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Trends in Performance of WASSCE Candidates in the Science and Mathematics in Ghana: Perceived Contributing Factors and the Way Forward

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Abstract

The trends in students' performance in science and mathematics at secondary school level were examined within a decade-long interval in Ghana. Using West African Examinations Council (WAEC) data from approximately 20% of schools countrywide, it was observed that the results did not provide a definitive pattern. Factors such as teachers' inability to complete between 50% and 75% of the curricula, insufficient-time to enact and complete the curriculum, lack of enough qualified teachers, and use of poor teaching approaches accounted for the trends. This study in Ghana has implications in teacher recruitment deployment in general as well as duration of secondary education globally to examine their efficacy.

Keywords

performance assessment, trends in WASSCE performance, secondary education and learning, performance in mathematics and science, factors affecting students' performance in mathematics and science

Background to the Study

The success and growth of nations powerfully connect to the quality of education provided to its citizens. This link between training and development informs the decision of several areas of the economy, including allocation of funds to the sector, as well as advancement of personnel capital and other resources to the education sector (Abreh, 2017; Blaug, 1970). Seen another way, to achieve education's goal of empowering individuals and systems for functional gains requires promotion of the advancement of cultural, moral, scientific, and technological knowledge, skills, and aptitude of children of appropriate school age to access and receive a quality education. The kind of knowledge, skills, and attitude made available to learners will, in turn, enable them to compete at innovative and highly entrepreneurial levels with their peers on both local and international platforms (Lee, 2006; Shanmugaratnam, 2006).

Education is said to be critical to the development of economies of all countries worldwide. However, the role of mathematics and science education is even more crucial for the accelerated expansion of economies and management of such new economies created through science-led technologies. Indeed, education's role in the empowerment of individuals and systems is not in contention, and Ghana has been inclined to use mathematics and science to occasion a technology-driven economy. For example, when science and technology approaches were engaged in the two main sea ports in Ghana, in less than 3 months, there were massive economic gains, decrease in clearing time, and decrease in fraudulent activities in the port, demonstrating the potential of these fields for accelerated expansion in the economy (Tarlue, 2017).

The education systems of nations are structured to meet the needs of their economies and developmental priorities. Although very subtle structural differences exist in the organization of education systems worldwide, most of them, if not all, are organized at three levels, namely, primary or basic, secondary, and tertiary. Secondary education as the name implies provides a bridge between primary/basic school and tertiary education. It is a postprimary/basic education program that prepares the students for middle-level jobs as well as provides the platform for others to progress to tertiary education. Therefore, secondary education is very vital in the life of a student as well as the nation. The issue is that when students are not successful at the secondary education level, it becomes challenging for them

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to progress to the tertiary level of the educational ladder, to acquire employable skills in either colleges of education, technical universities, or traditional universities in Ghana, for example.

It is, therefore, gratifying that Ghana's constitution mandates that all efforts should be made to ensure that education, particularly at the secondary level, gradually becomes universal and progressively free (Republic of Ghana, 1992). Furthermore, the current situation, where secondary education is free for first-year Ghanaian secondary school students, is a step toward increasing access and equity to secondary education.

In Ghana, the secondary education level provides comprehensive and technical/vocational education to its clientele. Thus, whereas some secondary school students take the comprehensive secondary education, which constitutes the simple majority in Ghana, others provide only technical/vocational education. Students at secondary schools in Ghana study four core subjects and a set of elective subjects (a minimum of three), which is determined by the type of program that students choose to study. In this 21st-century learning space, learners are encouraged to be critical and analytical. Thus, science and mathematics offer such a foundation for students to be critical and analytical in their thinking. It is, therefore, not surprising that, secondary schools across the globe make science and mathematics a compulsory part of the curriculum for this level of education.

