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ARTICLE

CONSTRUCTIVISM IN MATHEMATICS CLASSROOMS: LISTENING TO GHANAIAN TEACHERS' AND STUDENTS' VIEWS

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ABSTRACT

One of the challenges of implementing a new curriculum is how to bridge the gap between the underlining principles of the curriculum and the cultural and social orientations of the society which includes teachers and students. This article reports on a study that explored how the cultural and social orientations of teachers and students can influence the implementation of a constructivist curriculum in mathematics classrooms. The data for the study came from 250 students and 41 mathematics teachers, using questionnaires, observations, and interviews. The results showed that inasmuch as mathematics teachers and their students acknowledge the importance of student's active participation and teamwork, these practices have not been fully conceptualised into the Ghanaian mathematics classroom due to some cultural factors. Two main cultural factors were discovered from the analyses of the results. Firstly, the culture of acknowledging only correct answers in class has a negative impact on individual students' confidence and participation during mathematics lessons. Also, the culture of teamwork is not fully accepted within Ghanaian classrooms as most students find it difficult working in groups and accepting and appreciating each other's view. It was evident in all lessons that students were ridiculed by their peers when they provide a wrong answer to a question and this affected individual students' participation in the classroom. Therefore, we suggested that teachers should be pro-active in promoting a classroom environment which is free from fear and intimidation to motivate students to be actively involved in the classroom discourse.

Keywords: constructivism; culture; curriculum; learning; mathematics; teaching

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INTRODUCTION

The teaching and learning of mathematics until the early 1970s have been underpinned by the principles of behaviourism, and this is still applicable in most mathematics classrooms around the world. The principle of behaviourism, where the teacher is considered as the custodian of knowledge and expected to transmit that knowledge, has been highly criticised by a number of researchers after it has dominated the teaching and learning practices in many classrooms over the years. For example, Abrams and Lockard (2004, 6) explain that "the core of behaviourism, the reinforcement principle, does not adequately explain the complexity of thinking, memory, problem-solving, and decision-making". Wakefield (2007, 170) also alludes that research results have "yielded anomalies revealing its limitations as an overall account of psychological functioning". He adds that in most cases these theories fail to take into consideration the influence the mind has over behaviours. According to Rotfeld (2007, 376), behaviourism provides a "direction for social science research that would allow control and measurement of all relevant variables by ignoring human thought or cognition".

According to Boaler (2009), this approach to teaching and learning has been unable to produce students who are critical thinkers. Students who experience mathematics in this way are often unable to transfer the knowledge they have acquired in solving real-life problems. That is to say, most of these students do not understand the utilitarian nature of the mathematical skills and concepts that they have learned. It is for this reason that the search for new theories that help increase students' participating and engagement in the teaching–learning process has become necessary; hence, the evolution of the constructivist theory of learning in the early 1970s. Constructivism as a theory of learning contends that the individual learner brings past experiences and beliefs, as well as their cultural histories and world views, into the process of learning. These beliefs and cultural orientations influence how the individual learner interact with and interpret their encounters with new ideas and events (Lambert et al. 1995).

The study reported on concentrated on mathematics education within the Ghanaian context; by examining the theoretical shift in mathematics education from a teacher-centred approach to teaching to a more student-centred approach. The need for a student-centred approach to the teaching and learning of mathematics has been re-echoed explicitly in the new mathematics curriculum which was introduced in 2007. The new mathematics curriculum is underpinned by the principles of constructivism and aims at promoting students' active participation and engagement in the teaching-learning process in Ghanaian schools. The underlining principle of the new mathematics curriculum is based on the premise that each individual student should be given the opportunity to be actively involved in the teaching-learning process (MoESS 2007). However, the implementation of these curricula in Ghana has been influenced by the cultural orientations of the diverse backgrounds of the people.

Ghana has over 50 ethnic groups and over 100 different dialects and ideologies which shape and develop the nation's human and material development. These different

cultural values and institutions continue to exercise a deep influence on the way people think and acquire new knowledge (NCC 2004). Within a certain locality in Ghana, like in most African countries, it is possible to come across different cultural orientations and beliefs and this explains how Ghana's social, economic, political and educational practices are inherently tied to the cultural practices and orientations of the people. Despite these cultural differences, most school mathematics curricula in Ghana were adopted from different countries from the Western world, and the implementation has always created a big gap between theory and practice.

Apart from compatibility issues of the new mathematics curriculum about the cultural and social orientations within the Ghanaian classroom identified above, very little is known about how these underlining issues affect the teaching and learning of mathematics. As highlighted above, most of the adopted curricula reflect the shared values and meanings common to members of the group and how meaning is constructed which is most often different from cultural orientations and values of the country where the curricula are implemented (Mason 2007, 172). Thus, in most cases very little attention was given to the cultural orientations of the students and teachers, place or country where these new curricula were implemented in the early 2000s.

