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Mathematics Classroom Discourse in typical Ghanaian Public School: How does it look like?

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Abstract

This paper reports on a study which investigated the nature of classroom interaction and how that affects the way pupils learn mathematical concepts meaningfully. Observation of mathematics lessons of three primary six teachers from one District in Southern Ghana were recorded. This was followed by analysis of the rationale, general aims and objectives of teaching mathematics and the general teaching approach suggested in the preamble of the mathematics curriculum. The data collected were analysed qualitatively and presented as narrative description with illustrative examples. The results from the study revealed amongst others that the traditional school mathematics microculture constituted the dominant public discourse in the three lessons observed. Discussion of the findings and implication for mathematics curriculum development and delivery, and future research are provided.

Key words: classroom interaction; public discourse; mathematics; primary school; meaning-making.

Introduction

The government of Ghana recognises the role of Science, Mathematics and Technology in the attainment of the developmental agenda of the nation and has therefore identified the development of Science, Mathematics and Technology as one of the pillars for national development (MOEYS, 2004). Several interventions have therefore been put in place by the Ministry of Education to support the development of mathematics and science education in Ghana. One of such interventions was the designation of initially ten (but now eighteen) out of the then thirty-eight public Colleges of Education as

Mathematics and Science Colleges in 2008 to train teachers to teach Mathematics and Science, especially at the junior high school level. Despite these interventions, pupils' performance in Mathematics and Science in Ghana has not been as good as envisaged. At the primary school level, a study conducted to test pupils' level of numeracy showed that many of the pupils had low attainment levels (MoE, 2014). At the junior high school level the situation is not different. Pupils' performance in Mathematics at the junior high school level both locally and internationally has not been high. Ghanaian pupils' performance has always been rated low among the participating countries in TIMSS (see Mullis, Martin, Foy & Arora, 2012, for example).

Some research studies have investigated why pupils in the sub-Saharan African countries, such as Ghana, struggle with mathematics by looking at the teaching practices of beginning teachers and pre-service teachers in English and Mathematics (see Akyeampong, Lussier, Pryor, & Westbrook, 2013, for example). Some of these studies have often questioned the system of teacher preparation and argued that the system is not preparing teachers well enough to teach subjects such as mathematics to pupils (Akyeampong, Lussier, Pryor & Westbrook, 2013). Akyeampong et al (2013), for example, observed that initial teacher training did not equip both beginning teachers (Newly Qualified Teachers or NQTs) and pre-service teachers in Ghana to conceptualise teaching as problem-solving. It did not also help them to draw on the socio-cultural background of the learners to scaffold their learning to make the teaching of mathematics relevant. Others have questioned the Mathematics curriculum, and have described it as being outmoded (Anamuah-Mensah & Mereku, 2005). However, building on the work started by Akyeampong et al (2013), this study sought to contribute to literature on why mathematics is difficult for pupils. This was achieved by exploring how classroom interactions of experienced teachers help pupils to learn mathematics meaningfully, by drawing on Cobb and Bauersfeld (1985) conceptualisation of types of school classroom microcultures and relationship between social processes and psychological development of the learner. Experienced teachers in this context refers to teachers who have taught for more than ten years. In this study, I conceptualised classroom interaction as involving the social and sociomathematical norms of the classroom; here I am looking at explaining and justifying solutions, rationalising others' explanations, agreeing or disagreeing with others' ideas among others, both in general and specific to mathematical activities (Guven & Dede, 2017).

Explaining and justisfying solutions require a sound mastery of language of instruction. Durkin (1991), for example, argues that "Mathematics education begins and proceeds in language, it advances and stumbles because of language, and its outcomes are often assessed in language"(p.3). This quotation shows that mastery of the language of instruction by both the teacher and pupils is key to the quality of the classroom discourse and hence meaning making in mathematics. In classroom contexts where pupils or their teachers or both have limited mastery of the language of instruction, detailed explanation and justification of concepts by teachers or pupils or both is likely to be limited and this has the tendency to affect meaning making in mathematics.

The nature of the classroom interaction characterizes the public discourse in the classroom and hence the classroom microculture (Cobb & Bauersfeld, 1995) and learning outcomes in mathematics. A growing body of literature has shown that the quality of classroom interaction affects the quality of learning outcomes in mathematics in school (Guven & Dede, 2017; Bruce, 2007; Hiroshi & Heinz, n.d.; Pape, Bell & Yetkin, 2003; Cobb & Bauersfeld, 1995). Cobb and Bauersfeld (1995), for example, argue that "Mathematical meanings are considered to be products of interaction processes and to be specific to the microculture studied." (p. 166). Their argument is that mathematical meaning arises and gets stabilized in the process of classroom interaction. This shows that the process of classroom interaction is key to the development of mathematical meaning.

In this paper, therefore, the nature of classroom interaction is positioned as being a strong predictor of students' learning outcomes in mathematics. Looking at the study from the perspective of the dynamics of classroom interactions that produce mathematical meaning in the classroom of experienced teachers provides the opportunity to understand the nature of classroom interaction of typical experienced Ghanaian mathematics teachers who have taught for over ten years and benefited from some in-service training programmes after their initial teacher training. This provides the opportunity for reflections on how their classroom interactions compare with those of the newly qualified teachers reported in previous studies in the same context (Akyeampong et al, 2013).

