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The impact of effective teaching characteristics in promoting student achievement in Ghana

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ABSTRACT

This paper investigates the extent to which teacher behaviour in classroom affects student achievement gains in mathematics in Ghana. A representative sample of primary schools from three districts of the Upper East Region of Ghana was selected ($n = 73$) using stage sampling procedure, and written tests in mathematics were administered to all grade six students at the beginning and end of school year 2013–2014. Two observation instruments and a student questionnaire were used in collecting data on quality of teaching. Multilevel analyses revealed that teacher factors are associated with student learning outcomes. Implications for promoting quality in education are drawn.

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1. Introduction

During the last three decades international studies such as TIMSS and PISA published results on the performance of students in different learning outcomes for several countries around the world. These findings raised attention to both policy makers and the public since results were treated as indicators for the quality of education in each participating country. The media drew attention to the fact that some countries were found to perform less well than others and policy makers in these countries had to respond to criticisms about the effectiveness of their educational systems (Reynolds, 2006). Students in sub-Saharan Africa were found to perform less well than almost all the participating countries in these studies. This low student academic performance also emerged from evaluation studies conducted in this region and national assessments (Hungu et al., 2010; MOE, 2007, 2014; Moore et al., 2012).

In this context, policy makers in this region, and especially in Ghana where this study has been conducted, should search for ways of improving the quality of their educational system. To address this issue, policy makers may take into consideration the results of educational effectiveness studies which aim to address

the question of what works in education and why. Effectiveness studies did not only reveal that teachers and schools matter but also showed that the classroom level is more important than the school level in terms of explaining the variance in student achievement gains (e.g., Kyriakides et al., 2000; Scheerens and Bosker, 1997). Moreover, effectiveness studies and meta-analyses revealed that a large proportion of the classroom level variance can be attributed to teacher behaviour in the classroom; namely what teachers do in the classroom and how they interact with their students rather than to teacher personal characteristics, such as their beliefs and values (Muijs et al., 2014). For example, teacher ability to effectively deal with student misbehaviour, or teacher ability in providing structuring tasks to create linkage between different lessons and/or parts of a lesson can be considered as some aspects of teacher in-class behaviour that promote student learning outcomes (Kyriakides et al., 2013; Seidel and Shavelson, 2007). In fact, without effective teacher guidance and instruction in the classroom, learning cannot be achieved.

Factors related with teacher in-class behaviour have often been realized as uni-dimensional constructs. Such realization however is not able to provide a complete understanding of how the functioning of these factors may affect student outcomes. Consequently, many recent studies have started to consider teacher factors as multidimensional constructs, taking into account both their qualitative and quantitative characteristics when examining their functioning. This way, researchers may not only come to more holistic inferences on what makes teachers and

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schools effective, but also assist the development of specific strategies for improving educational practice (Kyriakides and Creemers, 2008).

Despite however the progress made over these years in highlighting the role that teachers have in promoting student learning, little of this strand of research has been conducted in developing countries; particularly in sub-Saharan Africa (Riddell, 2008; Muijs et al., 2014). Studies in sub-Saharan African countries mentioned above (i.e., SACMEQ, NEA) are based on cross-sectional data and explore the impact of various student background factors on student achievement. While studies of this nature shed some light on the status of educational attainment in these countries and revealed the importance of taking actions to promote learning outcomes; their findings cannot help policy makers identify ways of improving student learning outcomes due to their cross-sectional design. On the contrary, studies that collect data in more than one time point may demonstrate factors that affect student progress over time. At the same time, findings of educational effectiveness research (EER) stressing the importance of improving teaching skills to promote learning outcomes (e.g., Antoniou and Kyriakides, 2013; Muijs et al., 2014) may be seen as not relevant for promoting learning in classrooms with much more difficult working conditions (e.g., class size in developing countries is almost twice as big as the class size in developed countries). Additionally, studies conducted in developing countries have mostly focused on factors relating to the economic aspects of education, such as the provision of resources (e.g., Botha and Herselman, 2015; Stols et al., 2015; Uduku, 2015) and teacher content knowledge (Pournara et al., 2015), with fewer studies being focused on teaching skills that promote quality of teaching (Carnoy et al., 2015). The economic approach followed in these studies focused on estimating the relationship between the provision of educational inputs and educational outputs, assuming that increased provision of inputs would lead to increased outputs (Kyriakides, 2005). In this context, the study reported here investigates the extent to which teacher in-class behaviour should also be examined more systematically and more focused in-service training courses should be promoted based on both the quantitative and qualitative characteristics of teacher behaviour. Thus, the aim of this study is to identify the extent to which teacher factors included in the dynamic model of educational effectiveness (Creemers and Kyriakides, 2008) are associated with student achievement gains in mathematics in Ghana.

