to summarize and analyze those assertions we found relevant to help us to answer the major research question. In the analysis we moved between the final reflections and the field literature repeatedly to compare them. Some of the results of the comparison were expected but others were unexpected. Our definitions of expected and unexpected conform to those of Cole (1994). The author uses" expected" to refer to data that support ideas of authors in the literature, and "unexpected" as that do not confirm to ideas of those authors of the literature in the field. The email communication exchanges between us focused on clarifying meanings, reinterpretation of reflections, justification of reflections, additional reflections, questions for further reflection, and possible answers to precious questions or new questions for reflection.

Reflection is an indispensable characteristic of effective mathematics teachers. The research literature suggests that teachers learn effectively through their reflections (Berliner, 1994; Dewey, 1933; Jaworski, 1998; Mason, 2002). Jaworski (1998) and Mason (2002) distinguish between reflection-on-action as thinking back after the fact and reflection-in-action as being aware of inner thoughts and feelings while engaging in an act of teaching. Mason (2002) adds a third category of reflection: Reflection-through action. It is about teachers' awareness of patterns of their own professional practices. According to Dewey (1933) reflection is different from other forms of thinking in that it involves: (i)"A state of doubt, hesitation, perplexity, mental difficulty in which thinking originates and (ii) an act of searching, hunting, and inquiring to find materials that will resolve the doubt, to settle and dispose of the complexity "(p. 538). Dewey (1933) goes on to suggest that critical reflection has three main attributes: Openness, responsibility and wholeheartedness. Yost et al (2000) explain that openness relates to having the desire to listen to alternative views and having the courage to question one's own teaching beliefs and practices. They define responsibility as the desire to search actively for truth and apply the findings obtained to resolve problems. Finally, they state that wholeheartedness has to do with an attitude for making changes and critical evaluation of ourselves as mathematics educators, our organization and our society. Our reflections produced and utilized in this paper bear those characteristics of reflection-on-action and reflection-through action.

Nevertheless, we must admit that in producing and analyzing our reflections human subjectivities such as cultural biases, personal views and political positioning were likely to exert influence. To minimize such subjectivities and ensure objectivity in our analysis, each was allowed unfettered freedom to read and critique the reflections of the other. We should stress that, the notion of participant research does not presuppose a degree of emotion or passion detachment from the subject matter of the research. On the contrary, it is required of the participant researchers to maintain maximum transparency in their conduct of the research (Rosaldo, 1989).

Besides our professional narratives or experiences, we also made an increasing use of the international research literature. We used the University of Toronto electronic databases and the internet search engines like Ultra Vista, Google, and Yahoo to search for literature in the field of interest. Using descriptors "learning mathematics through second language", "learning mathematics using mother-tongue", "and mathematics education in Ghana/Africa", and "teaching and learning mathematics in English" interchangeably, we searched in the following databases: ERIC, EBSCO, JSTOR, PROQUEST, Education Full-Text, and Wilson Education Abstract. These databases displayed more than 200 articles, research reports, monographs, and conference papers. However, we confined our search mostly to peer-reviewed sources because they are easier to locate and are more authentic relative to others.

We also used the same descriptors or phrases in the databases to search the world web via Ultra Vista, Google, and Yahoo. The search netted more than 320 documents, including conference proceedings, academic articles, and research and project reports. Using our major research question and guided reflection questions, we determined which of the documents were relevant to assist us to answer the major research question. Much of the literature is generally about teaching or learning in second languages or L2 rather than mathematics specifically. A majority of the mathematics related literature in the field comes from the United States of America. Nevertheless, we were interested in the literature related to English-learners learning mathematics through English language. In the United States many of such learners speak Spanish as their primary language of communication (Khisty, 2006; Khisty and Chval, 2002; Moschkovich, 2007). South Africa with its multilingual classrooms and having one of the best research traditions in the African continent has produced numerous papers in the field of mathematics teaching and learning through English, a second or third language[3] to the majority of indigenous South Africans. Unfortunately, only a few of the literature is useful in helping us to answer our main research question.

Conceptual Framework

The conceptual framework of a research consists of concepts, assumptions, beliefs, and theories that support and contribute to shaping the research (Miles and Huberman, 1994). According to these authors a conceptual framework "explains either graphically or in narrative form the main things to be studied-the key

[3] We will use second language and additional language interchangeably.

factors, concepts or variables-and relationship among them (Miles and Huberman, 1994, p.18). A conceptual framework is thus a set of concepts that assists researchers to address either the research question(s) or purpose (s). In this paper, our conceptual framework is made up of dimensions of mathematics proficiency.