The Government of Ghana recognizes the role of science, math, and technology in the attainment of the developmental agenda of the nation. This recognition by the government has led to the identification of science and mathematics as one of the pillars for national development (Ghana Ministry of Education, 2014). To achieve this, the Government of Ghana has initiated some interventions and injected incentive schemes aimed at improving students' participation and achievement in science and mathematics, particularly at the secondary education level since the 1990s. For example, the Science Resource Centre Project, Ghana Investment Fund for Electronic Communication (GIFEC), information and communication technology (ICT)-related projects, Mathematics, Science and Technology Scholarship Scheme (MASTESS), and Secondary Education Improvement Project (SEIP) are but some of these interventions.

Performance at the secondary education level is said to be contingent on some related and interrelated factors (Chua & Mosha, 2015). Two of the factors that stand out in the current literature according to Chua and Mosha (2015) are those relating to the curriculum of science and mathematics and the teacher and teaching factors. The curriculum is known to direct the teaching, learning, and assessment practices that should go on in schools. Mainly, aspects such as the syllabus and textbooks influence educational attainment (Dembélé & Lefoka, 2007; Pridmore, 2007; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2016; World Bank, 2008). Also, the scope, balance, and relevance of the curriculum influence what stakeholders do with the curriculum as well as its ability to achieve the intended outcome.

Besides curricula issues, the best way to prepare, deploy, and manage teachers have been called to the fore. The fundamental step in attracting strong teacher candidates through investing in high-quality teacher education programs offers the most promising approach (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2008; Coalition for Teaching Quality, 2016; Darling-Hammond, Bransford, LePage, Hammerness, & Duffy, 2005). Besides, it was found that school districts that employ uncertified teachers mostly deployed them to underserved places, and such teachers were themselves typically of underserved backgrounds (Darling-Hammond, 1999). As noted by Hanushek, Kain, and Rivkin (2004), teacher mobility is even a huge problem in underserved places, leading to pockets of inequalities experienced in such areas particularly in rural schools in comparison with their urban counterparts.

In addition, other studies have shown that teacher quality, regardless of typology as in content knowledge, experience, training, and credentials, or general intellectual skills, is strongly related to student achievement and learning outcomes (Darling-Hammond, 1999; Hanushek et al., 2004; Wilson, Floden, & Ferrini-Mundy, 2001). Simply put, there is the high probability of high achievement on the part of students if teachers are skilled and professional in going about their duties and responsibilities when other factors are held constant. Teacher pedagogical practices are mostly dependent on their content knowledge, pedagogical knowledge, pedagogical content knowledge, and skills, which they apply in classroom teaching (Borko, 2004; Wilmot, 2009).

Literature also holds that underserved and hard-to-reach secondary schools contribute to the achievement gap that is evidenced in the rural–urban divide. It follows that assigning experienced, qualified teachers to low-performing schools and students is likely to pay off in better performance and narrowing gaps. One of the findings that made the challenge even more glaring is in the study of Laczko-Kerr and Berliner (2002), which shows that mathematics achievement of elementary pupils taught by new, uncertified teachers did significantly worse on achievement tests than did those taught by newly certified teachers. Besides the effect of qualification of teachers on students' performance, the factors affecting the low or steadily low performance in mathematics and science is multifaceted (Swars, Daane, & Giesen, 2006; Swars, Hart, Smith, Smith, & Tolar, 2007; West African Examinations Council [WAEC], 2014, 2015, 2016). The central attribute that those studies put forward is that teachers and teaching occupy a central place in modern trends in education, especially so, when learning outcomes and student achievement come to the fore.

Most of the useful teacher and teaching-related studies, for example, have focused on elementary or basic school. Although a few studies suggest that the teaching component is somewhat less in high schools, a lot more work and studies need to be conducted before delineating which areas of the secondary education system are suffering from research deficit in Ghana. There is the need to prod the system of education some more regarding incentives and working conditions that would attract highly effective teachers to traditionally hard-to-staff schools and underserved Ghanaian populace, to coordinate the access and equity at the secondary education level in Ghana.

