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Socio-cultural issues in mathematics: A missing variable in Ghanaian basic school mathematics teacher preparation

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Abstract

Sociocultural practices of pupils and their teachers have been positioned in literature as being asset for meaningful learning of concepts generally (Hedegaard & Chaiklin, 2005; Fleer & Robin, 2005) and mathematical concepts specifically (Presmeg, 2007). This paper draws on theories on the local aspect of mathematics, and teaching and learning to ascertain how the Ghanaian College of Education Mathematics curriculum deals with these aspects. The mathematics curricula at the colleges of Education in Ghana, the methods of teaching mathematics textbook and lessons from five experienced tutors of mathematics purposely selected from five Colleges of Education in Ghana constituted the main source of data. The documents were analysed qualitatively and presented as narrative description with illustrative examples. The study revealed among others that the College of Education Mathematics curriculum does not orient trainees to appreciate the local aspect of mathematics and mathematics pedagogy and recommends the need for curriculum developers to expose trainees to social and cultural issues in mathematics and mathematics pedagogy in order to make them better prepared as mathematics teachers.

Background to the study

Teaching and learning of mathematics has attracted the attention of not only mathematics education researchers in Ghana but also the government of Ghana. Ghanaian grade eight (JHS 2) pupils' abysmal performance in Trends in International Mathematics and Science study in 2003 (TIMSS) (MOEYS, 2004) examination called for the need to re-look at mathematics and science education at the Basic School level (Kindergarten to grade 12). In order to strengthen the teaching and learning of mathematics and science at the Basic School level, the Ministry of Education designated about a third of the thirty-eight public Colleges of Education in Ghana as science and mathematics colleges, with the aim of producing specialist mathematics and science teachers to handle mathematics and science at the Junior High School level. Ghanaian Mathematics education researchers have conducted research studies to throw more light on some of the difficulties pupils face learning mathematics by looking at how pupils experience some mathematical processes/concepts like counting (see Wilmot, 2008) and fractions (Amuah, 2003; Davis, Bishop & Seah, 2010). Others have also looked at issues relating to teaching and the teachers' knowledge in an attempt to understand why many Ghanaian school pupils especially in the public schools struggle with mathematics (Davis & Ampiah, 2008). However, no study has looked at the mathematics syllabus of the Colleges of Education, the approaches outlined in the methods of teaching mathematics textbook and the approaches tutors use in teaching some of the difficult concepts, for example, in order to ascertain how prospective teachers are prepared to draw on pupils' everyday mathematical practices and conceptions to scaffold their higher understanding of school mathematics. Meanwhile literature shows there is mathematical and scientific relevance of socio-cultural practices in Ghana such as games and toys (see Anamuah-Mensah, Anamuah-Mensah & Asabere-Ameyaw, 2009 for example).

Even though Laridon, Mosimege and Mogari (2005) have observed from their study in South Africa that teachers respond differently to ethnomathematical pedagogy, a growing body of literature points to the value of drawing on societal and cultural practices of students and teachers in teaching and learning (Hedegaard & Chaiklin, 2005; Fleer & Robbins 2005; Presmeg 1998). Presmeg (1998), for example, suggests that culture of both pupils and the teacher could be a useful tool in mathematics teaching and learning. Other researchers are also of the view that successful study of mathematics must take into account the many and varied experiences with which children come to school (Charbonneau & John-Steiner, 1988; Presmeg, 2007). For teachers to be able to draw on the many and varied mathematical experiences with which children come to school, training must equip them to be able to do that. Training must expose them to the varied mathematical experiences students bring with them into the learning situation and provide the prospective teacher the theoretical basis for using the varied mathematical experiences as asset in mathematics pedagogy.

Robitaille and Garden (1989) identified three levels of curriculum as the intended, implemented and the attained curriculum.

a) Intended curriculum – this constitutes what is expected to be covered in syllabus or course outline. This is what the experts decide as appropriate for the learner.
b) Implemented curriculum - this is what teachers are able to cover through the teaching and learning process. Often it is very difficult for teachers to cover the whole intended curriculum.
c) Attained curriculum - constitutes what the students learn from the implemented curriculum. This is often measured through the system

of examinations. In some contexts the examinations are administered by external bodies such as the West African Examinations Council (WAEC) and the Institute of Education in Ghana, in the cases of Senior High Schools and Colleges of Education respectively.

In this study, curriculum includes mainly what is planned in the syllabus and how this is implemented in textbooks and classrooms by mathematics tutors at the college of education level.

Three theoretical lenses were drawn upon to support the study. These were local aspects of mathematical knowledge, local aspects of pedagogy and school children's transition between contexts of mathematical practices. These theoretical perspectives were drawn upon to underpin the study because they provided the basis for analysis of how the curriculum of the Ghanaian pre-service mathematics teacher trainees exposes trainees to the local aspects of mathematics and mathematics pedagogy.