In the article, the researchers interrogate the mathematics teaching and learning in Ghanaian schools and analyse the various classroom discourses to understand the cultural orientations and epistemological views of mathematics teachers and students; and the congruence of these views with the principles of constructivism. The study findings, we believe, will provide an insight into the implementation of the new mathematics curriculum. The findings will also provide information for other countries in their quest for improving the teaching and learning of mathematics and adoption of a specific theoretical stand. Therefore, the study was guided by the following research questions (RQ):

RQ 1: What are mathematics teachers' and students' epistemological beliefs about mathematics teaching and learning?

RQ 2: What is the relationship between teachers' and students' epistemological beliefs and their classroom teaching and learning practices?

RQ 3: How do these beliefs influence the implementation of the constructivist principles of mathematics teaching and learning?

THEORETICAL FRAMEWORK

The principles of constructivism have been integrated into many school curricula across the world, although its implementation may vary because of the differences in the cultural orientations in these individual countries. However, the prime objective of these changes is to promote innovative methods of teaching and learning of mathematics. For example, constructivism reforms in the United Kingdom started in early 1980 with the introduction of a new mathematics curriculum to provide a new mathematics

classroom environment to promote conceptual understanding of mathematical skills and improve on students' problem-solving skills (Chambers 2008). In the United States, the introduction of the National Council of Teachers of Mathematics (NCTM) *Agenda for Action* in 1980, brought about a number changes in the way mathematics is taught and learned with the aim of helping students develop conceptual understanding of mathematical concepts and principles.

The situation in Ghana is not different from what has been discussed above. The Ghanaian mathematics curriculum like that of most other countries around the world has undergone major restructuring since the late 1980s. This restructuring of the mathematics curriculum has been necessitated by numerous research findings (e.g. Akyeampong, Pryor and Ampiah 2006; Ampadu 2013; Pontefract and Hardman). These research findings suggest that the Ghanaian mathematics classroom like most other classrooms in Africa is characterised by prescriptive instructional behaviours and passive learning styles among many students (Akyeampong, Pryor and Ampia 2006). The need for an improved means of mathematics curriculum delivery became the hallmark of curriculum reforms in Ghana

Constructivist theory in its various forms is based on the general assumption that learners actively construct their own knowledge based on their experiences, language, and culture (Glasersfeld 1993). Accommodating the specific cultural roots of the learner is critical in enhancing students' learning as well as their active participation int the teaching-learning process, and "it is necessary to integrate a culturally relevant curriculum in the existing mathematics curriculum" (Rosa and Orey 2011). That is, negating the cultural and social location of the child poses "dangers of cultural relativism and the denial of universal critical knowledge, as embodied particularly in the sciences and mathematics" (Vinod 2011, 10). Integrating the cultural and social location of the learner in the classroom discourse is one of the important components of effective group work which is one of the underlining principles of constructivism. That is, group work method of instruction is one way in which the constructivist theory has been conceptualised about classroom practices. Group work promotes high order thinking among students, and it helps both low and high achievers gain from each other (Ma 1996). It is for this reason that constructivism has become the dominant view of the teaching and learning of mathematics over the past three decades. However, for these groups to work more effectively require that the group members share some common social and cultural orientations that help them to critically reflect, and find possible solutions to the problem in question (Nasir Hand and Taylor 2008).

As highlighted above, the momentum of reforms in mathematics education began in the early 1980s in response to the societal outcry for innovative ways of teaching and learning mathematics. It is during this time that many researchers and educators advocated for the use of constructivism as the underlining theory for mathematics teaching and learning in our schools. This became necessary as a result of the numerous advantages associated with constructivism as a theory of learning.

Understanding the complex nature of how students learn and how teachers teach is "highly influenced by the social events that a person is exposed to; and these originate from the culture, social environment and traditions that one is exposed to" (Mwamwenda 2005, 89). Earlier research by Kawanaka, Stigler and Hiebert (1999, 91) suggests that the school curriculum and for that matter "teaching and learning are cultural activities which often have a routine about them that ensures a degree of consistency and predictability organised in certain ways that are accepted in each culture". Knipping (2003, 282) also found that the "culture of a particular group of people shapes the classroom processes and teaching practices within countries, as well as how students, teachers practice them".

This suggests that every mathematics curriculum should be underpinned by theories and principles of teaching and learning which are familiar and consistent with the cultural orientations of the people implementing these theories. For example, pragmatism which has become well-known underlining principles of most school curricula across the world has its link to the United States and addresses the acquisition of knowledge and skills necessary for teaching real-world problems" (Andrews 2010b, 19). Pragmatism has over the years influenced teaching and learning in most classrooms as a means of balancing the needs and aspirations of the society on the hand with the needs and aspirations of the student on the other hand (Andrews 2010a). People learn best through social interaction and are more likely to develop conceptual understanding of the subject matter when the curriculum delivery practices are consistent with the cultural orientations of the learner (Andrews 2010b). In this regard, US students are more likely to benefit from this theory than their counterparts in other countries as the principles of the theory are consistent with their cultural orientations.