The quest to investigate the system of education at secondary education level is necessitated by the recent poor performance of students in science and mathematics at West African Secondary School Certificate Examination (WASSCE; WAEC, 2014, 2015, 2016). Stakeholders in education and the general public have raised issues about the performance of students and the teaching and learning of science and mathematics countrywide. Although some stakeholders were of the view that the performance of students in science and mathematics is good, others are of the view that it is poor. With such divided opinion on the issue of performance of students, albeit the fact that there is little to no evidence to support these claims and assumptions, makes it crucial to investigate the trends in students' performance in the country. Besides, without credible evidence of trends in performance, it will mainly be difficult for state agencies in charge of education and policy makers, for that matter, to promulgate appropriate educational policies that are transformative. Thus, this study sought to provide data on trends in performance in science and mathematics at the secondary school level, which at present are not available in the literature. Furthermore, in the wake of the interventions injected in the Ghanaian secondary education system in recent years, the study additionally sought to solicit possible reasons for the trends exposed by the WAEC data. Consequently, three research questions were formulated to guide the study, which have been provided as follows:

Research Question 1: What has been the trend of the performance of WASSCE candidates in mathematics in Ghana from 2007 to 2016?

Research Question 2: What has been the trend of the performance of WASSCE candidates in science in Ghana from 2007 to 2016?

Research Question 3: What are the perceived contributing factors to students' performance?

Method

The exploratory survey research design was applied in the conduct of this study. The thrust of the study was to establish the trend of students' performance in WASSCE for the past decade in science and mathematics at first stage and, at a second stage, to identify some of the perceived factors influencing the trends as established. The exploratory survey design is the ideal design for the study because the trends in performance have little to no evidence regarding research output. In addition, this design was found to be appropriate because of its ability to rely on a representative sample that can generate large data capable of providing adequate generalization.

One hundred and seventy schools were carefully sampled from 875 senior high schools (SHSs) countrywide using the proportional stratified random sampling from each of the 10 administrative regions in Ghana. Within each school, the head of the school as well as heads of department of science and mathematics were purposively selected. However, regarding the teachers of science and mathematics, one teacher in each subject area was sampled per school using simple random sampling approach. Finally, 10 students from the 170 schools were randomly selected.

WASSCE results from 2007 to 2016 for the 170 schools for science and mathematics were used in this study to establish the trends in students' performance. The unit of analysis in this consideration being the letter grade. The grading system and interpretation (by percentage score required to earn the grade) used by WAEC presented as A1 for excellent, for raw scores from 75% to 100%; B2 for very good, for raw marks from 70% to 74%; B3 for good, for raw marks from 65% to 69%; C4 for credit, for raw marks from 60% to 64%; C5 for credit, for raw marks from 55% to 59%, C6 for credit, for raw marks from 50% to 54%, D7 for pass, for raw marks from 45% to 49%; E8 for pass, for raw marks from 40% to 45%; and F9 for failure, for raw marks from failure 0% to 39%. But tertiary institutions in Ghana, admit students who obtained Grades A1 to C6. However, in the case of the perceived factors influencing performance in science and mathematics, data were collected from heads of schools, heads of department of science and mathematics, or the head of both science and mathematics; a teacher each for the mathematics and science fields; and 10 students from each of the 170 schools.

The trends were limited to specific letter grades and, hence, our study's finding was narrowed in making an inferential judgment regarding time series as well as drawing on other inferential conclusions, including ones related to projections. There are other additional limitations to this analysis. For example, the number of candidates was not constant across years, and it might not be the same teacher who taught the students over the years who took the various sets of examinations in each of the schools for the past decade. Also, the entry characteristics of the candidates and the conditions under which the candidates studied in the schools were not uniform across schools and year groups. There were curricula and policy changes within the period and needed to be taken into consideration. Most potentially, the

number of years for which SEIP had been in place in Ghana (started in 2014) may rarely count toward the performance seen from 2007 to 2016. It is worthy to note that, there were no results for 2010 due to policy changes in Ghana that caused a 1-year lapse in completion as a consequence of the change in the number of years of schooling at the SHS level from 3 to 4 years in 2007.