Literature points to the local aspects of mathematics. Ethnomathematics researchers have argued for a difference between mathematics encountered in the local culture/society and school mathematics (Bishop, 1988; D' Ambrosio, 1985). Bishop (1988) for instance argued for a difference between "m" mathematics (encountered in the local culture/society) and "M" Mathematics (the western/international mathematics). Bishop further described two types of mathematics education as being enculturation and acculturation. According to Bishop, mathematics education as an enculturation process has to do with inducting the child in practices which constitute part of the child's own culture, whereas acculturation has to do with the process of inducting the child in Mathematical practices which are alien to the child's culture.

Literature also points to the local aspects of pedagogy. Some researchers argue that knowledge construction goes beyond the innate factors of the individual learner such as maturation (Hedegaard & Chaiklin, 2005; Vygotsky, 1978). Vygotsky (1978) for example emphasizes the role of social interaction in the process of teaching and learning. In Mathematics particularly, researchers have shown that the out-of-school mathematics practiced in cultures usually lend support to pupils' learning outcomes in the study of formal mathematics in school (Draisma, 2006; Cherinda, 2002; Presmeg, 2007; Saxe, 1988). Mathematics education researchers have shown that processes children follow in acquiring mathematical knowledge or doing mathematics in their societies and culture such as finger counting and verbalisation of results lend support for mathematics pedagogy in school.

However, most often these approaches do not have a place in mathematics classrooms in Ghana (Davis, 2012).

Ghanaian school children often go through a collateral transition experience (Abreu, Bishop and Presmeg, 2002; Davis, Bishop & Seah, 2009). According to Abreu, Bishop and Presmeg (2002):

> Collateral transitions, where there are two or more related practices requiring relatively simultaneous involvement... example is the situation where the school students' parents emigrated after being at school in their home country, and the student is exposed to one set of mathematical practice and representation at home and another set at school... (p. 17)

For example, in the home context children make use of empty tins in measuring (i.e. "cups", "Olonka" and so on). The metric system of measurement is not usually used in Ghanaian local markets either in urban or rural settings (GNA, May 2009). Financial news on national radio stations usually quotes prices of commodities in these local units ("Olanka" for example). The situation is the same for fractions (see Davis, Bishop & Seah, 2010, for example).

The language of instruction in school (especially at the upper primary level) is different from the language children use at home and even outside the classroom in most cases. The approaches students may use in the representation of a typical arithmetic problem may also differ between contexts (home/school), as Abreu (1993) observed with children of Brazilian sugar cane farm workers, where children are taught metric systems of measurement in schools while at home they used their local unit of measurement based on 'braças'. These struggles between school and home contexts of mathematical practices by Ghanaian students could be described as being collateral in nature. Literature suggests that such mismatch between out-of-school and school mathematics (as prescribed in school curriculum) usually constrains teachers from using out-of-school mathematics, since they are obliged to follow the school curriculum (Abreu & Duveen, 1995).

Mathematics teachers in contexts such as Ghana where students have to cross several barriers such as those between informal and formal level of mathematics and language barriers, often face a very difficult task taking students from the informal level of mathematics to the formal level of mathematics (Setati & Adler, 2001). The learning trajectory of a typical Ghanaian child from an ordinary Ghanaian home, where the parents are not highly educated and the child is deeply engaged in societal practices such as petty trading is different from that of a monolingual child from an advanced country such as Japan or United Kingdom (Setati & Adler, 2001).

A growing body of literature has, for example, shown that language is a cultural tool that has the tendency to mediate mathematics learning in school (Kozulin, 2003; Setati & Adler, 2001) and therefore training teachers for mathematics teaching in a multilingual context such as Ghana without orienting them to linguistic and cultural issues in mathematics teaching and learning is likely to affect students' learning outcomes and perceptions of mathematics. It is against the background of the several barriers that Ghanaian students have to cross in order to access the formal level of mathematics that this study was designed to explore how the curriculum of the Colleges of Education in Ghana orient trainees to the local aspects of mathematics and mathematics teaching. There is the call for Ghanaian mathematics teachers to make mathematics relevant to the societal practices of Ghanaian students (Myjoyonline, September, 2011). However not many research studies have looked at the way teacher training programmes are preparing teacher trainees to appreciate the local aspects of mathematics and mathematics pedagogy in the way that would enable them to draw on students' sociocultural context to teach mathematics meaningfully. This study will therefore add to literature on socio-cultural issues in mathematics teacher preparation, which is a relatively new area in Ghana.