Mathematics proficiency involves knowledge, skills and attitude in five strands (Kilpatrick et al. 2001). The five interrelated strands are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Conceptual understanding is about comprehension of mathematics concepts, operations, and their relationships. Students who have conceptual understanding of mathematics know more than isolated number facts and are able to explain similarities and differences between number concepts, operations and relationships among them. Procedural fluency refers to the knowledge and skills to apply mathematical procedures flexibly and appropriately in accordance with the contexts. Strategic competence is the ability to formulate, represent and solve mathematical problems. That is, it is about using mathematics to solve problems as well as pose problems. Adaptive reasoning relates to the capacity to explain things using logic, thought reflection, and justification. Productive disposition is "the habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (Kilpatrick et al, 2001, p.5). In other words, productive disposition involves the development of positive attitude toward mathematics.

Developing Student Mathematical Proficiency: Does Language Matter?

In the previous section, researchers, educators and scholars are quoted asserting a positive correlation between education in a foreign language and African educational failures like school dropout rates, low graduation rates, and poor mathematical achievement. A group of researchers and scholars wants to improve education quality in Africa through the adoption of indigenous languages as LOLT (Alidou and Brock-Utne, 2011; Bamgbose, 2007; Owu-Ewie, 2006; Obanya, 1980). Generally, the literature suggests that the use of a colonial language as official language negatively affects attainment of development goals, achievement of mass literacy, participation in international discourses and knowledge production (Bamgbose, 2007; Robinson, 1996; Wolf, 2011). So, what do these have to do with developing the mathematical proficiency of African children and adolescents? In this section we argue that the use of English as a LOLT in basic schools in Ghana hinder the students' development of mathematical proficiency. Using the student's home or familiar language as the LOLT has enormous psychological, sociological and educational benefits relative to the use of a colonial language (Todd, 1988).

In the past, researchers and policy-makers generally accepted that language influenced learning but not so much on the acquisition of mathematics skills, concepts and problem-solving (Cuevas, 1984; Flores, 1997; Gutierrez, 2002). That is, the prevalent notion was that a student's proficiency[4] of LOLT has a minimal effect on learning mathematics. This was because mathematics was conceptualized as numbers, calculation with numbers, shapes and manipulation of symbols (Hansen-Thomas, 2009; Janzen, 2008; Lager, 2006). Nonetheless, in the last two decades or so, researchers have observed that English language learners[5] (ELLs) who learn mathematics through English need proficiency in English in order to develop their mathematical proficiency (Abedi and Lord. 2001; Beal et al 2010; Parker et al. 2009; Schleppegrell, 2007). English language proficiency will ensure that these students are able to comprehend and apply mathematics skills and concepts to solve problems, develop logical thinking, recognize patterns, explore concepts and engage in critical discussion (Anderson, 2007; Garrison and Mora, 1999; Mestre, 1988; Moschkovich, 1999). Separating language from mathematics learning has led to the entrenched but mistaken belief that mathematics learning has nothing to do with language (Mcleman et al, 2012).

The influence of English language on mathematics learning can be viewed in two ways: natural language and technical language both of which form the mathematical register. Certain phrases and words have been adopted from the English language and given special meanings in mathematics. These include line, point, angle, sum, average, variable, mean, table, range, set, field, difference, degree, addition, set, and input, even and odd numbers. Apart from these terms, mathematics also uses the same English pronoun, connectors, punctuation, transitional words and other syntax. Technical words or vocabulary in mathematics include parabola, x-axis, y-axis, hypotenuse, distribution, parallelogram, asymptote, standard deviation, symmetry, compound interest, coefficient, term, sine, cosine, radian, equation, and rational numbers. Thus, ELLs who learn mathematics through English have to master the technical English language usage, along with ordinary English to understand what their teachers teach in order to develop their mathematical proficiency (Nordin, 2005). They would rather learn mathematics more quickly and grab mathematical ideas more efficiently if instructed in a familiar language.

[4] Language proficiency or linguistic proficiency is viewed in terms of four discrete micro skills: reading, writing, speaking and listening.

[5] We prefer the term English Language Learners (ELL) to English-As- a second language (ESL). The reason is that in the context of Ghana English may be third or even fourth language to some students.

Explaining, Communicating, Justifying Mathematically

In the case of Ghanaian basic school students, a vast majority of them are ELLs and have problems with ordinary English language let alone the specialized words borrowed from English and the technical mathematics vocabulary. Accordingly, the second author provides the following reflection:

> *The main problem with Ghanaian students (in Ghana) is not necessarily mastering the technical language of mathematics or the special mathematical meanings assigned to certain English words or phrases. It has more to do with expressing themselves in ordinary English sentences and making sense in those expressions. It is a problem most students at that level may deny because to admit it openly suggests one is stupid, knowing that in Ghana English language proficiency is equated with intelligence... though there is no connection whatsoever between the two. Students have a strong preference for number skill questions or those requiring procedural or computational fluency rather than those that require analysis, exploration, reasoning and communication. As a consequence most mathematics teachers avoid assigning to students activities that involve explaining mathematical concepts, supplying justification or making arguments.... not that Ghanaian students are incapable of reasoning mathematically but they can't do it with ease when using English compared to using their mother tongue... In one-on-one working with them I observed their extraordinary ability to articulate the meaning of mathematical concepts and principles*