The instrument used for establishing the trends on students was a performance data sheet. The data sheet was used to collect information on school and subjects as well as letter grade summaries for the various cohorts of WASSCE candidates from 2007 to 2016 except for 2010 as indicated earlier. In the case of the trends data, WAEC, the custodian of the data provided the data set in a secured format. Also, the views of the target respondents were sought in 2017 on the perceived contributory factors to the past performance of students in WASSCE.

From each of the 170 selected schools, heads of department of science and mathematics or the head of both science and mathematics (where applicable) and one teacher each of mathematics and science were selected to participate in the study. A total of 1,700 students made of 10 randomly picked students from each sampled school. The simple random sample selection procedures were applied in selecting the three categories of the samples (i.e., heads of department of science and mathematics or the head of both science and mathematics, a teacher each for the mathematics and science from the 170 schools, as well as 10 students per school). Data were collected using questionnaires to respond to the third research question. The questionnaires were meant for heads of the schools, heads of department for science and mathematics, science and mathematics teachers, and selected students.

The questionnaires explored the status of the schools, teacher characteristics including their academic qualification, as well as curricula-related issues as a way of unearthing some perceived factors associated with the performance trend of students. The questionnaires had both open- and closed-ended items. The questionnaires were subjected to validity tests to identify whether they measured what they sought to measure. Thus, the validity was enhanced by expert opinion of colleagues in the field, ethics review board, and the feedback from the pilot testing of the instruments. The feedback received were incorporated into the eventual data collection instruments. The internal reliability were estimated using the Cronbach's alpha reliability coefficient. These were found to be ranging between .85 and .98 for the different instruments used in the study and considered appropriate.

Data collection occurred in all the 10 administrative regions of the country concurrently by trained research assistants from the College of Education Studies, University of Cape Coast, Ghana, whose capacity was built specifically for these data collection exercises. Whereas STATA SE Version 13 was used to organize the performance data for the decade-long period into charts, the data collected by means of questionnaire on the perceived factors causing the type of performance, however, were entered into SPSS Version 20 base on which the descriptive tables and charts were prepared. The data gathered from the optional items were broadly analyzed using themes that emerged that offered insight into teaching and learning practices that occur at the secondary schools.

Results of the Findings

The results of the study have been presented and discussed according to the research questions. The first research question sought to establish trends in performance in mathematics (core) and science (integrated science) for 10 years duration at the SHS level in Ghana using WASSCE results. The performance of students in core mathematics is characterized by a high percentage of candidates with Grade F9. Figure 1 shows the performance of students across the years in core mathematics. The proportion of F9 obtained across the years remains about the largest regarding ratio of the grades earned. It can be observed from the stack performances that Grades C6 to F9 across the year groups were approximately 50% per year group or worse. Performance, however, improved steadily from 2007 to 2012 and decreased from 2012 steadily to 2015 and rose again in 2016 (see Tables 1 and 2).

In the case of the second research question, the performance grades of science improved progressively from 2007 to 2012 and decreased from 2012 gradually to 2015 and went up in 2016. The failure rate in integrated science was in the neighborhood of 30% for each of the years 2007 to 2009, 2014, and 2015. Apart from 2008 and 2015, where there were a few candidates who obtained Grades A1 and B2, it was observed that in the rest of the years, more candidates obtained Grades A1 and B2, comparatively. Again, the issue with 2015 performance comes to the fore. The performance in 2015 was the poorest compared with the other years in question. Also, apart from 2011, 2012, 2013, and 2016, where candidates obtained about 50% in Grades A1 to C6 cumulatively, the rest of the years had more students who achieved more cumulative Grades D7 to F9. This proportion across the years remains the most substantial grade that candidates got in integrated science except in 2011 and 2012. Figure 2 provides the trends in performance in integrated science for the sampled schools.