Research Questions

The following research questions were posed to guide the study:

1. How does the content of the mathematics curriculum at the College of Education level reflect the social and cultural practices of the Ghanaian school children?
2. How does the training of mathematics teachers for the basic school level (Year1- 9) in Ghana equip trainees to appreciate the local aspects of mathematics and mathematics pedagogy?

Method

The qualitative research method was employed to address the two research questions that guided the study. Even though this approach is noted for its subjectivity, it is recommended for the opportunity it provides for the collection of in-depth information on the issue under investigation (Holliday, 2002; Mertens, 2010). The research participants for the study consisted of five experienced tutors of mathematics, one each from five colleges of education namely Colleges A, B, C, D and E (all pseudonyms). Two of the tutors were females while the remaining were males. The colleges were purposely selected from two (out of the five) Conference of Principals of Colleges of Education (PRINCOF) in Ghana zones, namely Central

Western/Zone and Greater Accra/Eastern Zone. Four out of five of the colleges were selected from Central Western Zone and one from Greater Accra/Eastern Zone because of proximity of these colleges. The participants were also purposely selected from each of the colleges of education. In each of the colleges, only senior tutors who had taught mathematics for at least ten years, and were teaching methods of teaching mathematics at the colleges were selected. The average teaching experience of the research participants was 15 years. Also, all the tutors were experienced examiners for the national examinations conducted by the Institute of Education, University of Cape Coast at the college of education level. All the research participants were therefore well versed in curriculum delivery at the college of education level. Two of the participants had Master of Philosophy degree in Educational Measurement and Master of Education in Teacher Education as their highest qualification, each of the remaining participants had Master of Education in Mathematics Education as their highest qualification. The details of the background of each of the research participants are provided in Table 1.

Two main instruments were developed and used in the data collection. These were an observation guide and document analysis guide (to guide the analysis of the planned curriculum and the Mathematics for teacher training in Ghana textbook). The observation guide consisted of two sections, A and B. Section A elicited information on tutors' biographic data which included the name of their College of Education, the zone in which the College is located, their sex and years of teaching mathematics. Section B required the observer to take copious notes of the classroom interaction from the beginning of the lesson to the end of the lesson. The document analysis guide consisted of four main items. The first item looked at availability of course(s) that orients trainees to the local aspects of mathematics and mathematics pedagogy. The second item looked at the social and cultural relevance of each of the objectives of the mathematics courses taken by trainees in the planned curriculum. The third item looked at how trainees are oriented to the local aspects of mathematics and mathematics pedagogy through the introduction of the topic in the Mathematics for teacher training in Ghana textbook. While the fourth item looked at how trainees are exposed to the local aspects of mathematics and mathematics pedagogy in the development and evaluation of the topics in the textbook.

The main sources of data for the study were the intended/planned Mathematics curriculum of the Colleges of Education for both the generalist and the specialist Mathematics and Science programmes, the main methods of teaching mathematics textbook at the College of education in Ghana

(Mathematics for Teacher Training in Ghana) and observation of lessons of the participants. The lessons were observed in a method of teaching mathematics class in each of the colleges. The lesson observation was carried out by the author in the second semester (May/June, 2014). The rationale for observing lessons as an additional source of data was also to explore how some of the practices of these experienced mathematics tutors in the College of Education reflect the nature of the College of Education planned curriculum in mathematics. The lesson observed in each of the colleges was on the introduction of number bases. This topic was selected for two reasons. First, number has been identified as one of the topics Ghanaian basic school children and prospective basic school mathematics teachers have difficulty in (Anamuah-Mensah, Mereku & Ampiah, 2008; IoE, 2012; IoE, 2013, IoE, 2014). Chief examiners report on Mathematics-FDC 112: Number and Basic Algebra shows that trainees continue to perform poorly in this area. In the 2014 examinations, for example, only 33.8% of the total of 14513 candidates who took this paper passed. Number Bases was one of the topics that were identified as being difficult for the prospective teachers. Second, it is a concept many Ghanaian school children – especially those who assist their parents to sell in the market – experience in the everyday setting before they even start formal education. The data collected were analysed qualitatively and presented as narrative description with illustrative examples.

Table 1: Background of research participants

Participant	Sex	College	Academic qualification	Teaching experience at the college of Education level (in years)
One	Female	A	MPhil (Measurement and Evaluation), B. Ed (Mathematics)	22
Two	Male	B	M. Ed (Teacher Education), B. Ed (Mathematics)	13
Three	Male	C	M. Ed (Mathematics Education)	17
Four	Male	D	M. Ed (Mathematics Education)	14
Five	Female	E	M. Ed (Mathematics Education)	10

Results

In this section, the summary of the results from the lesson observation from each of the five colleges of Education are presented in Table 4. The results of the analysis of the College of Education planned curriculum in mathematics and the Mathematics for teacher training in Ghana textbook are also presented.