The first author made a similar reflection on the same issue, emphasizing that the problem of explaining, communicating and justifying mathematically are prevalent among ELLs:

> *I found that the difficulties ELLs experience in explaining and justifying mathematically are similar among that population of students... Even where I gave written explanations or analyses of concepts they would try to memorize them and reproduce them in exactly the same words, most of the time, inappropriately without considering the contexts. They usually showed frustration on their faces when I pointed out to them the inappropriateness of their explanations or justifications. No wonder these students often chose questions that involved calculation rather than those that required them to explain by comparing one thing with another; choosing one procedure/formula over others; justifying a solution/answer/procedure; demonstrating the effects of procedures on specific social variables; what some concepts mean... But as mathematics educators we fail to consider or underestimate the implications and challenges of teaching and learning through a foreign language (English language). This failure or underestimation is more likely to have a negative impact on the quality of teaching and learning outcomes in mathematics... ELLs at that basic level cannot engage in analyzing, communicating and justifying mathematically until they have attained English proficiency. By that time they might have lost interest in mathematics!*

To develop mathematical proficiency, Ghanaian basic school students need more than procedural skills. As we have noted about mathematical proficiency, students also need conceptual understanding which demands language proficiency for communicating or expressing their conceptions of mathematical ideas. If mathematics learning were merely number crunching or manipulating formulas there would be no problem for most ELLs. However, the learning of mathematics in the last few decades has taken the direction of analysis, communication and exploration all of which require language proficiency (Ernst-Slavit and Slavit, 2007). This direction of mathematics education prevents parroting of mathematics ideas without understanding and allows mathematics to be related to the life-world.

The National Council of Teachers of Mathematics (1991) stresses that students should spend more time on reasoning, problem-solving, communicating ideas, exploring the relationship among representations of mathematical forms and making connections between concepts. We found this suggestion crucial for developing mathematical proficiency. Unfortunately, the mother tongue of most basic school students in Ghana is non-English with the result that mathematics learning is a formidable challenge for them. How can the child learn mathematics effectively or successfully through English in which he/she is weaker? The situation is more dangerous when mathematics teachers are unaware of the language implications of teaching and learning mathematics through English and reason erroneously that since they were able to do it the ELLs should be equally able to do it. Indeed, at the commonsensical level, the mother tongue of the child is the language he/she is familiar with and can comfortably use for communication, analysis, and exploration of mathematical objects and concepts (Sua and Raman, 2007). As Obanya (1980) carefully observed thirty-two years ago, "It has always been felt by African educationalists that the African child's major problem is linguistic. Instruction is given in a language that is not normally used in his (or her) immediate environment, a language which neither the learner nor the teacher understands and uses well enough" (p.88).

The myth that mathematics learning transcends English language proficiency is to deny basic school students in Ghana the opportunity to develop mathematics proficiency through their home languages.-Languages they are familiar and comfortable with. In a research in South Africa, students reported that the use of their home language helped them to develop conceptual understanding of mathematics they were learning. Others indicated that the use of their home language allowed them to develop a positive or productive disposition toward mathematics (Langa, 2006). It is for this reasons we are arguing that learning mathematics through the indigenous languages of basic students in Ghana would assist them to develop their mathematics proficiency.

Mathematical Problem-solving

Mathematical problem-solving is considered the heart of mathematics learning more than learning to compute with numbers and identifying geometric shapes (Eshun, 2000; Halmos, 1980?). Problem-solving is a goal-oriented, cognitive activity that entails analyzing and interpreting a situation mathematically (Lesh and Zawojewski, 2007). A definition we find more acceptable is the view that mathematical problem (often called word problem) is any problem amenable to representation, analysis, and possible solution using mathematics methods or principles. It involves language, strategic thinking, and understanding of mathematics concepts. It also ranges from real-life problems to contrived puzzle-like problems. However, mathematical problem-solving is the Achilles' heel of ELLs who learn mathematics through English. They often make different types of errors which are purely linguistic in nature (Abedi and Lord, 2001; Feza-Piyose, 2012; Lager, 2006; Setati, 2005b; Zevenbergen, 2001). Zevernbergen (2001), for instance, gives an example of the use of the English preposition to, by and from in relation to temperature word problem for which ELLs may be vulnerable: The temperature fell to 10 degrees, the temperature fell by 10 degrees, and the temperature fell from 10 degrees. According to the author these prepositions signify either an increase or decrease in temperature, which require students to use addition or subtraction symbols to represent the temperature. Generally, most ELLs have difficulties in understanding subtle meanings embedded in words used in mathematical problems (Durkin and Shire, 1991). For example, most Australian Aboriginal students lack intuitive understanding and use of the English language. Therefore, it is not surprising that they often have difficulties in engaging problem-solving activities (Christie, 1985). Long time ago, Mestre (1988) argued that the language proficiency of the student mediates cognitive functioning and identified four forms of language proficiency influencing mathematical problem solving: (a) language proficiency in general; (b) proficiency in the technical language of the domain, and (c) proficiency with the specific symbolic language of the domain. The last two on Mestre's (1988) list constitutes the mathematical register that we have already talked about in the last subsection.

