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Investigating Demand and Supply of Mathematics Teachers in Ghanaian Senior High Schools

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ABSRTACT: *The study investigated demand and supply of mathematics teachers in Ghanaian senior high schools. The procedure involved a cross sectional survey that used a structured online questionnaire to elicited information on the demand for SHS mathematics teachers. A sequential explanatory mixed methods design was employed with a sample of mathematics teachers from 195 senior high schools in then 10 political regions of the country, selected purposely to complete a questionnaire designed using Google Forms (an online survey authoring software). This was followed by interview and observation of teachers from ten of the schools. The study revealed that demand for mathematics teachers in senior high schools exceed supply of mathematics teachers and the existing supply have distributional imbalances. The study recommends incentives should be provided for mathematics teachers who accepts teaching less endowed schools.*

KEYWORDS: demand. supply, distributional imbalances, mathematics teacher

INTRODUCTION

Prior to 2017, the majority of children in Ghana who reach basic stage 6 continue to Junior High School (JHS). For those who enter JHS, most are able to complete. The story was entirely different for entry into senior high school. The situation was that a significant number of students from JHS were not able to make it to senior high school (SHS). Before 2017, less than 50% of students from the JHS were able to make the transition into SHS (Akyeampong, 2017).

The students exiting JHS wrote their first external examination, the Basic Education Certificate Examination (BECE). The number of students who were able to meet the selection criterion from the BECE to the next stage of the Ghanaian education, qualified to be enrolled at the SHS or the Technical/Vocational school. However, due to the introduction of free senior high school policy by the government of the republic of Ghana in September 2017, every student who completes the JHS is expected to get entry to SHS. Currently, there is about 90% of students who completed JHS

are in senior high school (Mereku, 2019). The rationale behind this policy is to allow every student from the basic level equal opportunity to get access to senior high school education. All these groups of students are sitting in the same mathematics classroom to be taught by the same teacher and on the same topics, with the same teaching strategy. Since mathematics is a core subject at the senior high school, it makes it mandatory subject for every student to study (Fletcher, 2015; Graham, 1975). The government of Ghana implemented Free SHS policy in September 2017 which resulted in the rise of students' enrolment by 33.2% (Partey, 2018).

This situation according to the Ministry of Education is likely to create an estimated 24,880 students who would not be enrolled in senior high school in 2018 (MoE, 2018). The rise in number in 2017 academic year and projections into the future increase in number of enrollments in SHS triggered the government of Ghana through the ministry of education and Ghana education service to introduce a double track system. The implementation of the double track system is to allow government to cater for the excess enrollment, in order to ensure that, the Free SHS is available and accessible to all eligible students (Newton-Offei, 2018). In order to meet the needs of all these students, the mathematics teacher demand and supply needs to be investigated for appropriate decision making. The purpose of this study was to analyse the dynamics in demand and supply of mathematics teachers in senior high schools in Ghana.

Dynamics of teacher demand and supply

The teacher is anyone who has undergone complete professional education training and is regarded as a moral instructor, moral educator and a moral model for his students (Akinpelu, 2003). S/He is someone who teaches and imparts knowledge and skill, guard and guides the pupil, student or learner through worthwhile experiences resulting in knowledge, attitude or behaviourial change in the learner. However, it is only when the behavioural and attitudinal change in the pupil or student is positive that, one can assert that the teacher and probably the learner are the most important factors in any education system. The teacher determines to a great extent the success or failure of any teaching learning relationship and a proper implementation of the curriculum. It follows therefore that the quantity and quality of teachers in any educational system determine its strength and effectiveness (Chukwu 2011).

The demand for and supply of teachers especially mathematics and its related subject areas as physics, chemistry and biology have been in ascendency. This could be attributed to factors such as low production of mathematics and science teachers. Increasing teacher retirements and increasing student enrolment in many countries such as free senior high school in Ghana. The assessment and analysis of demand and supply of teachers in a country have to consider the dynamics of teacher labour market which operate within. In spite of this, it is extremely difficult to involve all the economic, social and psychological factors which may have bearing on demand and supply of teachers in the equation. According to SACE (2010) most people tend to restrict

issues concerning teacher demand and supply to classical economic analysis leaving these sociological and psychological aspects that could play major role in the analysis of teacher demand and supply. The sociological aspects include social perception of the teaching profession while the psychological part deals with the choices individuals make with regards to the teaching profession.

The labour market for teachers in many parts of the world especially in the sub-Saharan Africa does not operate in a free market per se not even in Ghana. Instead, the market operates within a monopoly market with a dominant purchaser of the services, in most case the government than multiple purchasers as in a free market. In view of this the purchase of teacher services does not necessarily obey the pricing principles that respond to demand and supply. It rather indicates the desire of the monopoly to pay leaving teachers with limited options to willingly supply their skills. As such there is always a danger that teachers are underpaid or overpaid, relative to other professions or relative to the scarcity of their service. However, the choices teachers make as free agents, also affect demand and supply within the monopoly system. This means the study of demand and supply should always consider government actions and the choices individuals make relative to teaching. It is reported that for over two decades in the United States, educational stake holders and governments have forced many school systems to lower standards to fill teaching openings, leading to high levels of under qualified teachers and, in turn, to lower student performance (Ingersoll & May 2010).

The remedy to the shortage of mathematics and science teachers is not far from fetch: the prevailing policy now and in many instances in the past has been to increase teacher supply (Rice, Roellke, Sparks & Kolbe, 2009; Fowler, 2008; Darling-Hammond, 2007). For instance, about two decades of implementing the 1987 reform in Ghana, a national study was conducted as part of efforts to address "the problem of making available an adequate number of trained teachers for instruction in schools" (Quansah, 2003, p.1). The study revealed that an estimated teacher shortage of 40,000 trained teachers in the country's public basic school system, with untrained teachers filling 24,000 of the vacancies. In response to this, Government's introduced a quick teacher preparation programme by distance which was dubbed "Untrained Teachers Diploma in Basic Education" (UTDBE), the programme targeted untrained basic school teachers who studied by distance using modules, with periodic face-to-face interactions with tutors to earn professional qualification for teaching in basic schools. Also, many measures have been implemented to recruit fresh graduates and candidates to teaching. These include career shift programs, such as Nation Builders Corps (NABCO) in Ghana and the American "troops-to-teachers" programme which was designed to entice professional into mid-career switches into teaching, and the teach for America programme which was made to lure academically talented graduates and candidates into under staffed school to go and teach.