Similarly, the ideas of constructivism were propounded in the works of Vygotsky and Piaget, and it is from these ideas that Ernest (1998) introduced social constructivism in mathematics education. The introduction of this principle into the teaching and learning of mathematics was as a result of examining the cultural and social orientations of the people Ernest was dealing with. The assumptions and underpinnings influencing this theory are, therefore, consistent with the cultural orientation of the people under consideration (Ernest 1998). From the above discourse, it can be deciphered that culture has a pervading influence on how students learn, how teachers teach and, how a new curriculum can be implemented effectively. For example, Bartell (2006) reports that mathematics is a neutral and culturally free discipline is one of the reasons why most students are unable to appreciate the utilitarian benefits of the mathematics they learn in school. That is, a mathematics curriculum which is experienced as real by a pupil can be developed only by adults who belong to the same cultural group as the pupil. Gutiérrez (2002, 172) argues that it is important to help students understand the social contribution of mathematics and this can best be achieved if students are made aware of how mathematics "contribute toward a positive relationship between mathematics, people, and society in ways that erase inequities on this planet".

Despite the global similarities in our quest for improved teaching and learning in general and more specifically in mathematics, the impact of cultural differences in individual countries cannot be underestimated (Nasir, Hand and Taylor 2008). The way people learn and acquire new knowledge is therefore influenced by their cultural orientations which affect both the teaching and learning processes. For example, one of the underlining principles of constructivism is "cooperative learning" where students interact effectively with one another to develop new ideas and knowledge. However, due to the cultural diversity in various classrooms, its implementation has become a major problem for both the teacher and the student (Nasir, Hand and Taylor 2008).

According to Nasir, Hand and Taylor (2008), the importance of how the features of different social contexts mediate what is learned cannot be underestimated in our quest for a more student-centred theory. They added that one of the earliest studies in this area is the analysis of why Kpelle students from Liberia have been underachieving in Western-style mathematics classrooms. It was established that there were no inherent difficulties but the transplanted concepts and methods did not make sense to the Kpelle culture. Kaino and Kasanda (2015, 68) allude that it was even established that "Kpelle illiterate adults performed better than North American adults when solving problems that belong to their indigenous mathematics". The differences between the two cultural orientations were, in fact, a major factor that accounted for the differences in performance (Nasir, Hand and Taylor 2008). These students were not relying on school type approaches in solving mathematical problems, but rather used visual and specific cultural artifacts to estimate mathematical quantities and to solve problems. It is for this reason, that the implementation and sustaining of constructivist theory in mathematics classrooms has become an issue of concern in most countries; not because the theory is not good but because of the differences in culture (Andrews 2010a). Most teachers find it difficult observing the learning process of students who are working collaboratively, especially when it is not in line with their own cultural, pedagogical practices (Pijls, Dekker and Hout-Wolters 2007).

METHODOLOGY

Research Design

Based on the objectives of the study and the limited literature, especially within the Ghanaian context, the research was exploratory in nature and employed a multi-phased mixed method approach. The first phase of the study employed a survey approach using a semi-structured questionnaire to elicit information regarding teachers and their students' beliefs about mathematics teaching and learning. This approach was used to provide quantitative data to map out the perceptions and epistemological beliefs of mathematics teachers and their students regarding their teaching and learning processes. The second phase of the study employed instrumental case study approach in examining

the actual teaching and learning practices of mathematics teachers and their students. The choice of instrumental case study for the second phase was informed by the fact that the researchers were interested in using these cases to provide an insight into the issue under consideration (Stake 1995).

The instrumental case study focused on the in-depth understanding of how mathematics is taught and learned in Ghanaian classrooms and how teachers' and students' beliefs and cultural orientations influence the implementation of the new mathematics curriculum. The choice of a case study approach was informed by the purpose of the study and the fact that the researchers had little control over events in research conducted in a real-life context as suggested by Yin (2003).

Participants

The data for the first phase study was collected from some 250 Junior High School (JHS) (12–14 years) students and 41 mathematics teachers from 12 schools. Of the 250 students, 103 (41%) were males and 147 (59%) were females; 33 (80%) of the teachers were males and eight (20%) were females. The 12 schools were made up of six rural, and six urban schools and these schools were selected for collecting data from the two main school classifications in Ghana (urban or rural). There are 72 JHSs in the metropolis and these schools are categorised into six educational circuits. The selection of the participants for the first phase of the study was made using a simple random sampling technique to select two schools from each of the six educational circuits. The schools in each circuit were grouped into rural and urban after which two schools (one rural and one urban) were selected from each circuit.

As mentioned, in the second phase of the study, two urban and two rural schools were chosen with the consent of the teachers and students in these schools for the case study. All the participants who took part in the first phase of the study were asked to indicate their willingness to participate in the second phase of the study. Seven schools (four urban and three rural) consented to take part in the second phase of the study, but one school withdrew later. For uniformity, the researchers purposefully selected the four schools for the second stage with the consent of the teachers involved.