Some studies have looked at classroom microcultures, focusing on the social and sociomathematical norms and their effect on sense making in mathematics and justification, at the secondary school level, using qualitative approaches (see Goose, 2004, for example). Others have employed quantitative approaches to look at the effects of inquiry based versus traditional mathematics approaches on students' understanding and comprehension at the secondary school level (see Ferguson, 2010, for example). Some studies have also investigated classroom microcultures, focusing on the social and sociomathematical norms of prospective mathematics teachers, using qualitative approaches (see Guven & Dede, 2017, for example). Other researchers have also looked at the effect of class size on classroom engagement and teacher-pupil interaction (see Blatchford, Bassette & Brown, 2011, for example). Blatchford, et al. (2011), for example, found from their study involving primary and secondary school students that class size had effect on the quality of classroom interaction and individual attention primary school children received from their teachers. Many of these studies were conducted in developed countries. However, not many of the studies have looked at the situation at the primary school level, and also in developing countries that do not perform well in international comparative assessment such as Trends in International Mathematics and Science Studies (TIMSS). Looking at the situation at the primary school level and in developing countries that are not doing well in TIMSS provides understanding of the picture across a spectrum of contexts.

Theoretical Framework

Cobb and Bauersfeld's (1995) analysis of types of school classroom microcultures provided the theoretical support for this study. Specifically, their distinction between two types of public discourse in the classroom and the general theoretical positions on the relationship between social processes and psychological development of the learner, provided the author with a theoretical perspective to study the nature of classroom interaction. These theoretical perspectives were important because the study sought to investigate the nature of classroom interaction and how that contributes to pupils' opportunity to make meaning from mathematics instruction in the classroom.

Regarding the distinction between their two types of public discourse in the classroom, Cobb and Bauersfeld (1995) identified two types of mathematics classroom settings based on the type of public discourse that normally takes place in the classroom. These are traditional school mathematics and inquiry mathematics microcultures. According to Cobb and Bauersfeld (1995), the public discourse in traditional school mathematics positions explanation as involving specifying instructions for manipulating symbols. Thus, in the tradtitonal classroom environment, mathematical knowledge is presented as a pre-packaged system of knowledge in which rules and procedures must be remembered and followed in order to be successful. The public discourse in an inquiry mathematics classroom, on the other hand, entails classroom interaction where "teachers and students appear to act as Platonists who are communicating about a mathematical reality that they experience as objective" (p.3). In the inquiry classroom, therefore, mathematical knowledg is presented as knowledge which can be discovered through social interaction in the classroom. These two types of school classroom microcultures in the author's view have implications for the opportunity of students to learn school mathematics, in the sense that the former is likely to promote acquisition of only procedural knowledge. The latter, however, has the tendency to afford pupils the opportunity to develop conceptual understanding of concepts since communication about mathematical reality will provide them the opportunity to make sense of mathematics.

Related to the school classroom microcultures is the relationship between social processes and psychological development of the learner. Cobb and Bauersfeld (1995) identified two general theoretical positions on the relationship as collectivism and individualism. They argue that "the collectivist position is exemplified by the Vygotskian tradition and in the sociolinguistic tradition" (p. 3). The Vygotskian perspective positions learning as being socially constructed through participation of the learner in the sociocultural practices (Vygotsky, 1978). This highlights the importance of co-participation of the learner in the process of development of conceptual concepts in the classroom. Here co-participation involves active participation of the learner in discovering mathematical truths but not mere response to teachers' questions as and when students are invited to do so. Cobb and Bauersfeld (Op cit) further explain that "the sociolinguistic perspective also characterises mathematics learning as an initiation into the social tradition of doing mathematics in school" (p.3). On the other hand, the individualistic theories "treat mathematical learning almost exclusively as a process of active individual construction" (p.3). Here, classroom interaction is expected to provide the individual learner the opportunity to attain growth in mathematical knowledge and experience, based on his or her ability, through personal and active construction of mathematical knowledge and understandings.

These two theoretical positions also have implications for the kind of classroom interaction and the opportunity for pupils to learn mathematics meaningfully. In the author's view, both attention on the group, that is, collectivism and the individual, that is, individualism are very important in mathematics teaching and learning. Attention could be on a group at one point in the classroom discourse, but may have to shift from the group to the individual at another point if the individual is being left behind or the individual needs to be given the opportunity to move at his/her own pace. These perspectives provided the lens to study typical classroom interactions in Ghanaian schools and suggest ways of improving instruction in mathematics in Ghana and other sub-Saharan African countries that share a similar situation to that in Ghana.

The Purpose of the Study and Research Questions

The purpose of this study was to contribute to the understanding of why Ghanaian public school pupils find mathematics difficult by exploring the nature of classroom interaction of teachers to ascertain how they promote meaning making in mathematics. This was done by inferring students' difficulties in learning and lack of meaning based on the examination of the opportunities to learn through lesson observations. The questions that guided the study were:

1. Which type of classroom microculture (traditional school mathematics or inquiry mathematics) does mathematics classroom interaction of experienced mathematics teachers in a typical Ghanaian primary school reflect?
2. How does the classroom microculture of the experienced teachers help pupils to learn mathematics meaningfully?