The Ghanaian basic school students also have difficulties with word problems. According to Awanta (2009), students show confidence in solving mathematical problems, especially numerical and routine problems. However, their confidence level with word problems drops as they move up the grade ladder when mathematical problem-solving becomes more complicated as a result of the abstract nature of the English language. The author admits that students' low competence in the English language is a possible cause of the difficulties they experience with mathematical word problems. Other researchers note that mathematical problems are difficult for Ghanaian basic students to read, understand and interpret (Mereku et al. 2005). In Ghana's basic schools problem-solving is hardly emphasized or made the central goal of mathematics teaching and learning, though the national mathematics syllabus requires teachers to organize lessons around investigation and inquiry (Ministry of Education, Science and Sports, 2007a & b).These problem-solving and problem-posing activities involve the English language, the LOLT, of which a majority of the students are not proficient. The second author provides the following critical reflection to explain why Ghanaian teachers minimize the teaching of problem-solving:

> *The English language is again the main problem, though conceptual and situational knowledge is needed as well to solve word problems comfortably. For word problems students have to read the information several times, analyze the information; determine the algorithms to apply; apply the determined algorithm to solve the problem, and justify their solutions. The English language is heavily involved in these processes. It is very frustrating for teachers to teach problem-solving in the math classroom because both the teachers and students have a limited English proficiency. The teachers have difficulties explaining things clearly and students don't have the English comprehension skills to understand or make sense of the problems to be solved. When mathematical problems are assigned students tend to spent excessive amount of time cognitively processing the linguistic aspects of the problems. Some teachers try to help out by separating the language in which the question is embedded from the mathematics and this is often a frustrating exercise as in most cases the two are inseparable. The fact is the language and the mathematics is bonded up together such that one cannot explain the mathematics without explaining the language. The net result is that teachers give up on teaching problem-solving or they teach the basic ones that are minimally-English dependent and whose solutions are simple at best.*

Frequently, the English language and mathematics are so bounded up together in word problems that it is futile to separate the two - sorting out the linguistic and mathematical aspects of the problem. This is not the case with native speakers of the English language who, focus mainly on the cognitive or mathematical aspects of the problem-solving:

> *In mainstream settings, native speakers, for whom English is nearly automatic, can focus primarily on the cognitive tasks of an assignment-learning new information, procedures, etc- however, the student with limited ability in English must focus on both cognitive and linguistic tasks-learning new vocabulary, structures and academic discourse (Anstrom, 1997, p.5).*

Similarly, the first author observes that Ghanaian basic school students who transferred to Canadian schools encounter the same linguistic difficulties, along with the cognitive aspects, in mathematical problem-solving since most of them do not have adequate understanding of the English language. This contrasts sharply with Asian students of basic school, who had learned mathematics in their own languages and transferred to Canadian schools. For these students, the linguistic aspects of problem-solving are their major concern, not the mathematical aspects. Once they have mastered the linguistic component, they excel far better than their Ghanaian counter parts who were taught in and learned mathematics through

English language in Ghana (Fredua-Kwarteng and Ahia, 2005).

We agree with Barwell (2010) that for ELLs sometimes "Sorting out the language of the question also entails sorting out the mathematics. In this case, attention to language is relevant and contributes to mathematical thinking and understanding".Consequently, teachers face a double challenge of teaching mathematics in English language while the students are still learning the language (Ferreira, 2011).This divided attention between language learning and mathematics learning is frustrating to both teachers and students. This may well explain why the Ghanaian basic school teachers give up on teaching word problems. The first author asks the following poignant question: "How do you teach word problems effectively to students in English a majority or all of whom are deficient in that language?" A fitting answer to that question is that the mathematics teacher also takes the position of a teacher of English. He or she has to combine the teaching of mathematics with the teaching of English. This role, we have to admit, would be very difficult for most mathematics teachers to assume. Thus, the obvious choice for the teacher who is also deficient in the English language is to avoid teaching mathematics problem-solving.