The Planned Mathematics Curriculum of College Education in Ghana

The Colleges of Education mathematics curriculum is designed in such a way that the first two years of training is used to consolidate trainees' content knowledge and to also expose them to methods of teaching mathematics at the basic school level. Six mathematics courses are taken by those who are offering the generalist programme. These are FDC 112: Number and Basic Algebra, FDC 122 Geometry and Trigonometry, FDC 212: Statistics and probability, PFC 212 methods of teaching primary school mathematics, FDC 222: Further Algebra and PFC 222: Methods of teaching Junior High School mathematics. The first two years are used to consolidate the mathematics content of the trainees. Trainees are introduced to methods of teaching in the second year, thus in the second year, trainees take courses in both the content and the methods of teaching mathematics. The curriculum outlines the objectives and the content to be covered in each of the courses. This provides the basis for analysis of how the courses orient the prospective mathematics teachers to the social and cultural issues in mathematics generally and the local aspects of mathematics and mathematics pedagogy specifically. Table 2 presents the objectives and the content of each of the courses taken by the prospective generalist mathematics teachers.

Table 2: Mathematics curriculum for generalist mathematics teacher trainees

Course	Content	Objectives
FDC 112	Sets, Ratio; Proportion; Rates; Scale; Real Numbers - Properties and Operations; Indices; Number Bases; Relations; Functions and Graphs; Algebraic Expressions; Equations and Inequalities	1. Demonstrate a sound knowledge of mathematical concepts and procedures in the content areas studied. 2. Make connections between mathematics and other disciplines and activities in daily life.

		3. Pose mathematics tasks in the content studied and solve them using appropriate procedures and tools including calculators and ICT
FDC 122	Lines and Angles, Polygons, Geometrical Constructions, Circles, Measurement of 2-D and 3-D shapes, Pythagoras Theorem and Simple Trigonometrical ratios, Movement Geometry and Vectors, Coordinate Geometry.	1. Review and consolidate concepts and skills related to Geometry and Trigonometry. 2. Discover relations involving shapes, perimeters, areas and volumes and use these to solve problems. 3. Relate and apply mathematical knowledge to solve problems in Geometry and Trigonometry, using appropriate procedures and tools including calculation and ICT.
FDC 212	Collection, organisation, representation, analysis and interpretation of data, Measures of Central Tendency, Measures of Dispersion, "probability of experiments" and simple events, relative frequency, combined events, and tree diagrams, Conditional Probability.	1. Demonstrate a sound knowledge of the topics and apply them in real life situations. 2. Collect, organize, represent, analyse and interpret data. 3. Pose mathematics tasks in the content studied and solve them using appropriate procedures and tools including calculations and ICT.
PFC 212	Factors influencing the selection and sequencing of the content of the Primary School Mathematics Curriculum;	1. Identify factors that contribute to the inclusion of topics for the primary mathematics

	Developing problem-solving and investigation skills. Development of number concepts and operations, preparation for lesson delivery, methods and materials for effective teaching and learning, use of the activity method and grouping of children for effective teaching and learning. Simple geometric concepts and relationships including measurements and assessment of children's achievement in mathematics.	curriculum. 2. Explain how children acquire the concept of number and design appropriate activities to enable children perform numerical operations. 3. Illustrate various activities that children can be engaged in to develop their understanding of mathematical concepts and relationships. 4. Discover various geometrical concepts and how they could be introduced to children. 5. Identify various ways for assessing children's learning in mathematics. 6. Solve mathematical problems and assist children to develop strategies for tackling problems in mathematics. 7. Explore ways in which the calculator and ICT could be used to enhance learning and problem-solving by children
FDC 222	Series and sequences, binary operations, Matrices and Binomial Expansion including Pascal's triangle.	1. Explain and discover patterns in simple series and sequences. 2. Apply matrices and binomial expansion to the solutions of problems. 3. Pose and solve problems which require the use of

Table 4: Summary of lesson presentation on number bases by college of education

College	Zone	Observation
A	Central /Western	**Topic**: Introducing Number Basis **Summary of observation**: - Teacher writes 578, 309 and 241 and asks students to read. - Teacher asks students to identify the place value of each digit in each of the numbers - Teacher requests students to write the numerals involved in the decimal system i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, - Teacher reminds students that in the decimal system the numerals are from zero to nine, and asks students if we have say base five what is the numerals that would be used? - Teacher once again reminds students that in base ten we do not have 10, so 10 is a group of ten - Students write 0, 1, 2, 3, 4 - Teacher explains that in base two the numerals are 0, 1 - Students read numbers in other bases i.e. 234_{five} and 1011_{two} as two, three, four base five and one, zero, one, one base two respectively - Students find the place value of digits of numbers in other bases i.e. 234_{five} is two five of fives, three fives and four ones - Teacher asks students convert 234_{five} to base ten
B	Central/ Western	**Topic**: Introduction of number bases **Summary of observation**: - Teacher tells students that to introduce number bases you start from base ten because we use the Hindu Arabic system - Teacher writes 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 (numerals for base ten) on the chalk board. - Teacher introduces the Diene's base ten