However, some researchers believe that the reasons for these staffing problems are more complex and varied than simply an insufficient production of new teachers and mere recruitment of

graduates to fill the understaffed schools (Ingersoll & Perda 2010; Ingersoll & May 2010). These researchers opined that beginning in the mid-1980s and continuing to the present, elementary and secondary student enrolments in the United States for instance have grown steadily. Over the same period, high school graduation course requirements increased in the core academic subjects, especially in mathematics and science. This led, in turn, to a dramatic rise in the number of students taking mathematics and science courses over the past two decades. Mathematics course enrolments grew by 69%, and science course enrolments grew by 60%. In addition, during this period, the number of teacher retirements increased by a striking 141%. All of these factors led to a large jump in the demand for new mathematics and science teachers, and it is expected that there could be worsening shortages if the trend continuous.

There are many factors which contribute to demand for teachers in a given educational system. These factors include the number of teachers on duty, teacher quality, student enrolment, Pupil Teacher Ratio (PTR), class size, number of classes, number of streams, teacher workload, number of teachers employed and Government policy. These factors were considered representative of the critical driving forces behind trained teacher availability and decisions as well as Government policies on secondary school teacher employment (Boe, 2006; MOEST, 2005b).
Supply of teachers can also be contributed by the inflows of people who are professionally qualified to teach but not teaching.

Another factor that needs serious consideration when it comes to sources of teacher supply is the nature and policies of the country on teacher licensing issues. The conceptual confusion compounds when we turn to the more important term, 'qualified teacher,' because of the different standards used. In a country like the USA, every state defines a qualified teacher quite differently, with varying requirements for knowledge of subject matter, pedagogy, curriculum, assessment, learners and learning (Darling-Hammond, Berry, Haselkorn & Fiedler, 1999). The America 'No Child Left Behind' Act defines a qualified teacher as one who has full state certification or a pass score on state teacher examination and who receives professional development which enhances subject matter knowledge, aligns with standards, and improves instructional strategies based on scientifically based research (Cochran-Smith, 2003).

However, in some counties such as was the situation in Ghana, qualified teaching standards are embodied or assumed to be embodied in the pre-service education curriculum; they are therefore not separately assessed outside the formal assessment of the pre-service course. A teacher is regarded as professionals just on the basis of their success in the examinations conducted by their training institutions such as the colleges of education and the teacher education universities (Cobbold, 2015). But the Education Act, 2008 (Act 778) makes provision for the implementation of Teacher Licensure in Ghana. According to Act 778, the National Teaching Council (NTC) is to "register teachers after they have satisfied the appropriate conditions for initial licensing and issue the appropriate license" (Kofie, 2017).

Finally, foreign qualified teachers who may be willing to work in the country's teaching field through various educational agencies like the UNICEFF, DANIDA, US Aid, etc could also be a source of teacher supply but this source of supply seems to be negligible in this contest. In view of these, many researchers of demand for and supply of teachers relate the supply of teachers to human capital, choice of labour and compensation theories (Boyed, Lankford & Wyckoff, 2004; Bobbit, et.al 1991, Kirby & Grissmer, 1991). These theories assume that as normal and rational human beings, people seek to maximize the benefit and satisfaction they derive from the work they do (Gilford & Tenenbaum, 1990). This means that the utility derived from one's work affects the individual's choice regarding the job, the human capital one would wish to invest in and geographic location of where an individual would like to work (Dolton, 2004; Murnane, Singer, John, 1989). It is therefore imperative for every nation that wishes to get more people into a particular field of job (profession) including teaching to consider the utility likely to be derived from the profession (teaching), not only in terms of pecuniary rewards (earnings, monetary incentives) of teaching but also its non-pecuniary rewards (opportunity costs, status of the profession, opportunities for self, academic and professional development, probability of being employed, more holidays). `

It is also important for policy makers and various stakeholders of education to recognize that even after an individual has chosen teaching as a profession, the one has the right to make a choice of a geographic location to work in or not to enter the teaching profession altogether (Falch & Strom, 2005; Shield et. al, 2004, Podgusky & Monroe, 2004). The decision regarding the location or area to teach is affected by many factors which may be financial, road network, social amenities, and other resources. In terms of utility derived from the teaching profession those teachers who find themselves in rural school, derived lower utility than those who are in urban schools that are resource endowed. Teachers who experience reduced utility will either exit the teaching profession in any least opportunity or move to schools that increase their utility by increasing the non-financial part of the utility.

METHODS

The study employed the pragmatist paradigm because it is believed that no single scientific method is adequate enough to explain the social reality of the world at a particular instance (Alise & Teddie, 2010). The current study sort to determine relationship among some social variables (demand and supply of mathematics teachers) which needs an interpretivist approach to understand how the context influence these variables (Creswell & Plano Clark, 2018). The other aspect involves the understanding of human behaviour, teaching strategies and practices which require the constructivist methods (Creswell & Plano Clark, 2018). The study therefore requires the combination of some ideologies from both positivist and constructivist and hence the use of pragmatist paradigm. The study employed the explanatory sequential mixed methods design. This design is in two phases to identify the level of mathematics teachers in senior high school and how

these levels are influenced by Ghana education service-school placement categories. The first phase of the study employed cross sectional descriptive survey to obtain two forms of data. One was students' enrolment information as well as teachers and school characteristics. In the second phase, interviews and observations were used to obtain data to triangulate and substantiate the data obtained from the survey in the first phase (Creswell, 2015). The data from the first phase was used to determine and report on mathematics teachers' demand and supply through different scenarios. A cross-sectional survey is mostly quantitative and usually collects descriptive data through questionnaires (Creswell, 2012; Robson, 2011). However, for detailed understanding of the various scenarios for demand and supply of the mathematics teachers in SHS, some qualitative data were used to create the real picture on the ground.

The accessible population for the study was estimated from the various platforms and contacts of the mathematics teachers available to the researcher. A total number of mathematics teachers on the various platforms was 432 in about 386 senior high schools in Ghana, and was used as the actual accessible population for the study. A sample of 204 senior high schools were purposively selected for the study but 195 mathematics teachers, one teacher from each senior high school who provided complete information on the questionnaire were involved in the final analysis.