However, students' performance in 2011 and 2012 was relatively outstanding in both subject areas. These two cohorts of students experienced a 4-year duration of the secondary program within which students were made to study only the core subjects of mathematics, English language, integrated science, and social studies, which were the main areas of poor performance of students exclusively in the

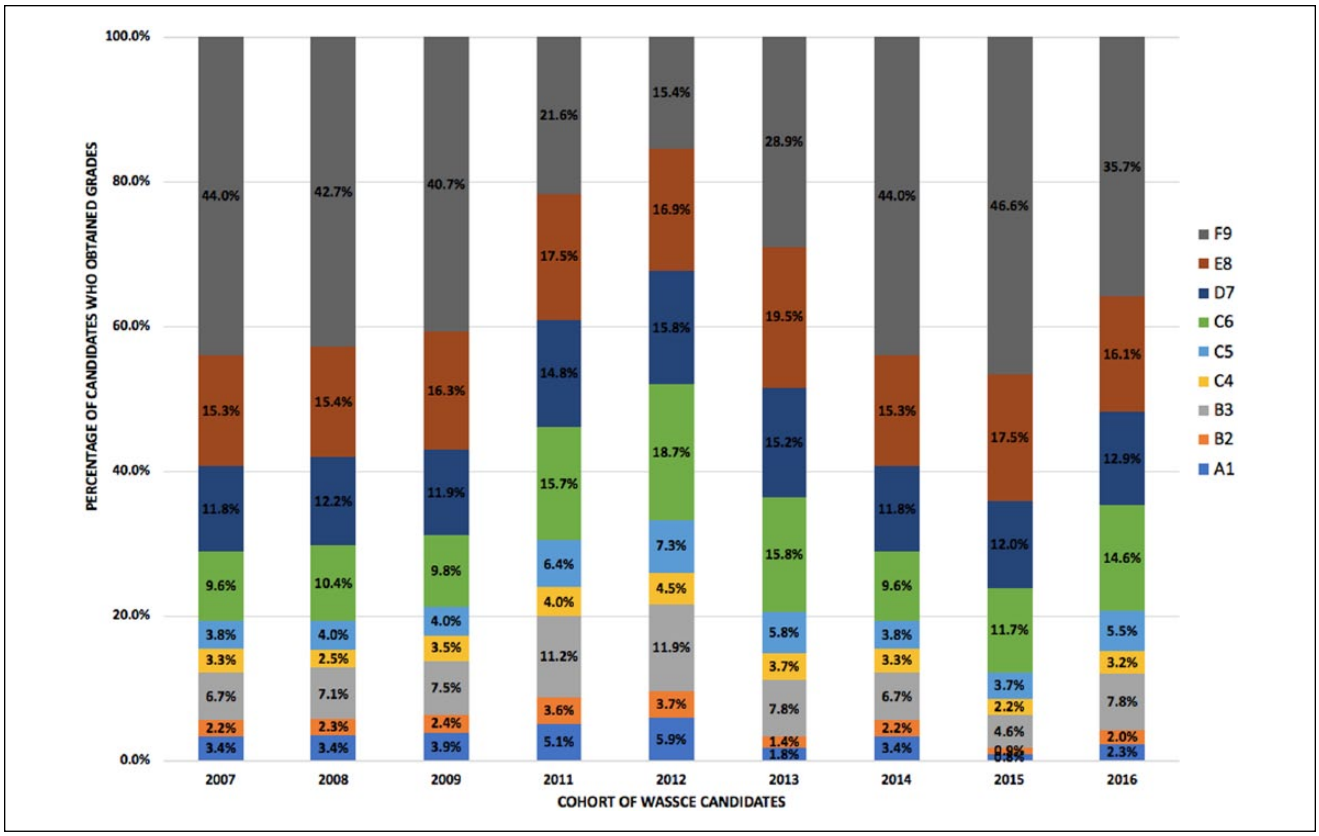

Figure 1. Bar chart showing the proportion of WASSCE grades obtained in mathematics for 2007 to 2016.
Note. WASSCE = West African Secondary School Certificate Examination.

Table 1. Distribution of Mathematics Grades of Sampled Schools for 2007 to 2016 in WASSCE.