		blocks and explains that the cube is the unit (10^0), the long is ten (10^1), the flat is hundred (10^2) and the block is one thousand (10^3) - Teacher introduces base 4 and explains that the cube is the unit (4^0), the long is four (4^1), the flat is four by four which is sixteen (4^2) and the block which is four by four by four which is sixty four (4^3) (still using the Dienes base ten blocks) - Teacher introduces base three and explains that in base three students have to group in threes; if you join three units you get a long. - Teacher tells the class that for base 3 we use the symbols 0, 1, 2 - Teacher tells the class that 3 is 10 (one zero) in base three - Teacher introduces conversion from base three to base ten and writes $3^0=1$, $3^1 = 3$, $3^2 = 9$, $3^3 = 27$ - Teacher introduces base five numerals and writes 0, 1, 2, 3, 4 and presents what he termed "base five apparatus as cube = 5^0, long = 5^1, flat = 5^2, block = 5^3" - Teacher introduces conversion from base ten to other bases by demonstrating how to convert eight to base five - Teacher asks students to make groups of five from eight bottle tops - Students form one group of five and three ones - Teacher uses the division algorithm and writes the final answer as $8 = 13_{five}$ - Lesson ends by teacher giving students some more exercises to try
C	Central/ Western	**Topic**: Number Bases (Numeration System) **Summary of Observation**: - Teacher introduces the lesson by telling students that the Romans use the numerals i, ii, iii in counting and asks students the name given to the system of counting we use in

Ghana

- Teachers explains to students that the system we use in Ghana is based on the Hindu Arabic numerals
- Teacher asks students how they would help their pupils to form the concept of number bases.
- Teacher asks students to sit in groups, (students formed, three groups, two groups were made up of ten students the other group made up of twelve students)
- Teacher supplies each group with bundles of sticks (27, 18 and ten respectively)
- Teacher asks each group of students to put each of the bundles of sticks in groups of ten, eight and six respectively
- Each group of students group the sticks (in tens, eight and six respectively) and presented their solution orally as the teacher enters the answer in a table. For 28, students called out the answer as two groups of ten and seven ones, three groups of eight and three ones and four groups of six and three ones.
- For 18, students orally called out the answer as one group of ten and eight ones, two groups of eight and two ones and three groups of six
- For ten, students called out the answer as one group of nine, one group of eight and a one, one group of six and three ones
- Teacher tells students it is important to indicate the base for numbers which are not in base ten
- Teacher tells students that 27 is three three base eight i.e. 33_{eight}
- Teacher poses the question "what is number bases"
- Students give answers such as "way of writing figures with base", "grouping of

		objects" - Teacher defines number bases as "Grouping objects in terms of definite groups" - Teacher introduces how to find digits of number bases and asks students to always start with ten - Teacher list numbers from one to forty on the chalkboard and explains to the class that 0-9 comes up regularly and tells students that ten digits are involved that is why it is called base ten - Teacher introduces base five and list the numerals as 1, 2, 3, 4, 10_{five}, 11_{five}, 12_{five}, 13_{five}, 14_{five}, 20_{five} and indicates that the digits for base five are 0, 1, 2, 3, 4 - Teacher drills students on the numerals for base twelve, base six and base two. - Teacher introduces place values, using the Dienes blocks and explains that cube = 10^0, long = 10^1, flat = 10^2 and the block is 10^3 - Teacher explains that in base ten numeration system, the value of a digit is ten times the value of the next digit to the right of it. - Teacher draws place value table for base ten numeration system and identifies the place value of each of the digits in 438 - Teacher presents the solution on the board as 4 = 4hundreds = 400, 3 = 3tens = 30, 8 = 8ones = 8 - Teacher solves another problem involving 1324_{five} in class and presents the solution as 1 five-five-fives, 3 five-fives, 2 fives and 4ones - Teacher ends the lesson by "saying in the next class we would look at operations on number bases"
D	Central/ Western	**Topic**: Numeration System - Number Bases **Summary of Observation**: - Teacher introduces the lesson by asking student "how do you count?" - Student count from 0, 1, 2, ..10, 11, 12, 13,

... 20, 21, 22, ...