2. The dynamic model of educational effectiveness

The dynamic model is multi-level in nature and refers to factors operating at four different levels: the student, classroom, school and educational system. The teaching and learning situation is emphasized, and the roles of the two main actors (i.e., teacher and student) are analyzed. Above these two levels, the model refers to school factors which are expected to influence teaching and learning by developing and evaluating school policy for teaching and policy for improving the school learning environment (SLE). At the highest level, the model refers to the influence of educational systems in developing and evaluating educational policy for teaching and learning. A major distinction of the model as compared to the integrated models developed in the 1990s (i.e., Creemers, 1994; Scheerens and Bosker, 1997; Stringfield and Slavin, 1992) is that a specific framework to measure the functioning of effectiveness factors is used. The model refers not only to how frequently each effectiveness factor is present in a class, school, or educational system, but also to *qualitative* characteristics of the functioning of each factor. Thus, each factor is defined and measured using five dimensions: *frequency, focus, stage, quality, and differentiation* (see Creemers and Kyriakides, 2015). Results of

previous studies provide support to the construct validity of the five measurement dimensions of the effectiveness factors at the classroom level, supporting the notion that viewing them as uni-dimensional constructs is rather restricting (Kyriakides and Creemers, 2008). Studies in the field of teacher professional development have also demonstrated the practical use of measuring both the quantitative and qualitative characteristics of teacher behaviour, in terms of being able to implement more focused and effective teacher training courses based on each teacher's specific professional development needs (Antoniou and Kyriakides, 2011; Antoniou et al., 2015). These studies however have only been conducted in western countries. Research in developing countries may examine whether the five measurement dimensions proposed by the dynamic model can be used for measuring effectiveness factors in a diverse context, providing further support to their generic nature and a basis for teacher professional training in developing countries.

Since this study is concerned with the effect of teacher factors, some further information about these factors is provided below. At the classroom level, the model refers to eight factors found to be related to student achievement (e.g., Brophy and Good, 1986; Muijs et al., 2014). The eight factors are: orientation, structuring, questioning, teaching modeling, application, management of time, teacher role in making classroom a learning environment, and assessment. These eight factors do not refer only to one approach of teaching such as structured or direct teaching (Joyce et al., 2000) or to approaches associated with constructivism (Schoenfeld, 1998). An integrated approach in defining quality of teaching is adopted. For example, the dynamic model does not refer only to skills associated with direct teaching and mastery learning such as structuring and questioning but also to orientation and teaching modeling which are in line with theories of learning associated with constructivism (Breklemans et al., 2000). Moreover, the different aspects of collaboration (i.e., teacher-student and student-student interactions) are included under the overarching factor concerning teacher's contribution to the establishment of the classroom learning environment. Table 1 presents the main elements of the teaching factors included in the model.

Longitudinal studies (e.g., Creemers and Kyriakides, 2009, 2010a, 2010b; Kyriakides and Creemers, 2008; Panayiotou et al., 2014) and meta-analyses (Kyriakides et al., 2010; Kyriakides et al., 2013) provided empirical support to the validity of the model but available data on the effects of these factors come from western countries. However, the transferability of models of school effectiveness generated from developed countries in another context is not straightforward. This is because factors determining educational effectiveness can be complex, interwoven and dependent on local context (Heneveld and Craig, 1996; Saunders, 2000). Schools in the industrialized and western countries share similar characteristics in terms of their context and therefore, the way results emanating from such countries apply in contexts that are different may be more complicated than assumed (Fleisch, 2007; Hopkins, 2002). More importantly, to be useful beyond the countries where they are initiated, studies offering policy guidance need to be based on a sound understanding of how far prevailing conditions are the same or different in other contexts (Saunders, 2000).

As a result of economic constraints in sub-Saharan African countries, the learning conditions in many schools are inadequate for education provision (Gauthier and Dembélé, 2004). Specifically, teaching and learning resources (e.g., classroom space, textbooks, usable blackboard, enough desk places), and particularly the quantity and quality of teaching are comparatively inadequate in these countries (Motivans et al., 2006). The Ghanaian educational environment therefore, which differs at a large extent in terms of school characteristics, quality and quantity of teaching, and

Table 1

The main elements of each teacher factor included in the dynamic model.

Factors	Main elements
1) Orientation	a) Providing the objectives for which a specific task/lesson/series of lessons take(s) place; and b) challenging students to identify the reason why an activity is taking place in the lesson
2) Structuring	a) Beginning with overviews and/or review of objectives; b) outlining the content to be covered and signalling transitions between lesson parts; and c) drawing attention to and reviewing main ideas.
3) Questioning	a) Raising different types of questions (i.e., process and product) at appropriate difficulty level; b) giving time for students to respond; and c) dealing with student responses.
4) Teaching modelling	a) Encouraging students to use problem solving strategies presented by the teacher or other classmates; b) inviting students to develop strategies; and c) promoting the idea of modelling.
5) Application	a) Using seatwork or small group tasks in order to provide needed practice and application opportunities; and b) using application tasks as starting points for the next step of teaching and learning.
6) The classroom as a learning environment	a) Establishing on task behaviour through the interactions they promote (i.e., teacher-student and student-student interactions); and b) Dealing with classroom disorder and student competition through establishing rules, persuading students to respect them and using the rules.
7) Management of time	a) Organising the classroom environment; and b) Maximising engagement rates.
8) Assessment	a) Using appropriate techniques to collect data on student knowledge and skills; b) analysing data in order to identify student needs and report the results to students and parent; and c) evaluating their own practices.

student background characteristics from the previous western countries in which the model was tested was chosen to further examine the generalisability of the dynamic model. Findings on what constitutes effective teaching from the perspective of a relatively less endowed educational system may be attained, upon which suggestions could be made not only for Ghana, but also countries of similar characteristics.

3. Methods

3.1. Participants

The study reported here was conducted in the Upper East Region, one of the ten regions of Ghana, which is located in the northern part and has a total population of 701 schools. The Upper East Region was selected firstly due to the fact that it was more easily accessible in terms of data collection and secondly due to the fact that it is one of the most disadvantaged/deprived regions in the country with a very low educational performance, as well as the fact that it ranks high when it comes to teacher shortage or unqualified teachers (MOE, 2014). Taking into consideration these features that differentiate the Upper East region from other countries in which validation studies for the dynamic model took place, as well as from other countries where studies concerning effective teaching were conducted, this area was chosen for this study.