3. How does the teaching of mathematics by experienced mathematics teachers reflect the everyday context experienced by pupils?
4. How does the classroom microculture in typical Ghanaian primary mathematics classroom of experienced teachers reflect the rationale for teaching mathematics and the suggested approaches to teaching mathematics in the Ghanaian primary school mathematics curriculum?

Method

In addressing the research questions, a qualitative exploratory method involving the use of observations and document review (Creswell, 2012) was adopted to explore the nature of classroom interactions and how they affect pupils' opportunity to learn mathematics. One hundred and one primary six pupils and their teachers from three public primary schools, one each from below-average, average and above-average achieving schools from one District in Southern Ghana participated in the study. The average teaching experience of the teacher was 21years with the minimum being 13years and the maximum being 34years.The list of primary schools in the District based on their achievement levels were collected from the District Education Office, since basic schools in Ghana are usually categorised based on their achievement in the national examinations as above-average, average and below-average achieving schools. Treating each of the achievement levels as the strata, the stratified random sampling procedure was used. The simple random sampling procedure was used to select one school each from the list of below-average, average and above-average performing schools. In each of the selected schools, all primary six pupils were purposely selected. The number of pupils from the above-average, average and below-average schools were 33, 43 and 25, respectively. Primary six pupils were considered because it constitutes the end of primary education and transition between primary and junior secondary school in Ghana. In addition, primary six pupils have used English as the medium of instruction for three years, so as compared to pupils below primary six, they were more likely to express their ideas in simple English in the classroom interactions. The use of below-average, average and above-average achieving schools provided the opportunity for the researcher to investigate the issue across contexts of schools.

One mathematics lesson was observed from each of the teachers in the schools. The topic that was treated in the lesson at the above-average achieving school was "Multiplication of whole numbers by a fraction", the topic treated at the average-achieving school was "Arranging combination of fractions in ascending order", while "Division of fractions" was treated in the below-average achieving school. In order to ensure that the study did not interfere with the topics teachers had planned to teach for the term in each of the schools, the author requested teachers to choose topics based on their scheme of work for the term. The lesson observation was followed by review of the rationale, general aims, general objectives, scope of the syllabus, approaches to teaching and learning mathematics in the 2012 Ghanaian primary school mathematics curriculum. The observation schedule was developed by the author and validated in a pilot school outside the research locale to ensure that they elicited valid response. The observation schedule was structured according to the theoretical framework, they focused mainly on the type of classroom microcultures and the relationship between social processes in the classroom and psychological development of the learner. The data collection was done by the author with the support of two trained research assistants, who were also experienced teacher educators in October, 2017. Each of the lessons was video taped, whilst field notes were also taken during the lesson observation. The three observed the lesson after which their observations were synchronised.

Permission was sought from the District Education office and the participating schools before the study was carried out. The research project was explained to the research participants. Consent of teachers was sought. While assent of pupils was also sought before the commencement of the study. The research participants were assured of anonymity and confidentiality. They were informed that pseudonyms/codes will be used to identify the schools and the research participants in the presentation of results so nobody will know what they said. Informed by the theoretical framework, the data obtained were analysed qualitatively and presented as narrative description with some illustrative examples. The distinction between two types of public discourse in the mathematics classroom and the general theoretical positions on the relationship between social processes and psychological development of the learner, provided the theoretical support for this study (as already noted in the theoretical framework). The analysis of the data therefore covered the nature of classroom interaction, how the teaching of mathematics reflects the context of pupils and the effect of classroom interaction on pupils' opportunity to learn mathematics meaningfully. Pupils who participated from the below-average schools were coded PL1, PL2, ... PLn. Pupils who participated in the average school were coded as PA1, PA2, ... PAn and those from above-average schools were coded PAB1, PAB2, ...PABn. The teacher from the below average achieving school was coded TB, while the teachers from average and above-average achieving schools were coded TA and TAB, respectively.

Results

In this paper, classroom interaction has been positioned as an important factor in mathematical meaning-making in mathematics classroom. The study sought to explore why mathematics is difficult for Ghanaian school children by investigating the dominant public discourse in the classrooms of experienced primary school teachers to ascertain how that helps pupils to learn mathematics meaningfully. As already noted in the purpose of the study, students' difficulties in learning and lack of meaningful learning was inferred through classroom interactions during lesson observations. Learning difficulties and meaning-making in mathematics by students was therefore not measured directly from the students. In this section, the results of the analysis of data on the nature of classroom interaction is presented. Analysis of the rationale, general aims and strategies for teaching and learning mathematics in the preamble of the primary school mathematics curriculum is also presented to afford discussions on the relationship between the classroom microculture identified through lesson observation, and those espoused by the primary school mathematics curriculum.

Nature of classroom interaction

Teaching Approach

The observation of the lesson of the two teachers brought to light that classroom interactions were mainly in English Language and vertical in the form of teacher posing questions and pupils responding to the teachers' question as shown in the excerpt of the lesson taught by the teacher in the above-average achieving school (TAB) below:

TAB: Today we are going to look at multiplication of a whole number by a fraction. By the end of the lesson I want you to be able to multiply whole numbers by fractions.