- Teacher asks students the base in which the numbers are written.
- A student responds by saying base one.
- Teacher explains that we do not have base one and explains that what has been listed is in base ten.
- Teacher writes the following question on the board "indicate the place value and the value underlined in each of the numbers (a) 58 (b) 685 (c) 8564 (d) 57862".
- Teacher solves the question with the class and presents the answer on the board as (a) tens, 50, (b) ones, 5 (c) Hundreds, 500 (d) Ten thousands, 50000.
- Teacher tells the class that these are number base, in base ten.
- Teacher introduces base five using the Diene's base ten blocks and asks a student to count in fives using the cubes (ones).
- The student counts 1, 2, 3, 4 and 5.
- Teacher tells students that in base five you cannot count five. Five is 10 (one zero) in base five.
- Teacher invites another student to continue with the counting and comes out with 1, 2, 3, 4, 10, 11, 12, 13, 14, 20 as the answer.
- Teacher draws students' attention to the fact that 10 is read "one zero base five" and 20 is read "two zero base five".
- Teacher introduces students to counting in base two and invites some students to the board to count in base two.
- A student counts one cube and picks a long (made of ten units) to represent one group of two (10_{two}).
- Teacher presents counting in base two drawing diagrams on the board and writes one cube = 1, 2cubes = 10, 3cubes = 11, 4cubes = 100, 5cubes = 101, 6cubes = 110.

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- Teacher writes the following question on the board "indicate the place value and the value underlined in each of the numbers (a) 58 (b) 685 (c) 8564 (d) 57862".
- Teacher solves the question with the class and presents the answer on the board as (a) tens, 50, (b) ones, 5 (c) Hundreds, 500 (d) Ten thousands, 50000.
- Teacher tells the class that these are number base, in base ten.
- Teacher introduces base five using the Diene's base ten blocks and asks a student to count in fives using the cubes (ones).
- The student counts 1, 2, 3, 4 and 5.
- Teacher tells students that in base five you cannot count five. Five is 10 (one zero) in base five.
- Teacher invites another student to continue with the counting and comes out with 1, 2, 3, 4, 10, 11, 12, 13, 14, 20 as the answer.
- Teacher draws students' attention to the fact that 10 is read "one zero base five" and 20 is read "two zero base five".
- Teacher introduces students to counting in base two and invites some students to the board to count in base two.
- A student counts one cube and picks a long (made of ten units) to represent one group of two (10_{two}).
- Teacher presents counting in base two drawing diagrams on the board and writes one cube = 1, 2cubes = 10, 3cubes = 11, 4cubes = 100, 5cubes = 101, 6cubes = 110.

- Teacher copies the table below on the whiteboard for base five
-

5^3	5^2	5^1	5^0

- Teacher copies the table below on the whiteboard for base two

2^3	2^2	2^1	2^0

- Teacher gives students the following tasks to do
  1. Write down (i) the place value and (ii) the value of the digit 2 in each of the following base five numerals (a) $13\underline{2}4$ (b) $\underline{2}431$ (c) $4\underline{2}31$.
  2. Write down (i) the place value and (ii) the value of the following base two numerals
     (a) $100\underline{1}1$ (b) $\underline{1}01001$ (c) $101\underline{1}01$.
- Teacher discusses the solution to each of the tasks with the class.
- Lesson comes to an end after discussion of the solution to the class exercise.

E — Greater Accra/ Eastern

Topic: Number Bases

Summary of Observation:

- Teacher introduces the lesson by drawing students attention to the fact the number system used in Ghana is one of the several number systems.
- Teacher tells students that the written symbol for numbers are called numerals and collection of numerals is called numeration system, Number is an idea of quantity.
- Teacher explains that since number systems are based on different groupings, there are numeration in different bases.
- Teacher explains that any number students see is in base ten unless otherwise stated and

list the numerals for base ten as 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

- Teacher teaches place value involving base ten; writes the number 2345 and explains that from the right, the digit five is a unit, the digit 4 is second from right and it is in tens or groups of ten, it is four groups of ten or 40, the 3 in the figure is third from right and it is tens of ten. The 3 therefore is written as 3 groups of 10 of ten. The place value of 3 is therefore 300, the 2 in the figure is seen as 10 of 10 of 10 giving 2 as 2 groups of 10 of 10 of 10 which is 2000.
- Teacher explains further that 2345 = 2000 + 300+40+5.
- Teacher introduces students to base five and lists the numerals as 0, 1, 2, 3 and 4. .
- Teachers draws students' attention to the fact that in base five the numeral five is not included
- Teacher asks students to write 2123_{five} in expanded form.
- Teacher presents the solution as 2(5x5x5) + 1(5x5) + 2(5) + 3
  2(125) + 1(25) + 2(5) + 3
  250 + 25 + 10 + 3
  $= 288_{(10)}$
- Teacher introduces conversion from base ten to other bases by converting 288 back to base five
- Teacher takes students through the division algorithm to obtain 2123_{five} as the final answer
- Teacher ends the lesson by explaining to students that in base ten we have 10^0, 10^1, 10^2, ... in base five we have 5^0, 5^1, 5^2, ... and in base two we have 2^0, 2^1, 2^2, ...