METHODS

Questionnaires

Two types of questionnaires were used in the study, namely, the teachers' questionnaire and the students' questionnaire. The questionnaires utilised in the study were extracted from Swan's (2006) teachers' and students' workbook questionnaire. Although Swan's questionnaire had a high Cronbach's alpha reliability coefficient of 0.85, showing that the scales were reasonably consistent and reliable, the researchers made some

modifications regarding language structure and to enhance the validity and reliability of the instrument.

The questionnaires were piloted using 20 students and 10 teachers after which the results from the pilot were used to modify the questionnaires. The questionnaires were administered to some 250 students and 41 mathematics teachers. The teachers' questionnaire had three sections, namely: Section A (teachers' age, years of teaching experience and educational qualification); Section B (teachers' priorities when teaching and the teaching methods they normally use); and section C (teachers' perceptions of their teaching practices). The students' questionnaire had two sections: the first section was used to gather students' background information, while the second section measured students' perceptions of their learning experiences.

Observation

After the first phase of the data collection process, the non-participant observation approach was used in collecting qualitative data about mathematics teachers and their students' actual classroom practices. For uniformity, the researchers used a common observation guide during the observation sessions. The researchers anticipated observing 12 lessons (three from each stream: JHS1, JHS2 and JHS3). However, in the first school, there were only two streams (JHS1 and JHS2) since the school was fairly a new school. In this school, the researchers observed only two lessons instead of the anticipated three. In addition to this, in the second school, there was only one mathematics teacher for the three streams, and he was willing to be observed once. In all, 10 lessons (from five mathematics teachers) in the four selected schools were observed, and each lesson lasted for 35 minutes, which is the normal duration of a period in Ghanaian JHSs.

Interviews

All five mathematics teachers whose lessons were observed were also interviewed to elicit more information regarding their teaching practices. In addition to this, 22 students (two from each of the 11 classes) were selected with the help of the class teachers to be interviewed. With the consent of the participants, the classroom activities, and the interviews were audio taped to complement the detailed field notes.

Data Analysis Procedures

Like the data collection process, the data analysis procedure was in two phases. In phase one, the quantitative data from the survey was analysed using the Statistical Package for Social Sciences (SPSS) 20 and Origin 6.0 software where descriptive and inferential statistics were used in examining the epistemological beliefs of the teachers and their students from the survey instrument. Concerning the study objectives, the qualitative (interviews and observation) data was analysed using a thematic analysis approach. This

approach was considered appropriate as the researchers were concerned about what the participants said or did during the interviews and classroom observations, rather than how they said or did it (Braun and Clarke 2006; Davies 2007).

The analysis of the classroom observation data was drawn from the field notes and the transcription of the audio recordings of the observed lessons which were completed in cognisance with the RQs and the purpose of the study. The units of analysis used were classroom practices, which involved the teaching and learning strategies (i.e. teacher-centred and student-centred teaching practices, passive and active learning practices) as well as observed cultural factors (i.e. individualism and collectivism) which influenced the teaching-learning process.

RESULTS

RQ 1: Teachers' and Students' Epistemological Beliefs

To understand the students' and teachers' epistemological beliefs, the respondents were asked to indicate the extent to which they agree or disagree with 12 statements. The results from this are shown in tables 1 and 2.

Table 1: Frequency of teachers' statements regarding mathematics teaching and learning

Item		Disagree		Agree	
		Frequency	**Percentage**	**Frequency**	**Percentage**
Traditional beliefs	I teach each topic from the beginning, assuming students know nothing	16	39	25	61
	I explain things carefully to students to help them avoid mistakes	0	0	41	100
	I ask students to complete easy tasks before attempting difficult ones	4	10	37	90
	I tell students which questions to do during lessons	15	37	26	63
	I go through one particular method for doing each mathematics question	26	63	15	37
	I encourage students to use the method I teach them	7	17	34	83

Item		Disagree		Agree	
		Frequency	Percentage	Frequency	Percentage
Contemporary beliefs	I use diverse approaches when teaching a particular topic in mathematics	1	2	40	98
	I draw links between topics and move back and forth between topics	5	2	36	88
	I ask students to work in cooperatively in small groups	3	7	38	93
	I encourage students to compare different methods for solving questions	2	5	39	95
	I help students to develop their own method of solving problems	11	27	30	73
	I encourage students to set their questions and try to solve them	9	22	32	78

From Table 1, mathematics teachers' epistemological beliefs are very complex to explain as they contain both behaviourist and constructivist beliefs. From Table 1, it can be argued that although the teachers ascribed more positively to student-centred statements, there was no statistical difference between their epistemological beliefs between the two world views. These epistemological beliefs suggest that the conceptualisation of the principles of constructivism, which are the hallmark of the new mathematics curriculum, has still not been fully achieved within the Ghanaian mathematics classrooms. For example, the majority (83%) of the teachers indicated that they encourage their students to use the method they teach them. Also, all the teachers stated that they explain things carefully to their students to help them avoid mistakes. Students who develop their own ways of solving problems and learning from their mistakes are very critical in promoting effective teaching and learning of mathematics as suggested by Boaler (2009).