TAB: Let's look at six times one-eighth.

TAB: [Writes] $6 \times \frac{1}{8}$

TAB: It means one-eight six times. One eight repeated ... or one-eight added six times

TAB: This procedure we are using is multiplication as repeated addition. So you will repeat one-eight six times.

TAB: So we have one, two, three, four, five, six. [writes] $\frac{1}{8}+\frac{1}{8}+\frac{1}{8}+\frac{1}{8}+\frac{1}{8}+\frac{1}{8}$.

TAB: Can you see that?

Pupils: Yes, madam [in chorus].

TAB: If you have fractions and they have the same denominator, you just add what?

Pupils: Numerator [in chorus].

TAB: Let's add the numerators

TAB: What is the answer, PAB20?

PAB 20: Six

TAB: Six out of what?

PAB 20: Eight.

TAB: Clap for him.

TAB: Let's look at another example...

It is evident from the interaction that pupil PAB, who was invited to contribute to the lesson just responded to the teacher's questions without explaining his answer. The teacher was interested in predetermined answers from the pupil. Again, pupils hardly posed questions to the teacher neither did they pose questions to their colleagues. The teacher's aim was to help the pupils to master rules and procedures. Issues relating to monologist nature of the classroom interaction will be discussed further at the final section of the paper as part of the overall discussion. These observations were not limited to only the above-average school. It was a common trend in all the three school types.

The sequence of lesson presentation was review of previous lesson, introduction of topic for the day and lesson delivery using the whole class approach. Exposure of pupils to formulae and how to use them appeared to be the main aim of the teachers in all lessons. The excerpts from the lesson from the below-average achieving school support these and some of the observations made earlier:

TB: [Writes division of fractions on the chalkboard]
TB: What did we learn in our previous lesson?
PB13: Dividing whole numbers ...
TB: Dividing whole numbers by what?
PB18: Dividing whole numbers by fractions
TB: So we looked at dividing whole number by fractions in our last lesson. In today's lesson we will look at dividing fractions by fractions.
TB: When we look at dividing fractions by fractions, we will get to a stage where we are going to use something called BODMASS. So let's look at dividing fractions by fractions.
TB: Let's start with an example [writes] $\frac{1}{2} \div \frac{1}{4}$
TB: If you recall, we did multiplication of fractions
Pupils: Yes sir [in chorus]
TB: Since we are dividing you change the sign to multiplication and turn one over four up side down. [writes] $\frac{1}{2} \times \frac{4}{1}$.
TB: Are you following?
Pupils: Yes sir [in chorus]
TB: After getting something like this [points at $\frac{1}{2} \times \frac{4}{1}$] what you can do is you can cancel two and four. So if the number cannot cancel each other, then you have to multiply the numerator by the numerator and the denominator by denominator.
TB: Okay how do we solve $\frac{1}{2} \times \frac{4}{1}$?
PB23: [puts up the hand]
TB: Yes, PB 23
PB23: One cannot cancel itself. When it cancels it will be the same. So you leave it as it is, and two can cancel itself one and go into four two times.
TB: What is next?
P23: You multiply and get two
TB: It is not necessary to say two over one. You do not have to say any number over one. Just mention the number. It is wrong, okay?
Pupils: Yes sir [in chorus]
TB: Let's take another example ...

Apart from the classroom interaction being vertical with the teacher always posing questions for the pupils to answer, the teacher did not give pupils the opportunity to discuss pupils' answers in detail to create a shared meaning of what they were learning. As with the lesson in the above-average school, the teacher appeared to be interested in predetermined answers. Very little attention was paid to students' understanding of concepts in the teaching and learning process. For example, pupils PB23's assertion that "one cannot cancel itself. When it cancels it will be the same. So you leave it as it is" was a misconception which the teacher should have dealt with but this was left unaddressed. Indeed, one divided by one is one so one cancel's itself once (using the student and the teacher's terminology for division).

At the average school where the teacher began engaging students in discussion about the topic the class was going to learn for the day and how that relates to previous topics done in primary four and primary five, the classroom interaction quickly turned into rules for solving mathematical tasks relating to the topic as shown in the excepts below:

TA: We talked about fractions and said it is a part of a whole. In arranging numbers we can do it in two ways, either in ascending order or descending order.

TA: When we say ascending order, who can tell me what it means?

PA25: Arranging something ....

PA1: Arranging something from the smallest to the other.

PA31: From the smallest to the biggest.

TA: Do you hear what she is saying?

Pupils: Yes madam [in chorus].

TA: I know you did it [ascending order of arrangement] in primary 4 and 5, so when they give you numbers and they ask you to arrange in ascending order, it means just arrange from the smallest to the biggest. Today, we are going to look at how to arrange fractions in ascending order, okay!

Pupils: Yes madam.

TA: Let's look at this example [writes] $\frac{1}{3}, \frac{1}{4}, \frac{1}{2}$ on the green board.

TA: How do you pronounce this [point at $\frac{1}{3}$ and asks PA38 to answer]

PA38: One out of three.

TA: Clap for her. It is not one over three but one out of three.