Using the stage sampling procedure, three out of the ten districts of the region were randomly selected. Thereafter, 73 schools representing about 10 per cent of the school population in the region were randomly selected. All grade six classes/teachers ($n=99$) and their students ($n=4386$) participated in this study. Grade six was chosen since it can be considered as the terminal point of primary education, it provides the essential building

blocks to the rest of the levels of education and/or work related skills to those who do not continue their education from that level (Odure, 2000). Out of this sample, 55 schools were public whereas 18 were private. The chi-square test did not reveal any statistically significant difference between the research sample and the population in terms of school type ($X^2=1.03$, d.f. = 1, $p=0.31$). In regard to the teacher sample, some descriptive statistics are provided in Table 2. It is important to note that, as shown in Table 2, more than 50 per cent of the sample's teachers have less than four years of teaching experience and only 13 per cent of them have a Bachelor of Education or any other Bachelor's degree. However, the chi-square test did not reveal any statistically significant difference between the research sample and the population in terms of teacher qualifications ($X^2=1.48$, d.f. = 1, $p=0.22$). Due to the fact that for the teacher population it was not possible to obtain the national data separately for the teachers that had a Teacher Certificate/Diploma from Training College and teachers that obtained a Bachelor of Education, the comparison of the teacher sample and population was made in terms of whether teachers a) only had a school certificate and b) had a higher education certificate. Such comparison was not possible to be made between the teaching experience and age of the sample and teacher population due to the fact that this information was unavailable for the national population.

In regard to the student sample, 49 per cent were male and 51 per cent female and the chi-square test did not reveal any statistically significant difference between the research sample and the population in terms of student gender ($X^2=0.95$, d.f. = 1, $p=0.33$). Moreover, the *t*-test did not reveal any statistically significant difference between the research sample and the population in terms of the size of class ($t=1.583$, d.f. = 3585, $p=0.11$). Specifically, for this study the mean class size was 43 students per class. Therefore, the student sample is representative

Table 2

Descriptive statistics concerning teacher age, experience and qualifications.

Variables		Frequency	Percentage
Age	Under 25	37	37.4
	Between 26 and 35	48	48.5
	Between 36 and 45	11	11.1
	Between 46 and 55	3	3.0
Highest Certificate	School Certificate (e.g. SSCE, GCEA Level)	33	33.3
	Teacher Certificate/Diploma from Training College	53	53.5
	Bachelor of Education/other Bachelor's Degree	13	13.1
Teaching Experience	0–3 years	51	51.5
	4–7 years	25	25.3
	8–13 years	18	18.2
	14+ years	5	5.1

of schools in the Upper East Region of Ghana in terms of gender, school type, and class size for which statistical data of this region are available.

3.2. Dependent variable: student achievement in mathematics

Ghana operates a centralized system with standard mathematics text books for use in all primary schools (MOE, 2007). The assessment of learning is however the responsibility of schools and their teachers. For this reason, written tests based on the prescribed curriculum were developed. Mathematics was chosen since research has shown that the school effect is greater in this subject as opposed to language where the home learning environment has a relatively larger effect (Melhuish et al., 2008; Reynolds et al., 1996; Rodriguez and Tamis-LeMonda, 2011). It would therefore be easier to detect the effect of quality of teaching on student learning outcomes in mathematics in case that it mattered. To gain an accurate insight on the teaching and learning activities used in grade six in Ghana, specification tables were first developed for both the pre- and post-test measures capturing the salient themes in the curriculum and mathematics textbooks. This was to ensure that the teaching and learning activities within each major content area of the curriculum were fairly addressed. In so doing, it was shown that the specified teaching and learning activities in the text books were more of the algorithmic type with relatively few problem solving activities. The tests produced covered tasks on basic operations, numbers and numerals, measurement, handling money, data collection and analysis, and a few problem solving activities. Some items included arranging numbers from the biggest to the smallest and vice versa, unit conversion and finding the perimeter of given geometrical shapes. The full version of the tests can be found in Azigwe (2015). The construction of the tests was subject to controls for reliability and validity (see Azigwe, 2015).

The pre-test measure was administered at the beginning of the school year in September 2013, whereas the post-test was administered at the end of the school year in July 2014. In both measures, the Extended Logistic Model of Rasch (Andrich, 1988) was used to analyze the emerging data. The analysis revealed that the scales in both measures had satisfactory psychometric properties. For each scale, the indices of cases (i.e., students) and item separation were higher than 0.85, indicating that the separability of each scale was satisfactory (Wright, 1985). Moreover, the infit mean squares and the outfit mean squares of each scale were near one and the values of the infit t scores and the outfit t scores were approximately zero. Furthermore, each analysis revealed that all items had item infit within the range 0.85–1.18. Therefore, each analysis revealed that there was a good fit to the model (Keeves and Alagumalai, 1999). Thus, for each student, it was possible to generate two different scores for his/her achievement in mathematics at the beginning and at the end of Grade 6, by calculating the relevant Rasch person estimates.

3.3. Explanatory variables: student background factors

In order to control for the effects of background factors, a student questionnaire was designed for collecting data on student and school background characteristics. Grade six students completed the questionnaires during the school year 2013; and the response rate was very high (89 per cent). The first section elicited each student's demographic profile and family socio-economic status (SES). The second section elicited information about parental support for home study, learning materials at home, and parental attitudes for learning.

3.3.1. Student background variables

Several background characteristics were taken into account, which were coded as follows: gender (boys=0, girls=1); educational level of father and mother (no education=0; middle school=1; secondary school=2; college/university or above=3) and occupational status of fathers and mothers (not employed, peasant farmer, laborer=0, commercial farmer, small scale business owner, public servant=1).