Number bases is covered in FDC 112 course (see Table 2). The lesson of each of the experienced mathematics educator shows that the topic was presented out of context to the teacher trainees. The lesson presentation basically involved reading numerals in given bases usually starting from base ten, then to base five, base two and so on, identifying the numerals for given bases usually starting from base ten, base five and so on, performing operations in a given base and then converting from one base to another. Not much was seen about the relationship between the topic and the social and cultural practices of students such as the systems of counting of fishes, oranges and tomatoes in Ghanaian local markets, for example (see Davis, Bishop & Seah, 2009, for example). The use of the base ten blocks in explaining other bases was common in almost all the Colleges of Education. For example, in College D a long made of ten cubes was used to explain one group of two (that is, 10_{two}). An informal conversation with the tutor from College E, revealed that this tutor had never thought of the possibility of drawing on students' sociocultural practices to teach Number Bases. This was evident in the tutors' response to the question: "have you thought about the possibility of using everyday practices in the Ghanaian society to teach this topic [number bases]?" The tutors response to this question was "no, it has never crossed my mind, how possible, please tell me."

Discussion

The College of Education mathematics curricula does not orient the prospective mathematics teachers to the local aspects of mathematics and mathematics pedagogy, meanwhile literature points to the local aspects of mathematics (Barton, 1996, 1998; Bishop, 1988; D'ambrosio, 1999; Matang, & Owens, 2004) and mathematics pedagogy (Draisma, 2006; Presmeg, 2007) and therefore the need for prospective mathematics teachers to learn about these aspects of mathematics. Analysis of the Ghanaian College of Education mathematics curriculum shows that sociocultural issues in mathematics and mathematics pedagogy are not included in teacher preparation; meanwhile many Ghanaian school children are living in two worlds within the same country. They often have to simultaneously engage in one set of mathematical practices and representation in out-of-school contexts and another set of mathematical practices and representation in school context (see Davis, Bishop & Seah, 2009). These students often experience cultural conflicts (conceptual discrepancy between what they bring from outside of school and what they experience in school) as they encounter different kinds of mathematics in the home and the school contexts. Conflict of this nature in itself is not bad in the educational setting

(Bishop, 2002), but the way conflicts are handled in the classroom setting is what makes the difference. Davis, Seah and Bishop (2009), for example, found that some Ghanaian primary school teachers usually ignore the cultural conflicts students bring with them in mathematics lessons by concentrating on what the curriculum requires them to do rather than understanding the source of students' difficulty. The tendency is that the student may adopt the new ways of doing things that may be alien to their culture, or may decide not to be part of the new cultural practice. In the later situation the student would often be branded as a failing student and be eventually excluded from school. Bishop (2002) gives accounts of how teachers make it impossible for students to engage in cultural interaction even when the student makes the initiative. Other studies support the fact that in some cases teachers' notion about the fact that out-of-school mathematics and in-school mathematics are mutually exclusive affects their teaching. Such teachers usually make no reference to out-of-school mathematics in their lessons (Abreu, 1995; Abreu & Duveen, 1995).

Previous knowledge of students includes their informal knowledge and the purpose of teaching school mathematics is to get students to the formal level of mathematics (formalization). Any curriculum which does not prepare teacher trainees to appreciate the need to take the societal and cultural practices of students into consideration in the process of teaching is therefore not giving the prospective teachers all what they need to teach mathematics meaningfully to students. Although the Ghanaian College of Education curriculum mentions the need for trainees to apply mathematics in their daily activities in two (FDC 112 and FDC 212) out of 12 courses, it does not provide trainees any theoretical basis to do that. It is one thing indicating what trainees have to achieve in the general objectives of a course and another thing designing the course in such a way that trainees would be equipped with the necessary knowledge and skills they need to teach mathematics meaningfully, drawing on the sociocultural practices of their students.