TA: We are going to arrange one out of three, one out of four and one out two in ascending order.

TA: When we look at it we can't tell which one is the smallest .... , unless you work it out. For us to be able to find out which one is the smallest we have to find the LCM [least common multiple] of the down numbers [denominators]..

It appears the main task was for children to remember rules and just apply them. The classroom interactions therefore focused on the realisation of this agenda. These issues will be discussed further in the final section of the paper as part of the overall discussion.

In each of the three lessons observed, classroom interactions was reduced to teachers posing questions occasionally and pupils responding to the teacher's question using short phrases. Pupils hardly asked questions and there was very limited explaining and justifications of response by pupils. Also, teachers hardly asked high order questions that required in-depth explanation of mathematical facts and justification of answers. This could be due to pupils' poor mastery of the English language, the language each of the teachers used in teaching each of their lessons. This issue will be revisited and discussed in detail in the discussion section.

How teaching of mathematics reflect the context of pupils

The use of contextual problems in the development of the topic was not evident in the classroom interactions in each of the contexts of schools. In teaching multiplication of whole numbers by fractions in the above-average achieving school, for example, teacher TAB worked two examples; $6\times\frac{1}{8}$ and $4\times\frac{1}{10}$, after which pupils were given these exercise $2\times\frac{3}{10}$, $4\times\frac{1}{12}$, $9\times\frac{2}{20}$, $6\times\frac{1}{15}$ and $7\times\frac{2}{5}$ to do in their exercise books. It is therefore evident that the topic was taught out of context. The mathematical concept that was taught had no link with reality such as comparing fractions of candy shared among pupils or real life problems involving comparing fractions of different crops in a mixed crop farm.

The results on the nature of the classroom interaction and how the teaching of mathematics helps pupils to relate mathematics to real life situation in the three school contexts have provided an insight to discuss the type of classroom microculture in typical Ghanaian public primary school mathematics classrooms and how that helps pupils to learn mathematics meaningfully.

Effect of classroom interaction on pupils' opportunity to learn mathematics meaningfully

The social process in the classroom, where the teacher who appears to know everything, and pupils who look up to the "all-knowing teacher", resulted in the situation where the social interaction produced very little effect on psychological development, both at the individual and group levels. This was evident in the unfulfilled promise of what pupils were told they were going to learn as a group in some instance; "when we look at dividing fractions by fractions, we will get to a stage where we are going to use something called BODMASS. So let's look at dividing fractions by fractions." (TB). Teacher TB in the below-average achieving school did not find space to create the opportunity for pupils to understand what the acronym BODMASS was neither did she use it to solve problems involving division of fractions. Lack of attention to pupils' contribution by the teacher and lack of collaboration among pupils denied some of the pupils the opportunity to attain psychological development at the individual level. For example, pupil PB23's assertion that "one cannot cancel itself. When it cancels it will be the same. So you leave it as it is" was an opportunity for pupil PB 23 to have obtained personal growth through the social process in the classroom. Others who had similar conception about one divided by one would have also understood. This issue will be discussed further in the discussion section.

The rationale for teaching mathematics and the suggested approaches to teaching mathematics in the Ghanaian primary school mathematics curriculum

The rationale, general aims, general objectives, scope of the syllabus, approaches to teaching and learning mathematics in the Ghanaian primary school mathematics curriculum is well documented and available online (see Ministry of Education, 2012). I will therefore not reinvent the wheel. In this section of the paper, I will provide just highlights of some of the main issues in the rationale for teaching and learning mathematics, and the suggested approaches to teaching and learning mathematics in the curriculum to enable me provide an analysis of the kind of classroom microculture, the social process and psychological development the curriculum envisages.

The rationale and the general aims of teaching and learning mathematics at the primary school suggest that mathematical training should empower the primary school pupils with mathematical thinking ability, problem solving skills, ability to communicate and good attitudes towards mathematics (MoE, 2012, pp.iv-v). For example, the rationale for teaching and learning mathematics at the primary level states that:

> The learning of mathematics at all levels [in the primary school] involves more than just the basic acquisition of concepts and skills. It involves, more importantly, an understanding of the underlying mathematical thinking, general strategies of the problem-solving, communicating mathematically and inculcating positive attitudes towards an appreciation of mathematics as an important and powerful tool in everyday life. (MoE, 2012 p.iv).

To achieve the rationale and the general aims of teaching and learning mathematics at the primary school level, the curriculum suggests the use of problem solving approaches and highlights the use of open-ended and contextual problems in the development of concepts as shown in the excerpts from the curriculum below:

> Children learn mathematics most effectively through the application of concepts and skills in interesting and realistic contexts that are personally known to them. This means that mathematics is best taught by helping children to solve problems drawn from their own experience ... Children need to be given various opportunities to work on open-ended problems (MoE, 2012, pviii).