3.3.2. Household economic durables

In measuring this variable, an attempt was made to include more culturally valid indicators of social and material assets (i.e., Lockheed et al., 1988). As such, as well as the conventional household economic assets, variables such as access to water, transportation, house type, waste disposal, land and live stock ownership were taken into account. The emerging data were analyzed with Principal Component Analysis to determine the weight for each of the items and an index was created (see Azigwe, 2015).

3.3.3. The home learning materials

Students were asked to indicate if they have a quiet place at home for learning. A list of learning materials was also provided from which the students indicated those available in their homes. The emerging data were also analyzed with Principal Component Analysis and an index was created for each student.

3.3.4. Opportunity to learn—Homework

The questionnaire included items for the students to indicate the level of parental support they received for homework and private tuition with the use of a Likert scale. From the emerging data, two indices were created for each student for learning opportunities (i.e., home work and private tuition).

3.3.5. Parental support

A Likert scale of the student questionnaire was concerned with the role of parents in supporting their children's learning. Confirmatory Factor Analysis (CFA) was carried out building on a three factor solution. This three-factor structure attained satisfactory goodness-of-fit indices ($X^2 = 274.5$, d.f. = 24, $p = 0.001$, CFI = 0.96, RMSEA = 0.05) and the following factors were created: a) *Parental attitude towards mathematics* (e.g., my parents believe it is important for me to study mathematics; my parents like mathematics), b) *Monitoring children's progress* (e.g., my parents make sure I did my homework before I sleep), c) *Oversee children after school time* (e.g., my parents know where I go after school; when I leave the house my parents ask me where I am going).

3.3.6. School level factors

A teacher questionnaire was also developed for collecting data on teacher age, gender, level of education, and teaching experience. The questionnaire also solicited data on school characteristics (i.e. school district, school location, and school type). This questionnaire was administered at the end of the school year 2014 to all teachers of the sample and an extremely high response rate (98 per cent) was obtained.

3.4. Explanatory variables at classroom level: quality of teaching

Three instruments were used to measure quality of teaching: a) student questionnaire, b) high-inference observation instrument, and c) low-inference observation instrument. Three rather than only one instrument were used since combining data generated from more than one source may provide a better insight of what is being measured, and in this case of the factors associated with quality of teaching and their five measurement

dimensions (Cheng and Marsh, 2010; Fresko and Nasser, 2001). A detailed description of these instruments can be found in Creemers and Kyriakides (2012). The two observation instruments are used to generate data about each factor of the dynamic model and their measurement dimensions except of the factor concerned with student assessment. These two instruments were used in studies conducted in Europe and support to their validity and reliability has been provided (e.g., Kyriakides and Creemers, 2008; Kyriakides et al., 2014). All classroom observations were conducted by the first author. Therefore, the inter-rater reliability of the data emerged could not be tested. However, the researcher attended a training on using the observation instruments and the inter-rater reliability emerged from the training was found to be satisfactory (above 0.76).

The student questionnaire measuring the factors of the dynamic model has been used in studies conducted in different European countries (see Kyriakides et al., 2014; Panayiotou et al., 2014). This questionnaire was adapted to the context of Ghana and was first piloted with 120 students in four primary schools in Ghana. The pilot study revealed that a number of items, especially those dealing with the differentiation and focus dimensions of most teacher factors, were not well understood by the students, and were thereby dropped (see Azigwe, 2015). The revised version of the questionnaire was able to measure all the eight effectiveness

factors of the model but not all measurement dimensions. By the end of the school year 2013–2014, the revised version of the student questionnaire was administered to the student sample and the response rate was extremely high (i.e., 83 per cent). During the same period, classroom observations were conducted to observe the teaching behaviour of all grade 6 teachers of the school sample (n = 99).

Confirmatory factor analyses (CFA) were conducted to test the validity of the two observation instruments and the student questionnaire. CFA was appropriate as the objective was to test whether the data fit a hypothesized measurement model (in this case, the assumptions of the dynamic model in regard to quantitative and qualitative dimensions of each factor). Each CFA model was estimated using maximum likelihood methods (ML). Several fit indices were used to evaluate the extent to which the data fit the models tested, namely, the scaled chi-square, comparative fit index (CFI), and the root mean-square error of approximation (RMSEA). Finally, the factor parameter estimates for the models with acceptable fit were examined to help interpret the models. For CFI, values close to 1.00 are most satisfactory to imply that the model has a good fit to the data, whilst for RMSEA even though values less than 0.05 are preferred, values at the level of 0.08 are considered acceptable (Bentler, 1995).

Table 3

Parameter estimates (and standard errors) for the analysis of student achievement in mathematics (students within classes).