The responses from the questionnaires were transferred into Microsoft Excel and Statistical Package for Service Solution (SPSS) version 20 and analysed. Descriptive statistics such as averages and percentages were generated from the data to enable the researcher present the findings. In addition, frequency tables, graphs and charts were also used for graphical representation of the demographic data.

Demand and supply model

The 'demand and supply' model is based on three fundamental variables in a given school system at a particular moment in time. These quantities are average class size, average number of teacher contact periods required by a class over a complete teaching cycle and average teaching load per teacher expressed in number of class contacts period per week (Williams, 1979). The standard average class size at the senior high school is assumed to be 40 students per class based on the GES recommended number of 40 students in a class (Ananga & Tamanja, 2017). The average number of teacher contact period per week for SHS is assumed as 22 period per week based on GES recommended periods for mathematics teachers in senior high schools. The average teaching load per teacher per week is defined as the number of classes the teacher is teaching per week and number of actual periods the teacher is teaching per week. These three quantities could be used individually to determine number of teachers needed in a particular moment in the school. For instance, if the class size is found to be more than 40 students then new classes should be created to accommodate the excess students which demands additional teachers to occupy the new classes created. Similarly, if the teachers work load exceeds the required 22 periods, then the excess are taken and given to new teachers. However, this way of analysing teacher demand is too simplistic

and does not reflect exactly what happens in senior high school. This study therefore combines these quantities to create possible scenarios that reflects what happens in senior high school for possible demand and supply analysis in chapter 4. For example, in a senior high school of 1200 students, the number of mathematics teachers required could be computed as follows;

$$Math\ teachers\ required = \frac{Enrolment}{class\ size} \times \frac{learnig\ period\ per\ classper\ week}{teaching\ period\ per\ teacher\ per\ week}$$

So, for our hypothetical 1200 students, class size is 40, learning period per class per week is 6 and teaching period per teacher per week is 22 (GES).

$$Math\ teachers\ required = \frac{1200}{40} \times \frac{6}{22} \quad = 8.18$$

This means that for a senior high school of 1200 students requires approximately 8 mathematics teachers.

RESULTS AND FINDINGS

This section looks at the extent to which the supply of mathematics teachers in Ghanaian senior high schools meets the demand for mathematics teachers to meet the increasing numbers of students due to free SHS. During the inception stage of the implementation of the government's free SHS initiative, there was public outcry for more educational resources and inputs in the face of inadequate classrooms capacity to contain large class sizes, urban-rural inequalities in mathematics teacher supply leading to large students to teacher ratio in rural schools (Konstantopoulos & Chung, 2009). These, together with other inefficiencies, led to the creation of double track system in some senior high school in the country. It was observed that 74% of the respondents of the study were in school running the double track system before the COVID-19 lockdown. The research question is intended to explore the current situation of mathematics teacher supply to find out whether or not it meets the demand for mathematics in SHS.

Mathematics teacher supply and demand based on enrollment and GES Student-teacher ratio (STR) requirements

The supply of mathematics teachers defines the number of teachers currently teaching mathematics in senior high school while the demand for mathematics teachers refers to the required number of teachers currently needed to teach mathematics in the schools (Mereku, 2000). To determine whether or not the supply of teachers adequately meets the demand of teachers in school, region or country depends largely on the country's policy on students to teacher ratio (STR). Student-teacher ratio (STR) is the number of students in a school divided by the number of teachers in the institution. For example, a student-teacher ratio of 20:1 indicates that there are 20 students for every one teacher. The term can also be reversed to create a teacher–student ratio. Smaller classes benefit all students because of individual attention from teachers, but low-attaining pupils' benefit

more at the secondary school level. Students in large classes drift off task because of too much instruction from the teacher to the whole class instead of individual attention, and low-attaining students are most affected. Research has shown that longer periods in small classes resulted in more increases in achievement in later grades for all students (Konstantopoulos & Chung, 2009). In mathematics, low achievers benefit more from being in small classes since all students are able to have individual attention from teachers. It would therefore, be prudent to begin examining teacher demand in Ghanaian senior high schools by taking a look at the national policy on STR. The teacher to students' ratio recommended by the Ghana Education Service (GES) is 1:40 at the senior high school. This STR has been used in research studies that involved representatives of the Ministry of Education. In their study on Managing the Effects of Large Class Sizes on Quality Education in Ghana, Ananga and Tamanja (2017) contend that the class size in Ghanaian senior high school stands at 40 students officially.

Table 1 Distribution of average class sizes for core and elective mathematics stated by the respondents

STR category	Respondents	Percent
Core Average Maths class size categories		
Class size less than 40	90	46.2
Class size between 40 -50	72	36.9
Class size more than 50	33	16.9
Total	**195**	**100**

	Total respondents	Min.	Max.	Mean	Std. Dev.
Core mathematics	195	21	65	42.5	10.14

Table 1 shows the distribution of average class sizes for core mathematics stated by the respondents. Using Benbow et al. (2007) argument that a class may be termed large when the pupil to teacher ratio (PTR) exceeds 40 students to 1 teacher, one can see from the table that 46% (i.e., nearly half) of the respondents indicated the average class sizes of their core mathematics classes met the GES STR requirement of 40:1 (see Table 1). This suggests the remaining 54% of the respondents are teaching in school that are operating with class sizes beyond the GES STR requirement of 40:1 and, therefore, are schools where demand exceeds supply. Also, the fact that the number of mathematics teachers in the schools range from as low as 2 to 24 and the estimated average enrollment of schools which participated in the study was about 1500, suggests many schools may have problems with ensuring a balance in teacher demand and supply. These initial observations made the researcher to subject the data to further analysis using three scenarios to gauge how the demand for core mathematics teachers in the participating schools exceed supply.

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Mathematics teacher supply based on school enrollment and STR

From the definitions of demand and supply discussed above, it is easy to be drawn into an erroneous argument of using class size and STR interchangeably. The analysis of demand and supply of teachers go beyond class size and STR despite the two could be contributory factors. Table 2 shows the participants' responses on their schools' number of active classes and the average class-size of a core mathematics classes.