On the other hand, from Table 1, it is imperative that teachers understand and acknowledge the immense benefits of the constructivist principles in promoting effective teaching and learning of mathematics. This is supported by teachers' stories from the individual interviews. However, there are still some underlining issues which are hindering the smooth transition, and complete acceptance and practice of constructivism in the classroom.

Table 2: Frequency of students' statements regarding mathematics teaching and learning

Item		Disagree		Agree	
		Frequency	Percentage	Frequency	Percentage
Traditional beliefs	I listen while the teacher explains	48	19	202	81
	I only do the questions I am told to do	50	20	200	80
	I practise the same method repeatedly on my question	92	37	158	63
	The teacher shows us which method to use and then asks us to use it	140	56	110	44
	The teacher carefully explains things to us so that we do not make mistakes	34	14	216	86
	The teacher expects us to follow the textbook closely	65	30	185	70
Contemporary beliefs	I discuss my ideas in a group or with a partner	124	50	126	50
	The teacher asks us to compare different methods for solving questions	100	40	150	60
	I look for different ways of solving mathematics questions	102	41	148	59
	The teacher normally marks our exercises and discuss our results with us	20	8	230	92
	The teacher normally gives us practical questions to solve	60	24	190	76
	The teacher guides us to develop our own methods for solving problems	109	44	141	56

Different factors influence the way students construct knowledge, but what happens in the classroom plays an important role in the individual student's learning process. From Table 2, contrary to the teachers' responses, the students ascribed more positively to traditional methods of teaching and learning, although there was no statistically significant difference between their beliefs. On the average, 66 per cent were in favour of contemporary (constructivist) beliefs as against 70 per cent for traditional beliefs.

It is also interesting to note that the dominance of the teacher in the teaching and learning process is evident in Table 2. For example, the majority (81%) of the students indicated that they listen while the teacher explains, and 80 per cent also indicated that they only do questions that they are asked to do. However, in the new curriculum, like any other constructivist classroom, the teacher is supposed to act as a facilitator instead of a transmitter of knowledge. This undermines the students' abilities to think critically and become reflective thinkers.

RQ 2: Teachers' Epistemological Beliefs and Actual Teaching Practices

What is the relationship between teachers' and students' epistemological beliefs and their classroom teaching and learning practices?

Table 3: Teachers' observed teaching methods

School	No. of observations	Lecture method	Activity method	Demonstration method	Group work method	Problem-solving method
A	2	Sometimes	Sometimes	Not at all	Not at all	Not at all
B	2	Sometimes	Often	Often	Sometimes	Sometimes
C	3	Sometimes	Sometimes	Sometimes	Not at all	Not at all
D	4	Often	Sometimes	Sometimes	Not at all	Not at all

In examining mathematics teachers' actual teaching practices, the researchers observed 11 lessons from four schools using observation protocol was designed in such a way that, the researchers could examine different teaching methods used in most classes. For the purpose of uniformity, each lesson was analysed under how often the teacher uses the following teaching methods: lecture method, activity method, demonstration method, group work method and problem-solving method. These methods were chosen because these are the methods explicitly defined in the national curriculum. As the new curriculum is geared toward moving away from a teacher-centred approach to a more student-centred approach, the use of lecture method has been discouraged in the new curriculum. Table 3 shows how often these teaching methods are used.

All the lessons observed followed a similar pattern where the teacher starts by asking questions relating to students' previous knowledge. This is a good start as it allows students to get involved in the teaching-learning process at the beginning of the lesson. However, since it was mainly done through questioning, the review of students' related knowledge was only targeted at those few students who knew the answers to the teacher's questions. Consequently, responses provided by the minority of students

were assumed to be the existing knowledge of the entire class. In all observed lessons, teachers acknowledged the varying learning styles of their students and tried using different methods of teaching to get all students involved in the teaching-learning process. However, it was interesting to note that this innovative approach in most cases did not yield expected results as students' participation was only through answering the teacher's questions. Subsequently, this targeted only a small group of students and most students only listened and copied notes from the board without any active participation.

Also, during the observation, it was observed that when students provided incorrect answers, their efforts were not acknowledged by the teacher and sometimes their peers mocked them. The impact of this was that most of these students were unwilling to participate in the teaching-learning process as they were not confident, shy or afraid of providing incorrect answers. It was also interesting to note that in all lessons where such incidents took place, those students did not answer any other questions or actively participate in the teaching-learning process for the rest of the lesson. Despite the importance of students' mistakes and misconceptions in the teaching-learning process as established by Willis (2010), providing incorrect answers is something that most of these students try to avoid.