	Model 0	Model 1	Model 2	Model 3	Model 4a	Model 4b	Model 4c	Model 4d
Fixed Part (Intercept)	−0.994 (0.080)	−1.014 (0.086)	−1.219 (0.117)	−2.118 (0.471)	−1.738 (0.458)	−1.775 (0.461)	−1.805 (0.458)	−1.882 (0.316)
Students' context								
Prior knowledge (Pre-test measure)		0.369* (0.014)	0.360* (0.014)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)
Educational level of mothers		0.039* (0.015)	0.046* (0.016)	0.038* (0.016)	0.036* (0.016)	0.036* (0.016)	0.036* (0.016)	0.038* (0.016)
Occupational status of fathers		0.071* (0.030)	0.084* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)
Home learning environment								
Learning Materials			0.042* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.041* (0.014)	0.041* (0.014)
Private tuition			−0.022* (0.10)	−0.022* (0.11)	−0.022* (0.10)	−0.022* (0.10)	−0.022* (0.10)	−0.022* (0.10)
Children are offered learning opportunities after school time			0.050* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)
School Context								
Aggregate of educational level of mothers				0.502* (0.111)	0.502* (0.111)	0.502* (0.111)	0.502* (0.111)	0.498* (0.110)
Teacher factors: High inference observation instrument								
Orientation					0.295* (0.083)			
Structuring						0.215* (0.065)		
Application							0.245* (0.072)	
Management of time								0.264* (0.083)
Random Part								
Classroom	54.9%	30.8%	30.7%	22.8%	19.9%	20.3%	20.2%	20.7%
Students	45.1%	37.7%	37.4%	37.4%	37.4%	37.4%	37.4%	37.4%
Explained		31.5%	31.7%	39.8%	42.7%	42.3%	42.4%	41.9%
Significance test								
X2	8131	6737	5791	5758	5746	5748	5747	5749
Reduction		1394	2340	2373	2385	2383	2384	2382
Degrees of freedom		3	3	1	1	1	1	1
p value		0.001	0.001	0.001	.001	.001	.001	0.001

	Model 0	Model 1	Model 2	Model 3	Model 4e	Model 4f	Model 4g	Model 4h	Model 4i
Fixed Part (Intercept)	−0.99 (0.080)	−1.01 (0.086)	−1.22 (0.117)	−2.12 (0.471)	−1.74 (0.471)	−1.79 (0.445)	−1.75 (0.448)	−1.85 (0.456)	−1.88 (0.455)
Students' context									
Prior knowledge (Pre-test measure)		0.369* (0.014)	0.360* (0.014)	0.359* (0.015)	0.359* (0.015)	0.358* (0.015)	0.358* (0.015)	0.359* (0.015)	0.358* (0.015)
Educational level of mothers		0.039* (0.015)	0.046* (0.016)	0.038* (0.016)	0.039* (0.016)	0.039* (0.016)	0.038* (0.016)	0.039* (0.016)	0.039* (0.016)
Occupational status of fathers		0.071* (0.030)	0.084* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.082* (0.033)
Home learning environment									
Learning Materials			0.042* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.041* (0.014)
Private tuition			−0.022* (0.10)	−0.022* (0.11)	−0.022* (0.10)	−0.022* (0.10)	−0.023* (0.10)	−0.022* (0.10)	−0.022* (0.10)
Children are offered learning opportunities after school time			0.050* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)
School Context									
Aggregate of educational level of mothers				0.502* (0.111)	0.494* (0.110)	0.495* (0.111)	0.480* (0.111)	0.501* (0.111)	0.498* (0.107)
Teacher factors: High inference observation instrument									
Questioning					0.23*(0.07)				
Modeling strategies						0.28*(0.08)			
Teacher-student Interactions							0.25*(0.06)		
Student-student Interactions								0.28*(0.08)	
Dealing with classroom Disorder									0.30*(0.09)
Random Part									
Classroom	54.9%	30.8%	30.7%	22.8%	20.8%	19.9%	19.3%	20.3%	20.4%
Students	45.1%	37.7%	37.4%	37.4%	37.4%	37.4%	37.4%	37.4%	37.4%
Explained		31.5%	31.7%	39.8%	41.8%	42.7%	43.3%	42.3%	42.2%
Significance test									
X2	8131	6737	5791	5758	5750	5746	5743	5748	5748
Reduction		1394	2340	2373	2381	2385	2388	2383	2383
Degrees of freedom		3	3	1	1	1	1	1	1
p value		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

* = statistically significant effect at level .05.

First-order CFA models were developed separately for each teacher factor with satisfactory results in terms of their fit to the data. For example, under the student questionnaire, the CFA model concerned with the structuring skills of teachers produced reasonable goodness-of-fit indices (i.e., $X^2=96.37$; $df=19$; $p<0.001$; $CFI=0.98$; $RMSEA=0.03$). Similar results emerged from the observation data about the fit of each factor. For example, CFA analysis of the items of the high-inference observation instrument measuring the structuring factor produced satisfactory goodness-of-fit indices ($X^2=5.8$, $d.f.=3$, $p=0.12$; $CFI=0.99$; $RMSEA=0.08$). Similarly, the first-order CFA models for the rest of the teacher factors produced satisfactory results (i.e., $CFI>0.90$, $RMSEA<0.08$). Analysis of the data emerged from the low inference observation instrument generated scores per each dimension of the five teacher factors that are measured with this instrument (i.e., application, modeling, orientation, questioning, and structuring).

4. Results

The MLwiN software was used in conducting multilevel analyses searching for the effect of the teacher factors on student achievement gains in mathematics. Separate multilevel modeling analyses were conducted for each of the two observation instruments and the student questionnaire. Since no effect of the teacher factors was identified through the student questionnaire the results of these analyses are not presented. Using the data from the

high inference observation instrument (see Table 3), the first step was to run a two-level model (classroom/teacher and student level) with no explanatory variables (i.e., empty model) to determine the variance at each level. The results showed that 55 per cent of the variance lied at the classroom level while the remaining 45 per cent was located at the student level. The variance was found to be statistically significant at each level. Then, in models 1 and 2, student background variables were added to the empty model to assess their relative importance on achievement. Specifically, variables such as students' prior achievement, educational level of mother, occupational status of father, learning materials, private tuition and provision of learning opportunities after school time had statistically significant effects on student achievement at level 0.05. However, the educational level of father, occupational status of mother, economic house hold goods, language at home, home work, and parental attitude towards mathematics were not found to have statistically significant effects on achievement at level 0.05 and were not included in the following models.