It is clear from the preamble of the 2012 primary mathematics curriculum that the classroom microculture envisaged in the rationale, general aims of teaching and learning mathematics and the suggested teaching strategies support the public discourse in an inquiry mathematics classroom. This is because if mathematical training is aimed to empower the primary school pupil with mathematical thinking ability, problem solving skills, ability to communicate and develop positive attitudes towards mathematics (MoE, 2012, pp.iv-v) and this is to be achieved through problem solving, then teachers and students have to act as Platonists in communicating about a mathematical reality

(Cobb & Bauersfeld, 1995). Mathematical knowledge cannot be presented as a pre-packaged set of rules to pupils to take without questioning as was seen in the excerpts from the three lessons observed but as knowledge that can be discovered through social interaction in the classroom. Emphasis on open-ended real life problems shows that the intention of the curriculum requires pupils to experience mathematics as a human activity which is open to proof by all, including pupils. The question is why are the actual classroom situations recorded through observations differ from what appears to be the intention of the curriculum? Discussions in the concluding section will shed light on it and provide suggestions for future research.

Discussion

The Type of Classroom Microculture

It is evident from the results of the study that explanation in each of the lessons observed in each of the three context of schools was positioned as mainly involving specifying instructions for manipulating symbols. This was evident in how each of the three teachers made the effort to ensure that the pupils followed rules for manipulating mathematical symbols without making sense of mathematics; "since we are dividing you change the sign to multiplication and turn one over four up side down" (TB), "... for us to be able to find out which one is the smallest we have to find out the LCM [Least Common Multiples] of the down numbers[denominators]" (TA). The public discourse that took place in all the classrooms reflected what Cobb and Bauersfeld (1995) termed "traditional school mathematics". This is because in each of the lessons explanation was reduced to provision of instructions for manipulating mathematical symbols.

The social processes in each of the three classroom contexts did not promote effective psychological development of the learners. While in each of the lessons some degree of pupils' involvement was observed, pupils' involvement was reduced to answering teachers' questions. They did not have the opportunity to question the approaches used by the teachers, neither did they get the opportunity to contribute their own ideas in the development of the topics. They did not have the opportunity to construct their own understanding of the concept being taught. Social interaction did not promote quality cognitive development because interactions in the classroom only equipped the pupils with procedures for manipulating symbols without understanding why the procedures work "since we are dividing you change the sign to multiplication and turn one over four up side down ..." (TB). In this case, the pupils were asked to change the operation sign from division to multiplication and multiply reciprocal of the divisor by the dividend to obtain their answer without creating the opportunity for them to understand why it works. This shows clearly that social interaction in the classroom did not promote co-construction of knowledge by the teacher and the pupils (Steele, 2001). This provided very limited opportunity for the development of mathematical thinking, problem solving skills, communication skills and attitudes. The collectivist position exemplified by the Vygotskian tradition and in the sociolinguistic tradition (Cobb & Bauersfeld, 1995), was not evident in each of the lessons.

Pupils did not have the opportunity to learn mathematics through real life problem solving, even though the topics afforded the use of such developmental approaches. For example, contextual problem involving comparing the sizes of portions of land a chief in a village shared among three clans could have been a meaningful context for teaching and learning arranging fractions in descending order. With such meaningful context and flexibility in language use by pupils in the classroom, experience and research have shown that Ghanaian school children contribute actively in discovering mathematical truth (Davis & Chaiklin, 2012).

Traditional school mathematics microculture and meaning-making in mathematics

This study investigated the public discourse in three school contexts, below-average, average and above average achieving schools, and the result has shown that the "traditional school mathematics" microculture constituted the dominant public discourse in each of the lessons observed across the context of schools. The findings from the study have provided insight to reflect on how the dominant public discourse affected meaning-making by pupils in the lessons observed. It is evident from the results of the study and ensuing discussion so far that the traditional school mathematics microculture does not give pupils the opportunity to learn mathematics meaningfully. It promotes rote learning. In this type of classroom environment, becoming successful in mathematics means listening attentively to the teacher, following the steps the teacher uses to solve the problem and memorising it. This can only help pupils to acquire procedural knowledge and therefore develop instrumental understanding of concepts rather than relational understanding (Skemp, 2006). Studies have shown that prescriptive instructional approaches such as the ones observed in this study do not equip students with the understanding of why mathematical processes work (Selling, 2016). On the other hand, studies have shown that inquiry mathematics classroom environment provides better learning outcomes in terms of students' achievement in mathematics than the traditional mathematics classroom environment (Furguson, 2010).

The finding shows that issues relating to quality of lesson delivery of Newly Qualified Teachers (NQTs) in primary mathematics classrooms in Ghana and some sub-Saharan African countries reported by Akyeampong, et al, (2013) may not be limited to Newly Qualified Teachers (NQTs) alone, but also to some experienced primary school teachers. It appears teaching to promote meaning making in mathematics through the use of developmental teaching approaches such as problem solving is absent in mathematics lessons of not only newly qualified teachers, but also in the classrooms of experienced teachers in different context of schools. Contrary to literature on the effect on class size on classroom interaction and individual attention primary school pupils receive from teachers (Blatchfort et al, 2011), in this study class size did not have effect on the quality of classroom interaction. The nature of classroom interaction in the below-average school, which had class size of 25 pupils was not different from the average achieving school, which had class size of 43.