Similarly, all the teachers were seen advising their students to avoid making mistakes, and this resulted in a situation where most students were seen copying what the teacher had written on the board and following the teacher's method rather than looking for alternative ways of solving the problem. This approach undermines the principles of constructivism where students are to be encouraged to develop new knowledge by exploring and trying different ways of solving problems.

In all four schools, the teachers tried encouraging the students to work in groups. However, it was clear that group work is something that has not been fully conceptualised into the Ghanaian mathematics classrooms. Although sometimes grouped, many students continued to work on their own and the only time they were seen talking to each other was when their task was completed, and they were comparing their answers. In addition to this, it was apparent that the teachers were uncomfortable using this teaching method as they went around looking at some individual work and providing individual feedback instead of focusing on the groups. Group work and problem-solving approaches were the least used methods in all lessons, and it was clear that the teachers themselves were unsure of the underlining principles of these methods of teaching and this is evidenced in the interview reports from the teachers.

As highlighted above, the teaching and learning practices of teachers and students from these schools are quite complex to explain as they contain both behaviourist and constructivist beliefs. The analysis of the actual classroom practices showed that though the teachers ascribed more positively to constructivist practices, their actual teaching practices were more instructional in nature.

RQ 3: How These Beliefs Influence the Implementation of Constructivist Principles of Mathematics Teaching and Learning

To find answers to this research question, the participants were interviewed to ascertain the reasons behind why they teach the way the do. The students were also interviewed to elicit information regarding their experiences as students of mathematics. Four themes, namely: (1) teaching for conceptual understanding; (2) the use of a variety of methods; (3) priorities when teaching; and (4) the national curriculum requirements, emerged from the teachers' interviews about their teaching practices and students' learning experiences. The first three themes shed light on their teaching practices, and the last theme addressed the teachers' views regarding students; learning experiences and participation. For ethical reasons and purpose of anonymisation, the teachers interviewed were given pseudonyms which are used in presenting the results.

The reports gathered from the teachers' interviews strongly support research findings that promoting conceptual understanding of mathematics concepts should and has been the aim of most teachers (Boaler 2009; Willis 2010). All four teachers interviewed expressed a genuine and deep-seated desire to make sure that students not only learn the procedures in mathematics, but also help them to develop conceptual understanding of the mathematical skills presented. Mr Asamuah and Mr Oduro, mathematics teachers in relatively small schools in two different villages, talked about their desire to help their students to develop conceptual understanding.

> I'm always interested in helping my students develop a deeper understanding of the concepts I teach them. This is the only way they can appreciate the beauty of the subject and also be able to apply these concepts in solving real life problems. (Mr Asamuah)
>
> I have over the years argued for the need to improve students understanding through the use of practical and concrete materials. The use of these goes a long way to help students to retain the knowledge they have acquired and can apply them in solving problems. I have tried to make my students understand the utilitarian benefits of the mathematical concepts that they learn and therefore uses practical examples to buttress the need for conceptual understanding. (Mr Oduro)

The individual differences that exist among students and the differences in learning styles call for the need to use different teaching methods to help attend to individual learning needs. The teachers interviewed acknowledge these individual differences and the differences in students learning styles. Mr Odum, an experienced mathematics teacher, spoke about the need for teachers to use different teaching methods:

> Hmmm. I have been teaching mathematics for the past 20 years, and I think one think most teachers do not pay attention to is the individual differences and differences in learning styles. I think there is the need for all teachers to be offered some training in this area so as to help cater for the individual differences in our classrooms.

According to Ernest (1994), teachers' beliefs and perceptions about mathematics education affect the way they teach and how they expect their students to learn.

Therefore, teachers have different priorities when it comes to teaching. All the teachers interviewed provided some intriguing revelations about their priorities when teaching. Mr Owusu, a teacher in a large urban school, expressed his dissatisfaction about the fact that examination has become the priority of most teachers:

> As for priority of teaching, we all know it is to help the students to understand and apply the mathematical concepts that they have learned in solving real life problems. However, the national curriculum is examination oriented, and we are therefore forced to teach in that line. For me, I am at helping my students prepare for their exam as that is what will be used to judge me. (Mr Owusu)
>
> I am always guided by the fact that understanding the concept is more important. I always make sure that my students develop conceptual understanding of the concept presented as this is what will help them to perform well in their examinations and in life and especially when they start working. (Mr Oduro)

According to Smith (1996), teachers' views and beliefs have always supported constructivist ideas and principles of teaching and learning. However, despite the numerous advantages associated with any theory, Andrews (2010b) argues that teachers' pedagogical and cultural orientations cannot be underestimated when implementing a new curriculum. The teachers' views regarding their students' learning and participation in class provided some interesting revelations which have either a direct or an indirect effect on the implementation of the new mathematics curriculum in Ghana.

The teachers' views about students' learning were consistent with both the principles of the national curriculum and their pedagogical and cultural orientations. For example, all four teachers interviewed indicated that students would be successful in mathematics if they played active roles in the teaching-learning process.