In model 3, school context variables were added to model 2. Mothers' educational level at school level had a statistically significant effect at level 0.05, whilst school location, school type and class size did not have statistically significant effects on achievement. Model 3 shows that 31.7 per cent of the variance in achievement is explained by the background factors, whilst 30.7 and 37.4 per cent of the variance remained unexplained at the classroom and student level respectively. The fit of this model was

Table 4

Parameter estimates (and standard errors) for the analysis of student achievement in mathematics (students within classes).

	Model 0	Model 1	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e
Fixed Part (Intercept)	−0.994 (0.080)	−2.118 (0.471)	−2.055 (0.427)	−2.031 (0.447)	−1.822 (0.432)	−2.091 (0.465)	−1.932 (0.445)
Students' context							
Prior knowledge (Pre-test measure)		0.359* (0.015)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)	0.359* (0.015)
Educational level of mothers		0.038* (0.016)	0.038* (0.016)	0.038* (0.016)	0.038* (0.016)	0.038* (0.016)	0.038* (0.016)
Occupational status of fathers		0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)	0.083* (0.033)
Home learning environment							
Learning Materials		0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)	0.040* (0.014)
Private tuition		−0.022* (0.11)	−0.022* (0.11)	−0.022* (0.11)	−0.022* (0.11)	−0.022* (0.11)	−0.022* (0.11)
Children are offered learning opportunities after school time		0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)
School Context							
Aggregate of educational level of mothers		0.502* (0.111)	0.502* (0.111)	0.502* (0.111)	0.502* (0.111)	0.502* (0.111)	0.502* (0.111)
Frequency							
Orientation			0.077 (0.076)				
Structuring			0.126 (0.074)				
Application			0.130* (0.055)				
Modeling			0.002 (0.062)				
Questioning			0.010 (0.083)				
Stage							
Orientation				0.045 (0.156)			
Structuring				0.206* (0.096)			
Application				0.163 (0.094)			
Modeling				0.002 (0.082)			
Questioning				0.085 (0.092)			
Focus							
Orientation					0.302 (0.978)		
Structuring					0.004 (0.456)		
Application					0.857 (0.834)		
Modeling					2.085* (0.981)		
Questioning					0.037 (0.897)		
Quality							
Orientation						0.064 (1.40)	
Structuring						0.086 (0.149)	
Application						0.676 (1.043)	
Modeling						3.563* (1.019)	
Questioning						1.991* (0.869)	
Differentiation							
Orientation							0.245 (0.356)
Structuring							0.172 (0.598)
Application							0.903* (0.273)
Modeling							0.033 (0.368)
Questioning							0.215 (0.476)
Random Part							
Classroom level	54.9%	22.8%	16.4%	17.2%	17.3%	12.1%	18.1%
Student level	45.1%	37.4%	37.4%	37.4%	37.4%	37.4%	37.4%
Explained		39.8%	46.2%	45.4%	45.3%	50.5%	44.5%
Significance test							
X2	8131	5758	5727	5733	5733	5702	5737
Reduction		2373	2404	2398	2398	2429	2394
Degrees of freedom		7	1	1	1	2	1
p value		0.001	.001	.001	.001	.001	.001

Note: Models 0 and 1 are the same as models 0 and 3, respectively of Table 3.

tested against model 2. The likelihood statistic (X^2) showed a significant change between model 2 and model 3 ($p < 0.001$), which justifies the selection of model 3.

The next step was to run different versions of model 4 (i.e., models 4a–4i). In each version of model 4 the first-order factor scores of the SEM models, which refer to the teacher factors of the dynamic model, were added one by one to model 3. The fit of each model was tested against model 3. The likelihood statistic (X^2) showed a significant change between model 3 and each version of model 4 ($p < 0.001$), which implies that variables measuring the

teacher factors have significant effects on student achievement in mathematics. Moreover, all the teacher factors have statistically significant effects on student achievement in mathematics. Finally, to examine the joint effects of the teacher factors on student achievement all the factors were entered in one model which was found to explain more variance in student achievement than any version of model 4 (i.e., 45 per cent).

Table 4 presents the results of the analysis searching for the impact of teacher factors and their dimensions as these were measured through the low-inference observation instrument. The

student background factors were first added to the empty model and then five different versions of model 2 measuring the impact of each dimension of the teacher factors measured through the low inference observation instrument were created. Thus, Table 4 presents the final model before entering the factor scores emerged by the low-inference observation instrument (see model 1), as well as the models measuring the impact of each factor and dimension (i.e., models 2a–2e). The five measurement dimensions of the factors, namely frequency, stage, focus, quality and differentiation were entered to models 2a–2e respectively and the following observations arise.

First, model 2a refers to the impact of the frequency dimension of the effectiveness factors on student achievement in mathematics. The frequency dimension of application was found to have a statistically significant effect on student achievement, while for the other factors no statistically significant effect was identified at 0.05 level. Second, in regard to the impact of the stage dimension of teacher factors (model 2b), the stage dimension of structuring was found to be associated with mathematics, whereas the stage dimension of the four other factors was not associated with student achievement. Third, the figures of model 2c reveal that the focus dimension of modeling is associated with student achievement in mathematics. The figures of model 2d refer to the impact of the quality dimension of each effectiveness factor upon student achievement. We can observe that model 2d explains more variance than any other alternative model 2, and this reveals the importance of using the quality dimension to measure the impact of teacher factors on student achievement. Moreover, the quality dimension of two factors (i.e., modeling and questioning) was found to be associated with student achievement. Finally, the figures of model 2e reveal that the differentiation dimension of application is related to student achievement, whereas the differentiation dimension of all the other factors is not associated with student achievement in mathematics. The fit of each model was tested against model 1. The likelihood statistic (X^2) showed a significant change between model 1 and each version of model 2 ($p < 0.001$). In the final step, all dimensions of the teacher factors were entered together in one model to determine their joint effects on achievement. Although not shown in Table 4, this model explained 53 per cent of the variance in student achievement.