Table 2 Descriptive statistics of school's average class-size stated by respondents

	Min	Max	Mean	Std. Dev.
Number of Active Classes in school (AC)	6	84	37	17

The results displayed in Table 2 indicate a maximum number of active classes of 84 while the minimum number was 6 in a school. The mean number of active classes was found to be 37. The Table 1 also shows that the least average size of active classes is 21 while the largest average size of active classes is 65 with a mean of 43. This situation suggests most schools are operating STRs which are close to the official one of 40:1, but this is not the reality. So, the demand (or the number of teachers required), indicated by the responses provided, were further analyzed based on the following

(i) the silent official STR and the actual STR that prevails in most school,
(ii) estimated total school enrollment,
(iii) the education system norms on number of core mathematics periods per week, and
(iv) GES quota on teaching periods per week.

The demand or number of teachers required to teach core mathematics in a school with a given number of active classes and average active classes' size were computed using mathematics model (1) below:

$$\text{Demand (or number of teachers required)} = \frac{Estimated\ Enrollment}{STR} \times \frac{LPPW}{MTP}$$

or

$$= \frac{NAC \times ASAC}{STR} \times \frac{LPPW}{MTP} \quad (1)$$

Where

NAC → Number of Active Classes

ASAC → Average Size of Active Classes

STR → Different SHS STRs – official 40:1 and actual 50:1

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LPPW → GES quota on number of Learning Periods Per Week learners are meet to be taught by the teacher, which is 6 at the SHS

MTP → GES quota on Maximum Teaching Periods per week per teacher, which is 22 at the SHS

The demand summaries obtained with formula (1) were categorized as:

- teachers in schools whose demand is not more than 10
- teachers in schools whose demand is between 11 and 20
- teachers in schools whose demand is between 21 and 30
- teachers in schools whose demand is more than 30.

Figure 4.3 shows the categories obtained with the mathematics model (1) and distribution of mathematics teachers (or schools) in demand categories obtained using the two STR scenarios – 40:1 and 50:1.

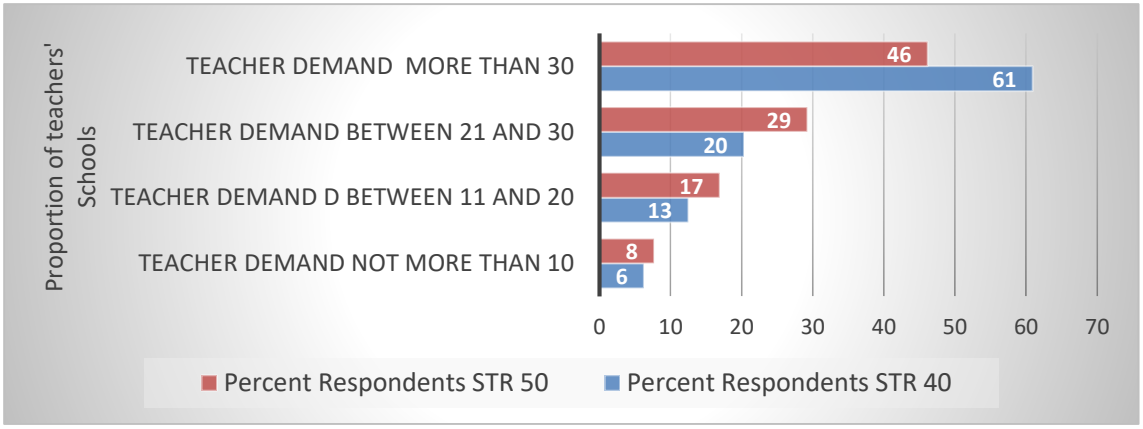

Figure 1: Distribution of mathematics teachers (or schools) in demand categories with the two STR scenarios

Figure 1 shows that there is not much difference in the proportion of schools whose teacher demand is not more than 10 or is between 11 and 20. Interestingly, where demand is 21 to 30 teachers, there is a 9% increase in proportion of schools with STR of 50:1, but when it comes to where the

demand is over 30 teachers, the proportion of schools with STR of 40:1 have higher demand with a difference of 15%. These show that neither the official STR of 40:1 or the realistic STR 50:1 ensures a good balance in teacher demand and supply in Ghanaian senior high schools.

Actual number of teachers at post were subtracted from the teacher demand figures computed with the formula (1) and the results recorded as the excess number of teachers required and were categorized as:

- supply is more than demand by less than10
- demand is more than supply by less than10
- demand is more than supply by between 11 and 20
- demand is more than supply by between 21 and 30
- demand is more than supply by more than 30.

Figure 2 shows the categories excess demand over supply obtained with mathematics model (1) and distribution of mathematics teachers (or schools) in these categories using the two STR scenarios – 40:1 and 50:1.

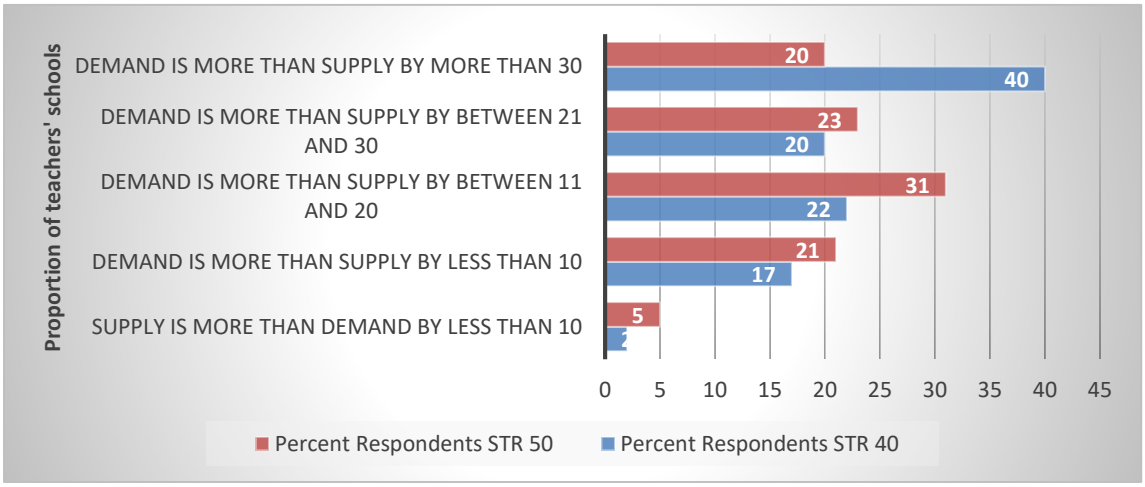

Figure 2: Distribution of mathematics teachers (or schools) in excess demand categories with the two STR scenarios

Figure 2 shows that if the STR is 50, there will be more schools with excess mathematics teachers than where the STR is 40 but these will happen in 5% or less schools. Also, if the STR is 50, there will be 9% more schools with 11 to 20 excess mathematics teachers than where the STR is 40. But where the demand is over 30 teachers, proportion of schools with STR of 40:1 will require double the number of teachers in schools with schools with STR of 50:1. Since the number of mathematics teachers available in schools of the respondents in this study range from as low as 2 to 24, that is,

because there are no schools with more than 30 teachers in the study, the hypothetical scenario using formula (1) does not provide a good illustration of the situation.