> For me, students will be successful in mathematics if they are actively involved in the teaching-learning process pay attention and follow the teacher's instruction and guidelines. I think we as teachers have to encourage all students to be actively involved in the teaching-learning process. (Mr Owusu)

Mr Odum, who has over 20 years of experience as a mathematics teacher, indicated that:

> You know those of us from the old school system are used to the structured and strict way of teaching. I think as our culture demands, children and for that matter, students ought to listen and emulate the adult in society. I followed my teacher's instructions strictly, and that was how I was able to pass my exams. I expect my students to be active participants in the teaching-learning process, but they cannot achieve the desired targets if they fail to adhere to my instructions and principles.

In addition to the above three major themes (i.e. importance of mathematics, students' participation, and teachers' role), three other themes were derived from students' interview responses, namely: (1) the importance of mathematics; (2) the students' participation in the teaching-learning process; and (3) the teachers' role The importance

of mathematics is well documented in the literature. As highlighted by Keith (2000), mathematics has become a pivotal subject in the school curriculum because of its connections with diverse fields. All 22 students who were interviewed acknowledged the importance of mathematics for their future academic and professional aspirations. It was, however, interesting to note that the majority of these students learn mathematics because it is a core subject and that they will need a pass in mathematics before they can get admission into the senior secondary school. One of the underlining principles of constructivism is students' active participation in the teaching-learning process.

As highlighted by Boaler (2009), students' active participation in the classroom is a key element for effective teaching and learning. All the students interviewed acknowledged the importance of their participation in the teaching-learning process. In as much as the students were willing to participate, their participation was influenced by some factors such as peer influence and culture. For example, eight students were of the view that they prefer to work alone as they will not be allowed to do cooperative work during their final examination. This suggests that the culture of working together has not been fully conceptualised within the Ghanaian context. Also, all the students indicated their willingness to participate in the teaching-learning process; but they prefer not to participate since they will be mocked at by their peers if they provide wrong answers.

The teacher plays an important role in the classroom. In a constructivist classroom context, the teacher acts as a facilitator in the teaching-learning process. Analysis of the students' interview responses showed that this idea has not been fully conceptualised in the Ghanaian classroom. For example, the students still perceive the teacher as the custodian of knowledge and that adopting the teacher's approach and methods of solving problems is the surest way of being successful in mathematics. Similarly, when the students were asked what it takes to be successful in mathematics, the majority were of the view that they have to follow the teacher's rules and practise the teacher's formulae. Although individual students learn or construct knowledge differently, it was interesting to note that all 22 students who were interviewed were of the view that how they learn or construct knowledge is to a large extent influenced by their peers and the teacher's actions and inactions. Unhealthy competition still characterises the classroom environment, and most students have developed the attitude of not participating in the teaching-learning process for fear of being mocked by their peers.

The results from the interviews suggested that students' active participation in the teaching-learning process is not encouraged as the teacher most often acknowledges only right answers and the classroom environment is quite intimidating for those who provide wrong answers. From the above discussions, students' and teachers' beliefs about mathematics education are contrary to the principles underpinning constructivism. As highlighted by Ernest (1989, 249), "teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics teaching and learning change consistent with the policy documentation". A change in the way mathematics is taught and learned in Ghanaian schools "depends fundamentally on the teacher's system of beliefs, and

the teacher's conception of the nature of mathematics" as well as the beliefs held by students (Ernest 1994, 1).

DISCUSSION

Over the years, reforms have raised students', teachers' and the general public's expectations for improved ways of teaching and learning. After the introduction of the new mathematics curriculum in Ghana, the expectations were very high following the abysmal performance of JHS 2 (Grade 8) in the Trends in International Mathematics and Science Study (TIMMS) with students' average score of 276 and 309 in mathematics in 2003 and 2007, respectively. These scores were significantly lower than the international benchmark average of 400 (Mullis, Martin and Foy 2008; UEW/GES 2003). Also, persistent criticism of teachers' inability to shift from a teacher-centred approach of teaching to more innovative teaching methods has put a lot of pressure on teachers and educators to look for improved ways of promoting conceptual rather than procedural understanding among students.

Therefore, it was not surprising that all five teachers were of the view that promoting students' understanding and active participation in the teaching-learning process is very important, which is consistent with the national curriculum recommendations. However, it was observed that the majority of students constructed their mathematical knowledge through the learning of procedures and formulae rather than comprehending the meaning of these procedures as established by (Baker 2008; Masingila 1993). It was observed that since teachers were trying to motivate and encourage students to actively participate in the teaching-learning process, their cultural and pedagogical orientations did not allow them to fully do this despite the immense benefits that this will bring to the classroom. For example, in all the observed lessons, the participation of the teacher overshadowed that of students, and in most cases, the teacher told their students what to do instead of acting as facilitator. It was also clear from the observations that students have not been introduced to the concept of social learning and lacked teamwork skills that are necessary to work effectively in groups to develop new knowledge. Teachers who are supposed to motivate students to develop the culture of teamwork fear losing control of their class as established by Ashton-Hay (2006).