According to Howie (2002), Schleppegrell (2007) and Mcleman (2012) language and learning school mathematics cannot be separated from each other and that language proficiency is needed to learn and make sense of mathematics. Research has shown that poor language proficiency, especially reading, can impede ELLs mathematics learning; hence, their attainment of mathematical proficiency. For instance, Parker et al (2009) maintain that English language proficiency in reading and writing scores are significant predicators of scores on mathematics assessment for 5th and 8th grade ELLs. This view is consistent with those of other researchers who posited that the mathematics performance of ELLs increases as their reading proficiency in English language increases (Abedi and Lord, 2001; Beal et al, 2010; Larwin, 2010). These researchers share the common view that there is a positive correlation between reading proficiency of ELLs and their mathematical achievement particularly problem-solving.

In spite of the overwhelming research evidence that English proficiency is needed to attain mathematical proficiency, Manu (2005) has challenged this empirical assertion. Researching in the context of mathematics teaching and learning through English in the nation-state of Tonga, Manu (2005) argues that there is a difference between inadequate mathematical understanding and inadequate language understanding. He goes on to assert that students' mathematical understanding and development of mathematical proficient depends significantly on the images students are able to associate in their first or indigenous language. He adds that by switching languages in the process of doing mathematics Tongan students are able to perform as much as their monolingual English speakers.

We do not doubt the veracity of switching languages during mathematics learning in order for ELLs to make sense of what they are learning. We have done it many times before during our learning of mathematics in elementary and secondary school days. Nevertheless, is it an inefficient way of learning mathematics? How long does it take for one to make the switch from English to Tonga or say from English to Akan[6] in the process of making sense of a specific mathematics concept? Obviously, native English speakers who do not have to make any switches have a great cognitive advantage over Tongan students learning mathematics. In addition, Manu (2005) states that understanding of mathematics is conditioned on the images the students are able to link to their first language. Thus, for understanding of mathematics to occur Tongan students or any ELLs have to first create images about the mathematics concept or problem and, second, link them to their first or home language. What about if some students are unable to create such images? What about if they create wrong images? The consequences, we venture to say, would be terrible for those students. We believe that overburdening ELLs with switching between languages and creating images are unnecessary for them to learn mathematics proficiently. If the first or home language is good enough as a medium of sense-making, why is it that students are not taught mathematics in their own Tonga language? It is for this reason that we argue that the development of basic school students' mathematical proficiency would be hindered if they are taught mathematics in English.

Moreover, it is tempting to confuse the Ghanaian basic students' low mathematical problem-solving ability with mathematics learning ability as it has happened to immigrant children in the United States (Salend and Salinas, 2003). That to say, the linguistic factor in mathematics learning has made it almost impossible to assess the true mathematical learning abilities of basic school students in Ghana. That is one of the reasons we have argued that the mathematical proficiency of these students would be hindered if they are taught and learned mathematics through English language.

To help basic school students to attain mathematical proficiency, some Ghanaian mathematics teachers switch code-they change from English to the indigenous languages of the students. The second author offers the following reflection:

> *I have used code-switching to the home language of students countless times when I was teaching mathematics to junior secondary school students in Ghana. And I have found it to be an effective tool for teaching and for helping these students to learn mathematics much more effectively. I used code-switching in one-on-one tutoring of students*

[6] Akan is one of the major linguistic groups in Ghana.

> *who were having difficulties in understanding or making sense of mathematics problems I taught in class. I also used it to teach mathematics concepts and associated problem-solving that I thought the students would find it difficult to make sense of. In addition, I found code-switching extremely useful for linking mathematics to the student life-world or cultural communities. I did this linking easily because I did not have to make any translations from the student home language to English... communication flew naturally for me. For this reason, I must say that code-switching is not only for the benefit of the students; the teacher also benefits because it makes teaching easier in terms of efficiency of understanding and use of time.*

Research has consistently demonstrated that using African languages in mathematics classroom enriches student understanding of mathematical concepts and problem-solving (Adler, 1998; Ampah-Mensah, 2009; Nicol, 2005; Matang, 2006; Setati, 1998, 2002, 2005a; Setati and Adler, 2001; Setati and Barwell, 2006; Whale, 2012). In Malaysia too, researchers have found that some teachers have been code-switching from English to Malay despite a government policy that made it mandatory to teach science, mathematics and technology exclusively through English[7] (Lan and Tan, 2008). Thus, instead of Ghanaian indigenous languages being banned in the mathematics classroom they should be used as the LOLT. Indeed, it is a valuable cultural capital that allows students to learn and teachers to teach mathematics more efficiently and effectively. Students use their mother tongue for three fundamental functions: sense making, understanding of new ideas and participation in conceptual discourses in the classroom (Setati, 2005; Setati and Adler, 2001). As a matter of fact, the use of students' home language helps them significantly to integrate known to the unknown phenomena mathematically, possibly leading to internalization of mathematical concepts and procedures. It also allows students to internalize and personalize mathematical ideas and apply them in various cultural contexts (Feza-Piyose, 2012). We found during our collective reflections that students are able to connect mathematics to activities in their cultural or indigenous communities when the LOLT is their home languages.