Mathematics teacher demand and supply based on teacher's workload

The research therefore explored a second scenario in which the demand for mathematics teachers in a school was associated with the workload of the mathematics teachers at post (i.e., the supply of teachers at the time of the study). The study estimated the workload of the mathematics teacher based on the following parameters:

- GES quota on number of periods per week learners meet to be taught by the teacher, which is 6 at the SHS (LPPW)
- Number of Active Classes (NAC)
- Total Number of Mathematics Teachers (TNMT) in the respondent's school.

The demand or number of teachers required to teach core mathematics in a school with a given number of teachers were computed using the mathematics model (2) below:

School's total number of core mathematics periods per week = $AC \times LPPW$

Average core mathematics teachers required = $\frac{NAC \times LPPW}{TNMT}$ (2)

Where

NAC → Number of Active Classes

LPPW → GES quota on number of periods per week learners are meet to be taught by the teacher, which is 6 at the SHS (

TNMT → Total Number of Mathematics Teachers in the respondent's school

The demand summaries obtained with the mathematics model (2) were categorized as weekly workload of schools with:

- less than 19 periods per week
- 20 - 22 periods per week
- over22 periods per week.

Figure 3 shows the proportion of schools whose workloads are below the GES workload requirement per week (i.e., less than 20 periods); within the GES workload requirement (i.e., from 20 to 22 periods per week) and above the requirement (i.e., over 22 periods per week).

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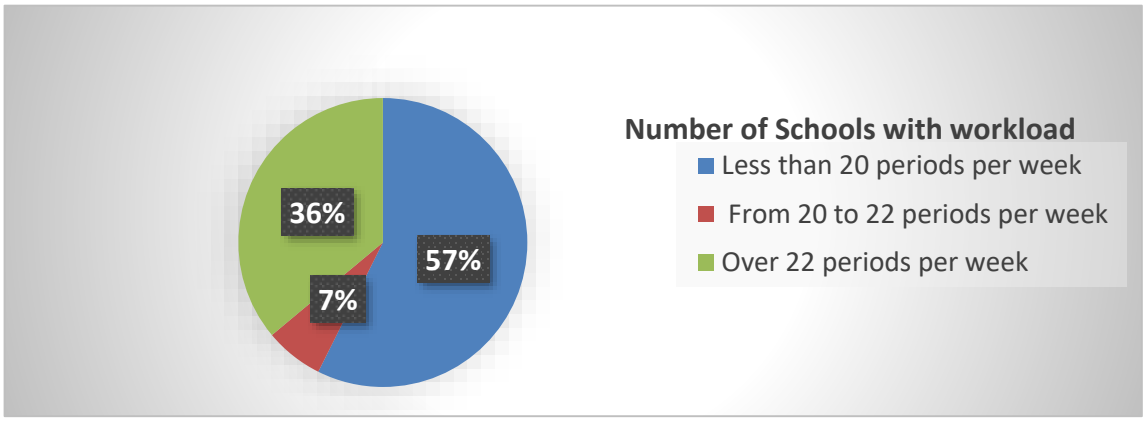

Figure 3 Proportion of respondents indicating their school's workload is below, within or above the GES workload requirement per week

It is obvious from this scenario in Figure 3 that the majority of the respondents (57%) are in schools which are doing less than the GES workload requirement per week (i.e., 22 periods) with only 7% doing this prescribed workload. It is clear from Figure 3 that most of the core mathematics teachers in SHS who participated in the study are in schools which are doing more periods per week compared with the GES required periods. There are 66 out of the 195 of the teachers (i.e., 34%) teaching over the GES workload requirement per week.

Mathematics teacher demand and supply based on adjusted teacher's workload

The analysis of teaching obtained with the mathematics model (2) in the second scenario uses only the number active classes and the number of mathematics periods per week per class which do not make room for class size and for that reason tend either to overestimate or underestimate the actual teaching workload. An improved mathematical model was as a result evolved by the researcher applying an approach that assigned weights based on the official GES STR of 40:1 to the number of students in each class or class size. The weighted class sizes were used as a base line for the adjusted teaching workload for teachers of core mathematics. The adjusted total teaching workload (ATTL) required by teachers of core mathematics in a school with a given number of teachers were computed using the mathematics model (3) below:

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$$\text{Adjusted Total Teaching Workload (ATTL)} = \left(1 + \frac{ASAC - RCS}{RCS}\right) \times MTP \qquad (3)$$

Where

ASAC →Average Size of Active Classes
RCS → Required Class Size based on official GES STR of 40:1
MTP → GES quota on Maximum Teaching Periods per week per teacher, (i.e., 22 at the SHS)

Figure 4 shows the proportion of schools, using the ATTL model, whose workloads are below the GES workload requirement per week (i.e., less than 20 periods); within the GES workload requirement (i.e., from 20 to 22 periods per week) and above the requirement (i.e., over 22 periods per week).