Having established that the teacher factors of the dynamic model had an impact on student achievement, an analysis of the effects of the factors on achievement by taking into account

differences in class size was also conducted to determine whether a significant difference would emerge. To do this, the total sample was split into different groups by taking into account the size of the class (i.e., from 15–34, 34–43, and 45–88). As regards the data from the high-inference observation instrument, all the teacher factors had statistically significant effects on student achievement irrespective of class size. No interaction with class size was also observed by comparing the data that emerged from the low-inference observation instrument.

Table 5 presents the effect sizes which emerged by calculating Cohen's d of the teacher factors and their dimensions as emerged from using the observation instruments. One can see that the effect sizes of all the factors and their dimensions are higher than 0.30, and in three cases (i.e., Application under the high-inference instrument, the frequency dimension of Application, and the quality dimension of Modeling) their effect sizes are much higher than 0.35. This is a finding that has not emerged in earlier studies conducted in European countries where the effect sizes of these factors were found to be much smaller (Kyriakides et al., 2013; Panayiotou et al., 2014).

5. Discussion

Four decades of research on effective teaching revealed the significance of teaching factors as the most important predictor of student learning outcomes (Muijs et al., 2014; Scheerens and Bosker, 1997). Unfortunately, little of this strand of research has been conducted in developing countries, particularly in Sub-Saharan African countries. Research output on school and teacher effectiveness has derived predominantly from the western and industrial school context (Riddell, 2008). The current study contributes in filling the gap with data on effective teaching from the perspective of Ghana.

First, this study seems to show that teachers and schools may matter more in developing rather than in developed countries. The multilevel analysis revealed that 55 per cent of the total variance in student achievement in mathematics was situated at the classroom level and only 45 per cent at the student level. This finding suggests that the classroom/teacher effect is much bigger in Ghana than in developed countries where studies conducted during the last four decades reveal that more than 60 per cent of variance is situated at the student level (see Creemers and Kyriakides, 2008; Scheerens and Bosker, 1997). Even after controlling for multiple background factors at student and school level, the variance component at the classroom level was still much higher (i.e., 30.7 per cent) than those reported in other effectiveness studies conducted in developed countries (e.g., Kyriakides and Creemers, 2008; Muijs et al., 2014; Panayiotou et al., 2014). This finding raises the importance of conducting effectiveness studies in Ghana and other African countries. Similar results were shown by Chowa et al. (2015) whose study was also conducted in Ghana and aimed at illustrating the effects of student- and school- level variables on student achievement in mathematics and English. Even though the study by Chowa et al. was focused on school rather than classroom level factors, multilevel analysis showed that more than 40 per cent of variation in academic achievement was between schools. In addition, using cross sectional data, Heyneman and Loxley (1982) found that SES was more important than school factors in determining children's academic performance in economically developed countries. Similar results are reported by Park (2008), who discussed how the association of the home literacy environment on reading achievement varies from country to country. The current study provides further evidence about the importance of teachers and schools in developing countries to use value added data and illustrate that the teacher effect is bigger than the effect of student background factors

Table 5

Effect sizes (as expressed by Cohen's d) of the teacher factors and their dimensions on student achievement gains in mathematics emerged from the high- and the low-observation instruments.

Teacher factors per observation instrument	Effect sizes
High-inference observation instrument	
Orientation	0.32
Structuring	0.34
Application	0.38
Time management	0.31
Questioning	0.33
Modeling	0.32
Teacher-student interactions	0.30
Student-student interactions	0.33
Managing classroom Disorder	0.34
Low-inference observation instrument	
Structuring: Stage dimension	0.33
Application: Frequency dimension	0.39
Application: Differentiation dimension	0.31
Questioning: Quality dimension	0.35
Modeling: Focus dimension	0.34
Modeling: Quality dimension	0.38

(including SES). Further studies in Ghana (or other contexts of similar characteristics) are obviously needed to determine whether this finding can be replicated.

Second, the teacher factors of the dynamic model and their measurement dimensions were found to have statistically significant effects on student achievement. In addition, the teacher factors were able to explain more variance in student achievement than the previous studies testing the dynamic model at classroom and school level. For example, in the longitudinal study conducted in six European countries (Belgium/Flanders, Cyprus, Germany, Greece, Ireland, and Slovenia), the additional variance in student achievement in mathematics explained by each of the eight teacher factors was attained at the range of 0.7 to 1.7 per cent (Panayiotou et al., 2014). In the current study, the variance explained by each of the eight teacher factors was in the range of 2.0 to 3.5 per cent. Moreover, the effect sizes (i.e., Cohen's *d*) of the teacher factors and their dimensions as emerged from using the observation instruments were much bigger (0.30) than those emerged in earlier studies testing the validity of the dynamic model (i.e., around 0.15). These results show that the teacher factors of the dynamic model are associated with student outcomes in both, different countries with more resource-rich contexts and countries with fewer resources, providing further support to the main assumptions of the model regarding the generic nature of these factors. These results are also partly in line with the results of meta-analyses which provide some support to the generic nature of these factors (Kyriakides et al., 2013; Seidel and Shavelson, 2007). The studies which were taken into consideration in these meta-analyses were not however based on developing countries and therefore these results from Ghana provide some initial evidence on their effectiveness in countries with fewer resources.