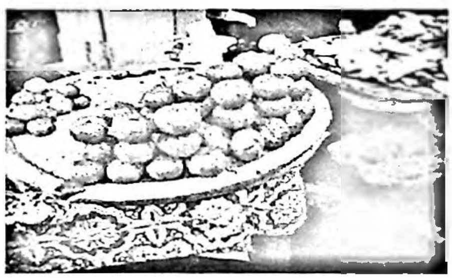
The findings from the results of this study show that the planned curriculum for both the generalist and specialist training in mathematics at the college of education level do not orient trainees to the local aspects of mathematics and mathematics pedagogy. Analysis of the results of the lessons on number bases shows that implementation of some of the planned curriculum does not also orient trainees to draw on the social and cultural practices of students to scaffold their deeper understanding of concepts. This was evident in the fact that none of the lessons made use of some of the numerous everyday practices of students in the process of the development of the topic. The lesson was delivered using either Diene's base ten blocks or bundle of sticks or bottle tops in each of the colleges. The use of Diene's base ten blocks made some of the concepts even more confusing. For example, the use of a long made of ten units to explain one group of two (10_{two}) and the use of flats made of hundred units to explain two groups of two (100_{two}) appeared to have rendered the use of this teaching learning material ineffective in most of the lessons observed. Informal interaction with each of the participants revealed that they did not have materials that would support the development of other bases apart from base ten. This shows the need to explore the possibility of using cheaper and readily available materials from the environment to teach concepts meaningfully to students. The question is, are these materials available in our Ghanaian society? I will show examples of what is possible at the end of this section.

Training does not also orient trainees to the local aspect of mathematics and mathematics pedagogy through the implementation of the planned curriculum. The results in Table 4 also show that measurement of attained curriculum in most cases was also done out of context. Evaluation exercises were mainly based on examples of what had been solved in the class. None of the evaluation exercise drew upon the social and cultural context of the students. Social and cultural context of students therefore had no place in the development of the lesson and the evaluation of the lesson in each of the colleges.

The results from the observation of the experts' lessons on Number Bases in Table 4 show that many of the everyday societal practices which can easily afford the development of Number Bases such as system of counting of fishes, tomatoes and oranges in the local markets across the country are not drawn upon to develop the concept meaningfully in school (see Figure 2). Counting of tomatoes, for example, could lead to the development of Bases Three, Four and Five, depending on the sizes of the tomatoes. All these useful resources are not employed to teach mathematics meaningfully in school because most training programmes for mathematics teacher educators at the university level do not provide teacher educators the opportunity to appreciate the local aspects of mathematics and mathematics pedagogy. They do not provide them the opportunity to acquire the theoretical basis of drawing on social and cultural contexts of their students in teaching and learning of mathematics. The procedures proposed by the experts reflect the approaches prescribed in Ghanaian textbooks and methods of teaching mathematics books (Martin et al., 1994). It appears some of the experts such as the tutor from School E do not consider sociocultural context of the students as an important variable in mathematics pedagogy.

It is possible to draw on the social and cultural contexts of students to teach many of the topics that have been identified as being difficult for students at the basic school level such as division. In teaching division, for example, societal practices involving the sale of vegetables such as tomatoes which involves grouping (see Figure 2) could be employed to teach the topic meaningfully. The sale of fishes also involve grouping. Practices involving measurement of vegetables and fishes by grouping support development of the concept of division in school. In teaching x divided by four, for example, the sale of garden eggs or tomatoes could form a context which will results in repeated subtraction of four or multiples of four till x items of the garden eggs are exhausted. Often these ideas are taught out of context, for example, repeatedly subtracting a number of pebbles, counting sticks and so on, which do not often help pupils to connect mathematics and everyday mathematical activities within their society or culture.

Grouping of four or five (depending on size)



Grouping of four or five (depending on size)

Figure 2: Local system of measuring

Conclusion and Recommendation

The current College of Education mathematics curriculum for both the specialist and generalist trained teachers do not orient the prospective mathematics teachers to the local aspects of mathematics and mathematics pedagogy. Sociocultural issues in mathematics and mathematics pedagogy are not included in teacher preparation despite documented evidence of the importance of local aspects of mathematics and mathematics pedagogy. Although local aspects of mathematics are missing in the College of Education curriculum, it is possible to employ them to teach mathematics meaningfully. How to employ more local aspects of mathematics in the development of methods of teaching mathematics textbooks in the Colleges of Education in Ghana is left for debate among mathematics education experts in Ghana. This is because there are several suggested ways of employing local aspects of mathematics in the development of mathematics lessons in school (see Hedegaard & Chaiklin, 2005; Presmeg, 2007, for some examples).

Exposing the prospective Primary and Junior High School teachers to sociocultural issues in mathematics will go a long way to help them develop lessons that would motivate their students to learn, by creating the opportunity for their students to appreciate the relevance of what they are learning to their everyday practices. Exposing them to sociocultural issues in mathematics will also help the trainees to conceptualize the relationship between everyday mathematical concepts and academic/school concepts. This will enable them to draw on their students' sociocultural practices in mathematics to teach school mathematics meaningfully.

It is therefore recommended, the mathematics curriculum for pre-service teacher training programme at the college of education in Ghana and other sub-Saharan African countries that share similar situation as Ghana should be revised to include a course or two that would orient the prospective mathematics teachers to the local aspects of mathematics and mathematics pedagogy.

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