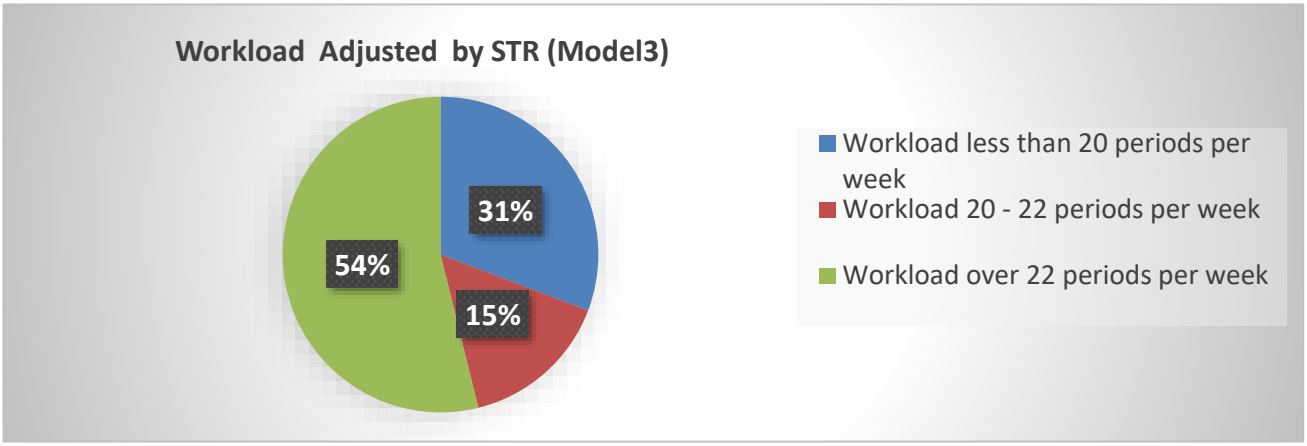

Figure 4 Proportion of respondents (using the ATTL model) indicating their school's workload is below, within or above the GES workload requirement per week

It can be seen from the Model 3 scenario in Figure 4 that though the majority of respondents (54%) are in schools which are doing less than the GES workload requirement per week (i.e., 22 periods) the proportion of teachers doing the prescribed workload doubled in the adjusted model from 7% to 15%. But those doing over the prescribed workload decreased in the adjusted model to 31% compared to 36% in the unadjusted model. The ATTL model seems to be a better predictor of teacher workload and can be useful for determining whether or not supply of teachers in a senior high school meets the demand. One can also compute the excess teaching load (ETL) by using;

ETL = $TCTL - RTL_w$ $(22\ periods)$ and adjusted excess teaching load (AETL) by; AETL = $ATCTL - RTL_w$ $(22periods)$. It should be noted that negative values of ETL and AETL means that the teachers in the school are teaching below the required 22 periods per week while positive values indicate that the teachers in such schools are teaching more than the required 22 periods per week.

The results have consistently shown that many mathematics teachers in senior high schools are teaching less than the prescribe workload or periods and many teach in classes whose class size are below the official GES STR of 40:1. But a substantial proportion of the teachers are above the official GES STR suggesting they devote nearly all their school time to teaching and, therefore, have more little time to deal with their numerous non-teaching tasks and responsibilities which are not usually considered in the contact hours for teaching workload including

- lesson planning
- marking classwork and homework
- recording pupil data for school-based assessment (SBA) and
- reporting to parents
- supervising pupils outside lesson times and marking classwork
- school trips and other general administrative duties.

But the fact that most of the schools have large class-sizes that are about double the GES required STR and that teachers in such schools need a lot more time to deal with the non-teaching tasks and responsibilities of their job, which are not usually considered in the workload contact hours decisions, raise questions that has to be considered by the Ghana Education Service.

Analysis of the qualitative data

The results from the quantitative analysis revealed that in general the supply of mathematics teachers does not meet the demand for the implementation of IEMC in that schools have high students to mathematics teacher ratio, mathematics teachers have high workload and other activities which do not actually contribute to the teachers' workload. Interviews with the teachers revealed the following themes as the reason why mathematics teachers think more mathematics teachers are needed in their schools. The themes are increasing enrollment due to free SHS, double truck, large number of classes, number of periods of mathematics teacher per week and other extra curricula activities.

Increased enrolment of students due to free SHS

All the six mathematics teachers who were interviewed pointed out that students' enrolment at the senior high schools have increased so much due the introduction of the free SHS. To the teachers

the rise in number in some cases do not necessarily increase the periods taught by the teacher but increased the teachers' workload such as marking and supervision.

One teacher puts it this way; *The population of students has increased due to the free SHS policy and some of the students are mathematically weak so it takes a lot of effort to get some of the students to understand anything you teach them within the same time. Sir you know the syllabus must also be completed so we are really suffering with this huge numbers.*

Another teacher also said; *the increase in the enrolment as a result of the government free SHS policy did not only increase the class size but the difficult and worrying part of it is marking. It's when you assess students after lesson and you see the heap of exercise books to be marked, then you appreciate the problem of teaching core mathematics.*

Some classes were visited showed that increase in enrolment has caused the creation of increased class sizes. The number of students in each of the classes in most of the classes were between 45 and 65. These large class sizes may require more than a single teacher of mathematics at a particular point in time for effective class management and control. This may also reduce some activities such as marking of exercises and tests by a single mathematics teacher.

Double truck system

The increase in number of students due to the introduction of free SHS without immediate increase in the facilities of the senior high schools necessitated the introduction of the double truck. The mathematics teachers who were interviewed indicated that most of the teachers teach both tracks as result of inadequate mathematics teachers and also, every student reads core mathematics and most of the subject areas are reading elective mathematics in recent times. It was observed that most of the school that are running the double track system have fewer number of students in a class as compared to the school that are running only the single track. This is evident in some of the photographs taken from some of the double track schools.

It was observed from some of the school that were running double tract system that the number of students in the classes were between 20 and 35. However, some of the teachers interviewed express some worries about the fact that some teachers have to teach in both tracks. The time tables of some of the teachers were assessed to ascertain the number of periods they take in the week in the various tracks and the samples are provided in Figure 5