Student Participation in Mathematics Classroom Discourses

In the mathematics classroom, teachers must create opportunities for students to participate in mathematical discourses (Boulet, 2007). Participation will allow students to seek clarification of mathematical concepts, learn from their peers and for the teacher to assess student understanding. Simply put, students' participation in the mathematics classroom assists them immensely to develop their mathematical proficiency. Nevertheless, the use of English as LOLT has the potential to stifle student participation even where the teacher is English proficient. In fact, the situation is terrible where English is a foreign language to both the teachers and students as it is the case in a vast majority of basic schools in Ghana. The teachers tend to adopt teacher-centered teaching strategies:

> *Classroom observation studies conducted in several countries in Africa (Benin Botswana, Burkina Faso, Ethiopia, Ghana, Guinea-Bissau, Mali, Mozambique, Niger, South Africa, Tanzania and Togo) reveal that the use of unfamiliar languages forces teachers to use traditional and teacher-centred teaching methods. Teachers do most of the talking while children remain silent or passive participants during most of the classroom interactions. Because children do not speak the language of instruction, teachers are also forced to use traditional teaching techniques such as chorus teaching, repetition, memorization, recall, code-switching and safe talk (Alidou and Brock-Utne, 2011, p.160).*

It may be argued that Ghanaian mathematics teachers use teacher-centered teaching techniques because of their desire to maintain autocratic control over their classrooms rather than to shield their English language limitations or those of their students. However the first author makes the following reflection:

> *It may be true that some teachers desire autocratic control of their classrooms. But why is it that all these autocratic teachers always ask their students the following question at the end of math lessons: Do you understand? Normally, when this question is asked the students are silent and looked at the teacher or each other. The students may have questions, suggestions or comments to make but they lack the English proficiency to do so. There are some teachers who will not ask such a broad question like "Do you understand?" Instead, they will ask specific questions like these to encourage discussion or discourse: Explain how we got to this part of the solution or how did we obtained this answer? What is the difference between the previous mathematical question and this one (pointing to the chalkboard)? Yet students still sit down and say nothing! Why? I believe there would be lots of responses if the students were to ask those questions in their home language... Some teachers used more aggressive method by calling on individual students- to answer specific math questions as a means of encouraging participation.*

The above reflection is in line with Brock and Alidou's (2011) review of the literature on general student participation in classrooms across Africa. They note that generally student lack of proficiency in the LOLT precludes them from effective participation in classroom discourses which certainly includes the mathematics classrooms. According to these researchers, rather African teachers view this lack of proficiency as an indication of laziness, stupidity and uncooperative attitude on the part of the students. They add that this teacher attitude stifles student motivation to participate in classroom discourses, especially girl-students who are normally shy and easily hurt emotionally with words. The second author notes that:

[7] The Malaysian government has reversed the policy that required teachers to teach science and technology exclusively through English.

When students are put on the spot to answer mathematics questions in English and are derided as dumb or shouted at for not able to do so, it psychologically discourages them from mathematics learning; they begin to have fears for mathematics learning. They begin to doubt their ability to do mathematics. The consequences are much worse when the teacher metes out corporal punishment to students who refuse to participate in classroom discourses or give wrong responses. Such draconian measures used to force students to participate in classroom discourses through English have bad consequences for mathematics education in Ghana. It has attracted only a few disciples for the discipline of mathematics, so to speak... These student-victims are invariably part of those who habitually skip math classes or fail mathematics courses... The situation would be totally different if students were invited to participate in mathematics classroom discourses in their indigenous languages.

Students in those situations are less likely to develop any positive mathematical identities which are shaped by factors such as culture, learning preferences and experiences with mathematics learning (Berry, 2003 Martin, 2007).

A majority of students in basic schools in Ghana do not develop a positive attitude toward mathematics due in part to their negative experiences with mathematics learning in basic schools. As Awanta (2009) indicates students in basic schools show remarkable interest in how mathematical formulas came about rather than how to use them to solve problems. However, who will help to illustrate or explain that to them? Awanta (2009) goes on to say that students in Ghanaian basic schools particularly junior high school (JHS) demonstrate interest in mathematics but such interest drops substantially as they enter senior secondary school (SHS). In fact, the development of a positive mathematical identity, one of the strands of mathematical proficiency, is important for students to sustain their interest in mathematics education through grade school to tertiary educational institutions.