Grades	2007	2008	2009	2011	2012	2013	2014	2015	2016	Total
A1	1,203	1,217	1,596	1,927	2,586	1,727	1,203	523	1,481	13,463
B2	775	806	994	1,379	1,615	1,375	775	562	1,283	9,564
B3	2,408	2,512	3,044	4,275	5,202	7,473	2,408	2,894	5,064	35,280
C4	1,173	898	1,425	1,518	1,951	3,499	1,173	1,387	2,085	15,109
C5	1,357	1,433	1,641	2,451	3,206	5,553	1,357	2,351	3,583	22,932
C6	3,440	3,670	4,019	5,966	8,165	15,033	3,440	7,424	9,491	60,648
D7	4,210	4,306	4,846	5,638	6,896	14,524	4,210	7,607	8,404	60,641
E8	5,482	5,471	6,661	6,632	7,375	18,568	5,482	11,101	10,518	77,290
F9	15,721	15,121	16,605	8,217	6,716	27,605	15,721	29,591	23,318	158,615
Total	35,769	35,434	40,831	38,003	43,712	95,357	35,769	63,440	65,227	453,542

Source. West African Examinations Council Data.
Note. WASSCE = West African Secondary School Certificate Examination.

first year. An exceptional performance of candidates also emerged in 2016, where there was a substantial improvement in students' performance in these subject areas vis-à-vis the preceding years of 2013, 2014, and 2015.

The third research question sought to identify reasons that account for students' performance in integrated science and core mathematics. Data gathered from heads of departments, teachers, and students were used to address the Research Question 3. Some of the issues explored in the schools relate to characteristics, curricular-related issues, professional and academic qualifications, completion of syllabi, teaching and learning materials, and teacher absenteeism. The qualifications that science and mathematics teachers of the selected SHSs hold are presented in Table 3. The highest qualification of SHS teachers was in two categories: first degree and second

Table 2. Distribution of Science Grades of Sampled Schools for 2007 to 2016 in WASSCE.

Grades	2007	2008	2009	2011	2012	2013	2014	2015	2016	Total
A1	838	370	1,215	1,405	3,023	3,677	838	851	3,924	16,141
B2	758	625	1,130	1,265	1,990	3,748	758	831	2,967	14,072
B3	2,017	2,549	3,579	4,363	5,623	12,975	2,017	3,164	8,282	44,569
C4	1,301	1,214	1,639	1,875	3,713	5,420	1,301	2,513	4,910	23,886
C5	1,230	1,549	1,885	2,162	3,453	6,269	1,230	2,489	4,099	24,366
C6	3,480	4,834	5,748	6,576	7,778	17,250	3,480	6,313	9,321	64,780
D7	6,166	6,029	6,425	6,866	9,096	18,272	6,166	10,506	11,121	80,647
E8	9,046	8,512	8,345	7,384	6,250	15,282	9,046	14,480	10,297	88,642
F9	10,883	9,705	10,825	6,315	2,819	12,241	10,883	22,334	10,193	96,198
Total	35,719	35,387	40,791	38,211	43,745	95,134	35,719	63,481	65,114	453,301

Source. West African Examinations Council Data.
Note. WASSCE = West African Secondary School Certificate Examination.