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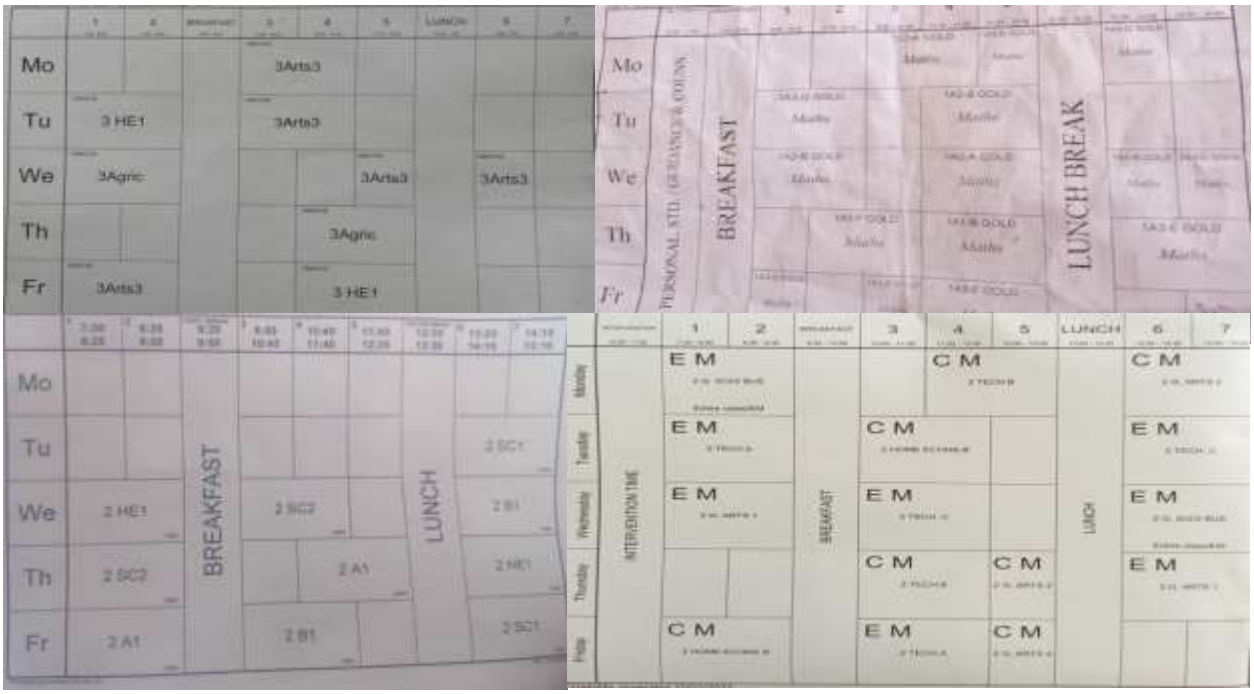

Figure 5: Pictures showing the time tables of some mathematics teachers

Time table of core mathematics teacher in one of the senior high schools visited who teaches 20 periods per week for 1hour per period. Some senior high school mathematics teachers' time table show that some teachers teach 28 periods per week for both core and elective mathematics. One mathematics teacher who is also guidance and counseling officer for students revealed that that teacher teaches 24 periods per week with each period lasting for 1 hour. An interview with a mathematics head of department reveals that

"*as head of department, I teach 16 periods per week, mark all the lesson notes of the 18 staff members in the department, serve on the examination committee and the disciplinary committee"*

In an interview with one of the teachers was is teaching 28 periods per week, the teacher said that

"*I teach every day and at times getting time to rest is a problem because I start in the morning and will visit class upon class one after the other throughout the day"*

Increased in the number of classes

Some of the mathematics teachers interviewed indicated that the outbreak of covid-19 pandemic and its associated protocols caused their schools to reduce the class sizes which resulted in creating

additional classrooms which have increased the number of periods of existing teachers especially mathematics teachers. In one of the schools visited, a class that consisted of 55 students was divided into two and one of the classes was moved to an uncompleted building. It was observed that the mathematics teacher could attend to individual students but the teacher complained that the number of contact hours with the same 55 students had doubled because he had to use the same contact time teach the second group.

Extra curricula activities

Mathematics teachers in senior high schools in Ghana perform other activities in their school apart from their core mandate of teaching students. Mathematics teachers who were interviewed revealed that outside preparing notes, teaching and marking students' exercises and test offer activities such as class advisors (form masters), masters on duty, serve on committees like sport committee, disciplinary committee, entertainment committee, welfare committee, time table committee and examination committee. Other teachers said they serve as house masters/mistresses, and head of departments. All these activities the mathematics teachers said add to their workload in the school but no wait is assigned to these extra curriculum activities.

One mathematics teacher lamented*;*

"I attended mission senior high school and during our time the bell boy would get up 3:00am and wait till 4:00 am to ring the bell for rising and everybody would be up. There was no teacher on duty coming to wake us up but today in my school, the headmaster demand from masters on duty to be at the dormitory at 4:30 am to wake students up before going to prepare for class. It is so difficult for those of us who live outside campus"

Another mathematics teacher said;

"*can you imagine, even student's entertainment teachers are supposed to be there to supervise yet nothing is given to the teacher as remuneration! For me it is not surprising that most students seem not to do well in mathematics because the work is huge but the labourers are small especially in this school. The headmaster is too difficult and if I get the chance I will leave because some schools do not worry their teachers like here"*

One other mathematics teacher said

"*I teach 28 periods a week, and unfortunately there is no teacher for PE and because I have passion for sports, I have ended up being the PE instructor for the school. I am on field almost every day including Saturdays to train students in various sporting activities but I am not even remunerated for that"*

It could be deduced from the reports that there seems to exist some differences in what pertains in senior high schools that brings inequality in work conditions for mathematics teachers in senior high school. The researcher was going to interview 10 mathematics teachers but on the fifth person, it was realized that the respondents were providing almost the same answers which indicated a saturation point of the interview so the researcher ended the interview at that point.

FINDINGS

The analysis of the demand for and supply of mathematics teachers in Ghanaian senior high schools based on students-teacher ratio and mathematics teachers' workload revealed that mathematics teachers demand exceed supply. This means that mathematics teachers in SHS are less than the number of mathematics teachers needed to teach in the schools.

The study also revealed that there are mathematics teachers' distributional imbalances and inequalities in mathematics teachers' workload in Ghanaian SHS. This indicates that while some school have more mathematics teachers resulting in less workload for the teachers, other school have less mathematics teachers resulting in more workload for the mathematics teachers in such schools.

CONCLUSION

The results showed that mathematics teachers' supply does not meet demand for mathematics teachers in senior high school in Ghana. The study also revealed that there are inequalities in the workload of mathematics teachers. The adjusted demand and supply model is the most appropriate model for analysing the dynamics of mathematics teacher demand and supply.

Recommendations

In order to balance demand and supply of mathematics teachers and fair distribution of mathematics teachers in SHS, educational stakeholders and players could institute some incentives for students who accept to read mathematics education programme in the universities to encourage more student to read mathematics education programme and also offer special incentive packages for mathematics teachers who accepts posting to schools with inadequate mathematics teachers so as to attract more qualified mathematics teachers into such schools.