Relationship between the classroom microculture in typical Ghanaian primary mathematics classrooms and those espoused in the general aims, rationale for teaching mathematics and the suggested approaches in the pre-amble of the Ghanaian primary school mathematics curriculum

The findings from this study have shown that gaps exist between the classroom public discourse envisaged by the primary school mathematics curriculum as spelt out in the preamble and the actual public discourse observed from the lessons from each of the teachers.

While the rationale for teaching mathematics, the general aims and suggested teaching approaches support inquiry mathematics classroom microculture, the actual classroom practices of teachers observed reflected the traditional school mathematics microculture. While the curriculum emphasize development of mathematical thinking ability, problem solving skills, ability to communicate and attitudes towards mathematics through the use of developmental approaches such as problem solving (MoE, 2012, pp.iv-v), teachers used approaches that promoted memorisation of rules in carrying out mathematical procedures.

There could be several reasons why what seems to be a gap between the intention of the curriculum and outcome of its implementation exist. However, three of them would be discussed based on research and experience. These are (1) linguistic problems, (2) mismatch between rationale for teaching mathematics, the general aims and suggested teaching approach in the pre-amble of the curriculum on the one hand, and the specific objectives for individual topics and the suggested teaching approaches for teaching such topics on the other hand, and (3) lack of short term demand driven training for teachers.

Durkin (1991) posits that "mathematics education begins in language, advances and stumbles because of language, ... assessed in language" (p. 3). This shows that language plays a major role in the nature and quality of classroom interaction. It is the means through which advanced modes of thoughts are communicated from one individual to others (Sutherland, 1992). The language of instruction therefore has the tendency to influence the type of public discourse in the classroom and hence the kind of classroom mathematics microculture. In a class where the pupils have good mastery of the language of instruction, pupils are likely to express their ideas freely without being concerned about any form of embarrassment through the wrong use of language. This enhances the quality of classroom interaction and pupils' opportunity to learn mathematics meaningfully. However, in public school classroom contexts like Ghana where many of the children can barely express themselves in the language of instruction and are also shy of expressing their ideas because of fear of being embarrassed when they make grammatical errors (Abenyega & Davis, 2015), they hardly contribute to class discussions. They hardly ask questions or share their views about the topic being discussed.

Usually, only the few who can express their ideas in the English language participate in the classroom interaction. This might have contributed to the vertical nature of classroom interaction, in which teachers dominated the lessons. The teachers do most of the talking and invite pupils to come in as and when they deem it necessary to do so. The pupils' mastery of English language might have therefore been one of the major factors that affected the nature of classroom interaction in each of the lessons observed. Promoting classroom microculture which reflects inquiry mathematics requires good mastery of language of instruction. This calls for flexibility in the language of instruction at the upper primary level if pupils are expected to actively engage in classroom interactions that promote critical thinking, problem solving, communication and attitudes. As already suggested in Davis (2011), the Ghanaian language should always be available as an additional resource. What is the point teaching a child in a language the child struggles to understand? It appears the language of instruction policy in Ghana should be looked at again critically to ascertain whether the system is not setting up pupils who have weak mastery of the English language to fail.

There appears to be mismatch between rationale for teaching mathematics, the general aims and suggested teaching approach in the preamble of the curriculum on the one hand, and the specific objectives for individual topics and the suggested teaching approaches for such topics on the other hand. The suggested approach to teaching the ordering of fractions in the same curriculum, for example, does not support the use of problem solving approaches which was mentioned in the preamble of the curriculum. The approaches do not draw on a single real-life problem to exemplify how comparison of fractions could be taught in context through problem solving. They reflect pretty much what the teacher followed in the lesson. This trend is not limited to only the mathematics curriculum, it reflects the presentation of the development of mathematical concepts in some of the popular textbooks. In teaching volume of cuboids in primary five, for example, one of the popular textbooks provides an activity involving measurements of lengths, widths and heights of given cuboids and finding the product in each case, after which the formula for finding the volume of a cuboid is provided. Some exercises are given, afterwards (Yeboah, 2011, p. 69). Such approaches equip pupils with only procedural knowledge without helping them to acquire conceptual understanding of procedures since the activity did not explain why children should measure the lengths, width and the heights and multiply them. The children have to follow the author's prescriptions unthinkably. Clearly, the teaching approaches used by the teachers reflected those suggested in many of the best-selling mathematics textbooks and suggested the approaches to teaching specific topics in the mathematics curriculum.

This shows that while the preamble of the curriculum suggests approaches that support inquiry mathematics classroom public discourse, the suggested approaches for teaching individual topics such as comparing fractions and approaches suggested in other curriculum materials such as textbooks reflect tractional mathematics classroom public discourse. This might have contributed to the predominance of the traditional mathematics classroom public discourse observed in the lessons. It is evident that the intention of the curriculum is excellent but the concrete approaches that would lead to the realisation of these intentions is what mathematics education researchers in Ghana and developed countries that are interested in international cooperation in education should engage with.