It is possible that teacher conceptions of the nature of mathematics are a motivational force for maintaining or adopting teacher-centred pedagogy. A sterling example is a conception of mathematics as a fixed and sequential body of knowledge that is learnt by rote, algorithmic or repetitive procedures (Wilcox et al, 1992). The other example is mathematics as a body of absolute truths which exist separate from the learner or as a toolkit of rules, formulas and procedures that are used to attain specific purposes (Mayers, 1994). We wonder if these conceptions of mathematics will influence a teacher to ask students questions or prevent students from asking questions. It is probably true that if students are not getting what they perceived as satisfactory responses to their questions, they will not be encouraged to ask questions in the mathematics classroom.

From our perspectives, most Ghanaian basic school teachers adopt the traditional, teacher-centred teaching methods as a cover up for their own lack of proficiency in the English language rather than their subject-matter knowledge. Mereku (2003)'s research demonstrates that 83% of Ghanaian primary school teachers surveyed admitted that they never gave meaningful answers to their students' questions in the mathematics classroom and about 79% of them used teaching methods that do not promote discussion. More recently, a majority of students in basic schools (junior secondary) reported that their mathematics teachers used teacher-centered strategies that promoted passivity on their part (Ampadu, 2012). Certainly, the teacher-centered pedagogy includes safe-talk as Alidou and Brock-Utne, (2011) have identified - structuring mathematics teaching in such a way that it leaves no room for discussion, debate or questions. It also includes dictating notes to the students to write and copying volumes of notes from the chalkboard, even where the students have access to approved textbooks. Why would teachers promote discussion in the mathematics classroom when they, like their students, struggle with the English language (Brock-Utne, 2005)? Naroth (2010) states that observations of teachers in South Africa revealed that, they limit discussion in the mathematics classroom due to student English language limitations. Therefore, both teacher and student lack of English proficiency negatively affects the development of the students' mathematics proficiency.

Nevertheless, based on Brock-Utne and Alidou's (2011) review of the literature teachers allow more discussion and are more confident in their teaching abilities when they use familiar or home language of the students as a LOLT. On the part of the students, when the LOLT is their home language they are more active, confident and comfortable participating in classroom discourses and other learning activities as the second author stated in his reflection. Moschkovich (2002) makes similar observations with Spanish speakers in the United States. That is why we are arguing that using English language as the LOLT in basic schools in Ghana hinders the students' development of mathematical proficiency. Both teacher and student need to use a language they are comfortable with, so that they can express their thoughts, feelings, and cultural elements in the mathematics classroom without difficulty, fear, shame or humiliation.

Student Culture and Mathematics Learning

In the previous subsections, we argued that the development of basic school students' mathematical proficiency requires that the LOLT should be their home language. The use of student s' home language has a higher probability of opening up opportunities for incorporating elements of their community mathematics culture[8] into school mathematics. Such incorporation is extremely important for developing

[8] We used student mathematics culture synonymously with community mathematics culture.

basic school students' mathematical proficiency. The first author offers the following insight:

> *Infusing the mathematics classroom with students' mathematics culture has the purpose of eliminating the gap between students' home mathematics practices and those of the school. Home mathematics practices use different procedures, rules; they are unwritten, and do not use any written symbols. But incorporating them into the classroom practice could help students to make a smooth transition into school mathematics and develop positive attitude toward mathematics... In fact students immediately realize that mathematics is part of their culture rather than being separate from it and that one does not need the brains of an elephant, so to say, to engage in it and enjoy it.*

This quote is consistent with that of Polya (1962), a passionate advocate of problem-solving pedagogy, who stated that students should cognitively and emotionally own the problems they are asked to solve before they would have the desire to solve them. As Wilson (1992) observes a good deal of the education of African children and adolescents occurs "around the village, in the market place, among peers, and while watching adults perform traditional tasks or hunt or make music or exercise skills in one of African's many crafts. Models of schooling in much of the (African) continent derived from the West, and came as a package complete with Western style curricula, books, examination and often Western language" (p.126). Therefore, mathematical concepts and problem-solving activities should be related to those sources where Ghanaian children and adolescents receive their primary socialization experiences. But this is difficult to occur smoothly unless basic school's LOLT is a Ghanaian language.

Researchers agree that the socio-cultural environment in which children and adolescents are parented and socialized into the world have influences on their development of pre-school number concepts, geometric patterns and problem-solving strategies (Allardice and Ginsberg, 1982; Charbonneau and John-Steiner, 1988). Students bring these understandings and meanings of mathematical concepts, measurement and procedures into the mathematics classrooms and use them to conceptualize mathematics they are taught (Abreu et al 2002; Fleer and Robins, 2005).These mathematical understandings and meanings should be utilized and made the starting point of mathematics education in basic schools (Wilson, 1992; Gerdes, 2008). Second, the incorporation of student mathematics culture into the school mathematics classroom would facilitate the smooth transfer of knowledge acquired in the classroom to problem-solving in different situations in the student community. We view as a travesty of mathematics education that begins inside the classroom and ends at the door of the classroom when the students leave for their homes or communities.