Third, the study provides support to the argument that an integrated approach to effective teaching should be adopted. Factors related to both direct and active instruction (e.g., time management, structuring) and constructivism (e.g., orientation, modeling) had statistically significant effects on student achievement. This finding empirically corroborates the theoretical underpinnings of the dynamic model which, by pursuing an integrated approach, incorporates factors from both instructional perspectives at the teacher level. Based on the findings reported above, it can be claimed that teacher factors are even more important in promoting quality of education in developing rather than developed countries. Further studies in Ghana and other African countries are however needed to test the generalisability of the findings of this study.

Fourth, the integrated educational effectiveness models developed in the 1990s (i.e., Creemers, 1994; Scheerens and Bosker, 1997; Stringfield and Slavin, 1992) were only concerned with the quantitative aspects of effectiveness factors. Kyriakides and Creemers (2008) demonstrated the need for the use of a measurement framework that incorporates both the quantitative and qualitative dimensions of teaching. The current study also demonstrated the advantage of using both the quantitative and qualitative dimensions for measuring teaching quality. For example, as the data from the low-inference observation instrument have shown, whereas the frequency dimension of the five teacher factors (i.e., orientation, structuring, application, and questioning) explained an additional variance of 6.4 per cent; the qualitative dimensions explained much more of the variance in achievement than the frequency dimension (i.e., 10.6 per cent). Moreover, adding all the dimensions of the five teacher factors in one model explained an additional variance of 13.2 per cent. These findings provide further support for the need of effectiveness studies to incorporate in their measurement framework both the quantitative and qualitative aspects of teaching.

However, the importance of using different dimensions to measure the teacher factors only emerged from the data collected through the low-inference observation instrument. In view of the complexity of measuring the act of teaching, a triangulation of sources of evidence (e.g., classroom observation and student questionnaires) is needed in order to attain valid and reliable data on quality of teaching (Berk, 2005; Goe and Croft, 2009; Hiebert and Grouws 2007). In this direction, two observation instruments and student questionnaires were used in collecting data on quality of teaching in Ghana. The results of various CFA analyses provided support to the validity of the instruments but also revealed that only the low-inference observation instrument was able to measure qualitative characteristics of teacher factors in relation to the stage, focus, quality and differentiation dimensions. This finding should be taken into account in measuring quality of teaching in developing countries.

At this point, the limitations of this study should be acknowledged. Firstly, even though the validity of the data collected has been demonstrated, it should also be acknowledged that classroom observations in this study have only been conducted by one observer. Future studies should consider conducting classroom observations by more than one observer so as to examine the inter-rater reliability of the data collected. Secondly, it should be acknowledged that this study was only conducted using a sample of Grade 6 students and examining the effect of the teacher factors only on mathematics achievement. To further examine the generalizability of these results more studies are needed in other developing countries that also take into account other cognitive (i.e., language, science etc.) and non-cognitive outcomes (i.e., affective, psychomotor). In addition, data in this study were only collected from one region in sub-Saharan Africa. Therefore, taking into account that contexts may vary within countries in sub-Saharan Africa and across regions, the need for similar studies to provide policy makers with more nuanced insights is evident. In this respect, it should also be acknowledged that this is a quantitative study and therefore it is not in a position to examine the extent to which the classroom ecological context and instructional resources have an effect on learning (Carron and Chau, 1996; Urwick and Junaidi, 1991). This was not the main focus of this study since this study aimed at finding whether effectiveness factors at teacher level have an effect on student achievement and therefore future studies may also focus on other factors that may affect student learning. Finally, it should be mentioned that this study only took place for one year therefore the long-term effect of the teacher factors could not be examined. Future studies may consider collecting data for more than one school year so as to examine whether changes in the functioning of the factors lead to changes in learning outcomes.

Implications for theory and practice can also be drawn since this study reveals that the knowledge base of EER for effective teaching may be relevant for both developed and developing countries with poor working conditions. Based on the effect sizes attained for the teacher factors, it could even be claimed that the teacher factors are probably more important for promoting student learning outcomes in developing countries. The results of this study may thus be used by education policy makers in Ghana as well as countries with similar contexts, so as to focus teacher training efforts on teaching skills that were found to be associated with student learning. Since a large number of teachers in Ghana and other sub-Saharan African countries are unqualified (i.e., do not obtain any teacher certificate/diploma or Bachelor in Education), the results of this study may be used as guidelines, demonstrating areas of improvement. For example, as shown in Table 2, more than 30 per cent of the sample's teachers are only qualified with a School Certificate and do not obtain any higher education degree. Policy makers may thus use these results and based on a focused,

reflective approach identify priorities for improvement for teachers in Ghana. Based on these priorities, teachers may be provided with the opportunity to develop individual action plans for improvement, especially taking into consideration the diversity of teacher intake in Ghana's schools (see Creemers et al., 2013).

At this point, it is important to note that the study searched for the impact of teacher rather than school factors included in the dynamic model of educational effectiveness. One may assume that school factors are more dependent on the structure of the educational system and the available resources that the school management team may use to develop and evaluate its policy for teaching and the school learning environment. Further studies are therefore needed to see if not only the teacher but also the school level factors of the dynamic model are associated with student achievement gains.

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