Akyeampong et al. (2013), attributed the poor quality of teaching of newly qualified teachers to the initial teacher training. However, this study has shown that it goes beyond that. Lack of demand driven short term professional development programmes for school teachers may also contribute to the predominance of the traditional mathematics classroom public discourse in the lessons observed. There are no structured systems in place to support the continuous professional development of teachers through short teachers training programmes aimed at updating the knowledge and skills of teachers, neither are there avenues for teachers who are struggling with any given mathematics content or an approach to teaching mathematics to obtain support from the Ghana Education Service. The majority of the in-service opportunities are upgrade programmes that lead to the award of degrees or diplomas. The question is how then does a teacher who is having difficulty with the teaching of a topic or applying a developmental teaching approach or managing a class get help without necessarily enrolling on an upgrade programmes? For example, experience and research have shown that Ghanaian teachers often have difficulty drawing on the local context in teaching mathematics (Davis, 2010; Davis & Seah, 2016). If teachers have difficulty drawing on the local context, then they are likely to teach out of context as was seen in the lessons observed. Naturally, such teaching approaches would not support inquiry mathematics classroom microculture but rather the traditional mathematics classroom microculture because they provide very little opportunity for mathematical thinking, problem solving, communication and development of positive attitudes.

Contrast between what happened in class and what a different approach might have looked like.

It was evident from the results of the observation of the three lessons that teachers from all the three school contexts employed approaches that gave pupils very little opportunity to make meaning of mathematics. The structure of their lessons were similar; review of what was learnt previously/declaration of the objective of the lesson for the day, development of lesson using the exposition method, with the teacher occasionally asking questions from pupils and evaluation of the lesson by giving pupils related task to do. Each of the classroom interactions was teacher-centred. There appears to be no difference in the quality of classroom discourse across the three school context, from the lesson observation. Further studies would be needed to provide insights into what might account for the differences in performance of pupils across the three school context.

In the view of the researcher, a teaching approach that draws on everyday practical experiences of pupils to scaffold their understanding of school concepts, together with flexible language of instruction might have produced some different results. In teaching comparing fractions in the average-achieving school, for example, the classroom discourse would have promoted meaning making if the teacher had connected the concepts to the everyday real life experience of children such as comparing one-fourth of an orange to one-eight and one-sixteenth of the same orange. This would have made the concept more visible to the the pupils than the use of LCM at that stage of the lesson. The classroom discourse might have been more dynamic than it was in the three lessons, if the teachers had adopted an approach that permitted pupils, especially those with limited English language proficiency to express their ideas freely in any language of their choice, that is, in either

English language or the local language. Experience and research with Ghanaian primary school children have shown that in the classroom context where pupils who struggle to express their ideas in the English Language are permitted to express their ideas freely in the local language, the quality of class discussion improves (Davis & Chaiklin, 2015).

Conclusion and Implication

The author positions classroom interactions as an important factor in meaning making in mathematics teaching and learning and contributes to the understanding of why Ghanaian public school pupils find mathematics difficult by exploring the nature of classroom interaction of three experienced teachers to ascertain how their classroom interactions promote meaning making in mathematics. The author concludes that the dominant public discourse in each of the lessons observed was the traditional school mathematics microculture (Cobb & Bauersfeld, 1995). This discourse type affected the quality of lessons observed. It reduced meaning making in mathematics teaching and learning to correct reproduction of mathematical facts by pupils. Gaps existed between public discourse envisaged in the preamble of the mathematics curriculum and the public discourse observed during lesson delivery. In other words, gaps existed between the intentions of the curriculum and what was observed in the actual classroom situation. While the rationale and general aims of teaching mathematics in the preamble of the syllabus projected inquiry mathematics classroom microculture, the actual classroom practices reflected traditional school mathematics microculture. The results have implications for teachers' professional development, curriculum development and delivery in mathematics and future research.

It was evident from this study that the approaches used by the teachers reflected what was in primary mathematics textbooks. This implies that, there is the need for Curriculum Research and Development Division (CRDD) of Ghana Ministry of Education to ensure that the content of the basic curriculum materials in mathematics such as textbooks support the attainment of the general aims and objectives of teaching mathematics in Ghana, which include development of mathematical thinking, problem-solving, communication and attitudes. The findings from this study also point to the need for the National Teaching Council to create opportunities for teachers who want to update their knowledge and skills without necessarily obtaining degree/diploma to be able to do so. The National Teaching Council could create National Centres of Teaching Support across the country, where teachers who need support in areas such as pedagogy, content or classroom management could go and get the needed support. These National Centres of Teaching Support could collaborate with the teacher education universities and Colleges of Education across the country to offer support to teachers who have challenge with any aspect of their professional practice. The recommendations relating to curriculum development and delivery, and teacher professional development, if implemented, may go a long way to improve meaning making in mathematics lessons in the public schools that were involved in this study and those that share similar characteristics with the schools that participated in the study.

Although the study involved observation of classroom practices of only three primary six teachers, one each from below-average, average and above-average achieving schools, the findings may point to what may be happening in the classrooms of other experienced teachers in Ghana and other sub-Saharan African countries that share a similar situation to that of Ghana. Examining the situation across many primary schools in different school contexts might give a better picture about the dominant mathematics classroom microculture in Ghanaian primary schools. Further research can therefore be conducted on a large scale to examine the nature of classroom interaction of experienced primary school mathematics teachers and how that affects the quality of learning outcomes in mathematics. Such a project may also consider observation of each teacher more than once since this self funded project lacked funds to carry out such a large scale data collection.

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