Moreover, even though students learn well when they make mistakes, and their misconceptions are rectified through independent learning as established by Willis (2010), teachers were seen not to have confidence in their students. As indicated above, all the teachers were seen going around during group or individual work telling the students which formulae or approach to use so that they do not make mistakes. This was further emphasised during the interviews, where some teachers explained that providing or receiving correct answers is paramount and therefore they encouraged students to avoid making mistakes as such mistakes will cost them dearly in their final examinations. This method of teaching limits students' extension of their knowledge

and does not stimulate independent learning among students (Willis 2010). Similarly, as established by Brown (2000, 91), this approach also fosters a "climate of defensive learning in which learners try to protect themselves from failure, from criticism, and from competition with fellow students".

The implementation of the principles of constructivism in mathematics goes beyond the dichotomy of theory and practice as the role of culture in the teaching and learning process cannot be underestimated as highlighted by Andrews (2010a). Constructivism is premised on the belief that learners actively participate in the teaching-learning process to create, interpret and recognise knowledge in individual ways (Windschitl 1999, 167). However, the individual student's ability to be actively involved in this process is based on his/her acceptance into the group, respect, and acknowledgment of diverse individual views and working together to synthesise these divergent views to develop new knowledge.

The results of the study have established that students' active participation has been undermined in one way or another. Using students as the focal point, the culture of teamwork, accepting and appreciating each other's contribution have not been fully conceptualised in Ghanaian mathematics classrooms. The results further showed that individual students' participation is highly influenced by the kind of responses received from the rest of the class as those who provided wrong answers were ridiculed by their peers and this impacted negatively on their participation. It was therefore not surprising that the culture of teamwork or students working together was not evident in all lessons.

On the other hand, the culture of acknowledging only correct answers on the part of the teacher was another factor affecting students' participation and implementation of the new curriculum. This led to situations where only those who were confident and knew the answers to the question asked to participate in the teaching-learning process, and this was just a handful of the students in the class. In addition to this, the culture of "the adult is always right" was evident in most classrooms as students were seen most often accepting the teacher's answers, methods, and decisions without asking for clarifications, explanations, and justifications.

CONCLUSIONS AND IMPLICATIONS

Although mathematics teachers and students reported teaching and learning practices were complex to describe as they contain both traditional and constructivist beliefs, teachers' actual teaching practices were more directive. The results showed that cultural orientations within a specific classroom could either make or mar the sustenance of constructivism in a mathematics classroom. Due to the gap between the teacher's cultural orientations and what is expected of him/her in implementing the new mathematics

curriculum, it was interesting to note that all the teachers believed that when their students can provide correct answers, it means they have taught well.

Placing emphasis on correct procedures and answers only leads to passive participation among students, which negatively affects their attitude and achievement (Ellsworth and Buss 2000). Teachers should assess their teaching based on their students' ability to participate in experiences that accommodate problem-based learning, inquiry activities, and dialogues with peers and teachers that exposes students to multiple sources of knowledge and opportunity to demonstrate their understanding in diverse ways (Windschitl 1999, 167).

Implementing and sustaining constructivism in Ghanaian mathematics classrooms is, therefore, problematic as the cultural orientations of the country do not encourage teamwork and acknowledgment of individual contributions in the teaching-learning process. Thus, the way forward is for teachers to be proactive in promoting classroom environments free from intimidation and fear. This will not only avoid unnecessary competition among their students, but will also motivate more students to be actively involved in the teaching-learning process.

There is also the need for sensitisation workshops for teachers to help them understand the important role that students' mistakes and misconceptions play in the teaching-learning process and also the need to acknowledge each student's contribution. Also, students need to be encouraged to understand the importance of group work in developing conceptual understanding of mathematical concepts as a means of instilling the culture of teamwork in them. As suggested by Parkinson (2009), the use of peer-assisted learning support strategies will not only help in improving student performance but will go a long way in inculcating the culture of teamwork in classrooms.

Considering the cultural and pedagogical orientations of the Ghanaian teacher, it is recommended that Ghanaian teachers, therefore, ought to be encouraged to develop their lessons in such a way that they are oriented toward problem-solving where the teacher assumes the role of a knowledgeable guide, rather than an arbiter of what is correct, as suggested by Parkinson (2009) and Lim (2007).

Although the study findings were limited to only 12 JHSs, the implications of the study for further policy development in the area of mathematics education are promising for Ghana and other countries in similar situations. For example, the findings suggest that there is the need for a second look at the competitive nature of the Ghanaian school curriculum as this promotes procedural understanding of mathematics concepts rather than conceptual understanding. Similarly, the findings suggest that no matter the numerous advantages associated with particular theoretical underpinnings of mathematics education in a particular country or region, its implementation in another country or region is highly influenced by the cultural orientations of the people.

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