Further, we believe that incorporating students' mathematics culture into mathematics education would help them to make sense of the mathematics they learn at basic school, especially in their early formation of mathematical concepts (Okpoti, 2001).Sense-making in this case has to do with developing understanding of mathematical concepts, principles or procedures by connecting them to existing knowledge or previous experiences. Students make sense of mathematical concepts and procedures by constructing their own meanings through a combination of personal experiences and cultural traditions (Pirie 1998). Furthermore, children and adolescents are most likely to participate actively in mathematics activities and discourses familiar to them and this would facilitate their development of mathematical proficiency.

Invariably, when basic school students in Ghana learn and are taught mathematics through English their mathematics culture is ignored and this severely affects the development of their mathematical proficiency. The students only learn the colonial language of English without learning the culture that goes with that language. The full participation in any culture includes its language and the culture the language represents (Gollnick and Chinn, 2006).It is almost impossible for students in Ghana to participate in an English culture in any form. This is why Ghanaian language should be used as the LOLT, so that students could relate what they learn to their cultural experiences, apply it to their lives and make what they learn part of their life-world. From our reflections, student mathematics culture in Ghana consists of how the larger society conceptualizes quantity, measurement, design, navigation, and rationalization in various activities (Bishop, 2004).

The practices of student mathematics culture are significant for mathematical education research in Ghana. As Zevenbergen, (2008) states in reference to Australian Aboriginal peoples, "It would help to identify the mathematics in cultural activities in order to provide legitimation of those activities, so as to illustrate that indigenous people are capable of undertaking the mathematics of school activities",(p.510). While we are not sure of the mathematical or quantitative methods used in all the activities in student mathematical culture listed above, we are very sure that some of them such as subtracting without regrouping, counting in blocks; adding and multiplying using doubling and halving; measuring quantities using metal, plastic and gourd containers could be used to develop many cognitively intriguing but mathematically challenging activities for basic school students.

As well, embedding mathematics teaching and learning in the rich geometric cultural practices of student communities such as basket, mat, cloth and hat weaving have been noted as a means of galvanizing student interest, enthusiasm and self-confidence in mathematics learning (Gerdes, 2008). Ghanaian society, like their counterparts in other parts of Africa, has developed sophisticated geometric concepts which should be part of the mathematics curriculum and of the teaching practices in basic schools (Gerdes, 2003). But this is only possible if such geometric sources are made integral part of the mathematics curriculum and instruction in basic school.

Conclusion

In this paper, our primary objective is to answer this question: How does the learning of mathematics in English at the basic school in Ghana help or hinder students' development of mathematical proficiency? The primary data for this research was derived from our professional reflections and narratives. Using Ghanaian basic school students as our case study, we found that learning mathematics through English language may hinder the development of mathematics proficiency of these students. These students encounter tremendous difficulties expressing their thoughts on mathematics concepts through English; engaging in mathematical problem-solving; participating in discourses in the mathematics classroom. Additionally, they are unable to bring their home or community mathematics practices and ideas into the classroom.

Based on our analysis, we offer the following recommendations as the anchors for developing and improving the mathematics proficiency of students in basic school:

(1) The Ghanaian Ministry of Education, along with the universities and community leaders should develop mathematics registers for the major Ghanaian languages. Mathematics register refers to mathematical uses of a language, including equivalent mathematics words, phrases and concepts and their meaning in those languages. Developing mathematics register is not exclusively an elitist project for mathematics educators, scholars and researchers. It is a collaborative project between these professionals and the leaders of the communities that speak the language for which the register is being developed. Since those major Ghanaian languages have written forms (utilizing the Roman orthography) developing mathematics registers for them should not be a complex project.

(2) The teaching, learning and assessment of mathematics at basic school should be conducted in the primary language of the students. This would enable students to develop mathematics confidence and problem-solving skills. However, the students should continue to learn English as a subject in the curriculum.

(3) Mathematics teaching, learning and assessment should be linked to and connected to the student life-world and their communities.

(4) Mathematics teachers should encourage and allow students to bring into the mathematics classroom cultural artifacts, tools, games and practices to demonstrate their inherent mathematical operations, patterns, relationships, logic and problem-solving.

The research has provided many broad, critical ideas for future mathematics education research projects in post-colonial societies. For instance, future research could focus on studying the comparative effectiveness of teachers using an indigenous language to teach mathematics in one setting, and using the English language to teach mathematics in another setting. Future research could also include the voices of students in basic school, those of their parents and community leaders. Similarly, a future research project could be initiated to study the issue of developing and using mathematical registers in indigenous languages.

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