In determining the workload of mathematics teachers, one needs to take into consideration the class sizes of the teacher and the number of periods of the teacher together with standard student teacher ratio but not just the number of periods of the teacher.

References

Akinpelu, J.A. (2003). Ethics and the teaching profession. In A.O. Banisaye, I.A. Nwazuoke and A. O. Kediran (Eds) Education this millemium: innovations in theory and practice. Ibadan Macmillian Nigeria Publishers Limited

Akyeampong, K. (2017). Teacher educators' practice and vision of good teaching in teacher education reform context in Ghana. *Educational Researcher, 46*(4), 194-203. http://dx.doi.org/10.3102/0013189x17711907.

Alise, M. A., & Teddlie, C. (2010). A continuation of the paradigm wars? Prevalence rates of methodological approaches across the social/behavioral sciences. *Journal of Mixed Methods Research,* 4(2), 103-126. https://doi.org/10.1177/1558689809360805

Ananga, E.D. & Tamanja, E.M. (2017). *Managing the Effects of Large Class Sizes on Quality Education in Ghana.* Retrieved from. https://issuu.com/educationinternational/docs/managing_the_effects_of_large_class

Bobbitt, S. A., E. Faupel, et al. (1991) Charectoristics of Stayers, Movers, and Leavers: Results from the Teacher Follow up Survey. Washington, D.C, *National Centre for Education Statistics*.

Boe, E. E. (2006). Long-term trends in the national demand, supply, and shortage of special education teachers. *Journal of Special Education*. 40, 138–150. doi:10.1177/00224669060400030201.

Boyd, D., Lankford, H. & Wyckoff, J. (2004). Analyzing the Determinants of the Matching of Public School Teachers to Jobs: *Estimating Compensating Differentials in Imperfect Labor Markets*. San Francisco: Stanford University.

Chukwu L. C. (2011) Teacher Demand and Supply: A Critical Factor in the Universal Basicn Education (UBE) Scheme in the South-East Zone of Nigeria. *The Nigerian Academic Forum* Volume 21 No. 1

Cochran-Smith, M. (2003). The multiple meanings of multicultural teacher education: A conceptual framework. *Teacher Education Quarterly*, Spring, 7-26.

Creswell, J. W. & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage

Creswell, J. W. (2012). *Qualitative inquiry and research design: choosing among five traditions*. 3rd ed. Thousand Oaks, CA: Sage.

Creswell, J. W. (2015). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.

Darling-Hammond, L., & Sclan, E. M. (1996). Who teaches and why: dilemmas of building a profession for twenty-first century schools. In J. Sikula (Ed.), *Handbook of research on teacher education* (2nd ed., pp. 67-101). New York: Simon and Schuster.

Dolton, P. (2004). "Recruiting High-Quality Teachers." *Journal for Institutional Comparisons* 2 (4): 11-20.

Falch, T. & Strøm B. (2005) "Teacher Turnover and Non-Pecuniary Factors." *Economics of*

Education Review 24 (6): 611-631

Fletcher, J. A. (2015) *Social Justice and Philosophies of Mathematics Education in Ghana, Philosophy of Education Society of Great Britain, Annual Conference*. New College, Oxford

Gilford, D. M. and E. Tenebaum (1990) Precollege Science and Mathematics Teachers: Monitoring Supply, Demand, and Quality. *Panel on Statistics on Supply and Demand for Precollege Science and Mathematics Teachers*, Committee on Natioanl Statistics. D. M. Gilford and E. Tenebaum. Washington, D.C, National Academy Press

Graham C. J. (1975). *The history of Education in Ghana. London*: McMillan.

Ingersoll, R., & May, H. (2010). *The magnitude, destinations and determinants of mathematics and science teacher turnover*. Philadelphia: University of Pennsylvania, Consortium for Policy Research in Education.

Ingersoll, R., & Perda, D. A. (2010). *Is the Supply of Mathematics and Science Teachers Sufficient?* Retrieved from http://repository.upenn.edu/gse_pubs/224

Kirby, S. N., & Grissmer, D. W. (1991). Sources of teacher supply: Some new evidence from Indiana. *Educational Evaluation and Policy Analysis,* 13, 256–268

Kofie, P. B. (2017). Teacher licensing in Ghana. *institute for liberty and policy innovation.*Konstantopoulos, S. & Chung, V. (2009). What are the long-term effects of small classes on the achievement gap? Evidence from lasting benefits study. *American Journal of Education 116(1) 125-154.* DOI: 10.1086/605103

Konstantopoulos, S. & Chung, V. (2009). What are the long-term effects of small classes on the achievement gap? Evidence from lasting benefits study. *American Journal of Education 116(1) 125-154.* DOI: 10.1086/605103

Mereku, D. K. (2019). Sixty years of teacher education in Ghana: Successes, challenges and the way forward. *African Journal of Educational Studies in Mathematics and Sciences Vol. 15, No. 2,* 72

Ministry of Education, MOE (2018). Pre-tertiary Mathematics Education Curriculum, National Council for Curriculum and Assessment (NACCA). Ministry of Education, Accra

Newton-Offei, A. (2018). Free SHS and Double-tracking will survive and thrive. Modernghana.com

Partey, A.P. (2018). Implications of a double-track school calendar on SHS. https://www.ghanaweb.com/GhanaHomePage/features/implication.

Podgursky, M., R. Monroe, et al. (2004) "The Academic Quality of Public School Teachers: An Analysis of Entry and Exit Behavior." *Economics of Education Review* 23 (5): pp. 507-518.

Quansah, K. B. (2003). *Teacher demand and supply: The next decade*. Cape Coast: University of Cape Coast.

Rice, J., Roellke, C., Sparks, D., & Kolbe, T. (2009). Piecing together the teacher policy landscape: Multi-level case study findings from three states. Teachers College Record, 111(2), 511-546.

Robson, C. (2011). *Real World Research*. West Sussex: John Wiley and Sons Ltd.

SACE - South African Council for Education (2010). *A review of teacher demand and supply*; Identifying research gaps and the role of SACE.

Shields, et al. (2004) To Teach or Not To Teach? *Panel Data Evidence on the Quitting Decision* Bonn: IZA.