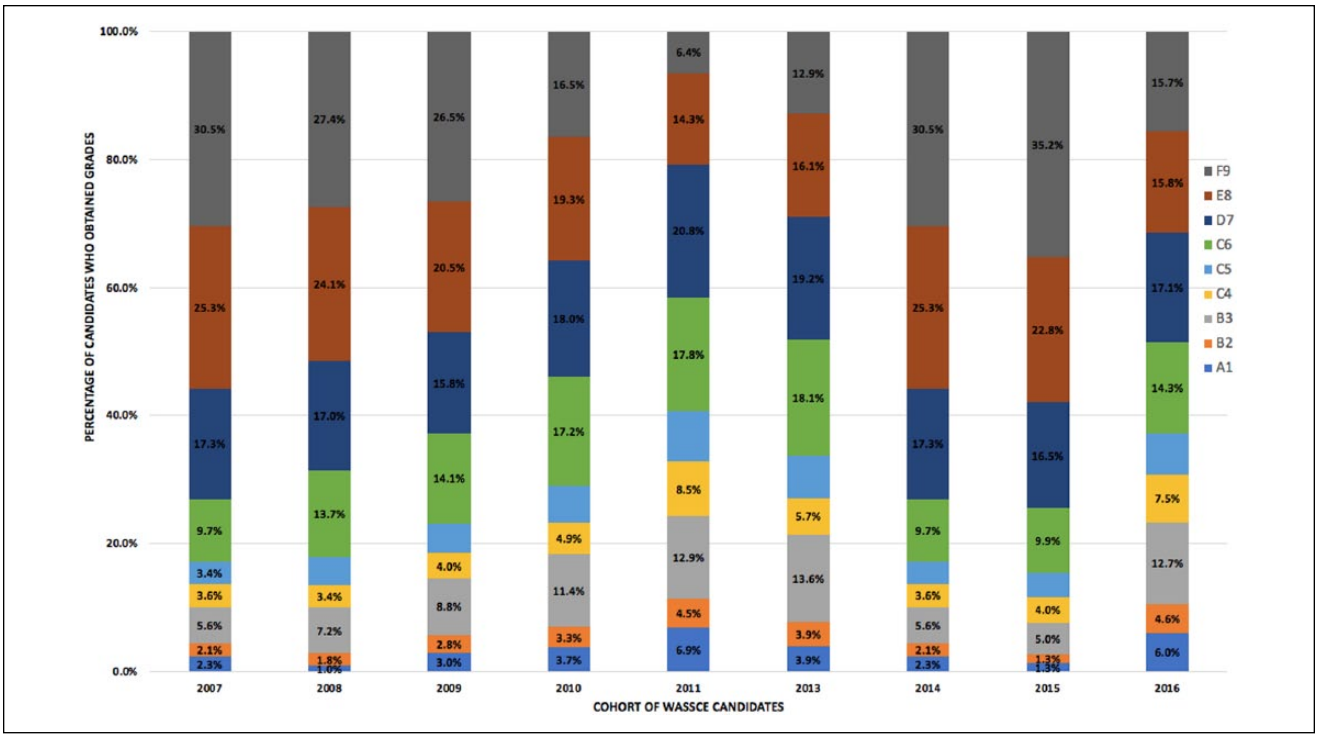

Figure 2. Bar chart showing the proportion of WASSCE grades obtained in science for 2007 to 2016.
Note. WASSCE = West African Secondary School Certificate Examination.

(master's) degree holders in the specific disciplines with a professional teacher training. For the science teachers, the majority (78.5%) possess bachelor's degree in science or basic education, whereas the rest (21.5%) possess higher degrees (i.e., MEd and MPhil degrees). Similarly, among the mathematics teachers, 86.7% possessed first degrees, whereas the remaining 13.3% had higher degrees.

The data collected showed that some science and mathematics teachers were teaching out of their subject area of specialization. Table 4 shows the distribution of the number of teachers teaching in their area of specialization and those instructing out of their areas of specialization. Examples of qualifications possessed by teachers teaching out of their subject areas as reported by the heads of department included BSc (agriculture), BSc (computer science), MSc (engineering), and BEd (technology); these were examples of those teaching science. Similarly, mathematics teachers who were teaching out of their area of specialization came from backgrounds including BSc (financial mathematics), BA (economics and statistics), and BSc (mechanics).

Table 3. Distribution of Highest Academic Qualification of Senior High School Science and Mathematics Teachers.

Highest academic qualification	Number of science teachers (*N* [%])	Highest academic qualification	Number of mathematics teachers (*N* [%])
BEd (science)	120 (36.9)	BEd (mathematics)	129 (41.6)
HND/BSc/BA	126 (38.8)	BSc (mathematics)/BA/HND	121 (39.0)
BEd (basic education)	9 (2.8)	BEd (basic education)	19 (6.1)
MEd (science)	27 (8.3)	MEd (mathematics)	27 (8.7)
M. Phil. (Science education)	11 (3.4)	MPhil (mathematics education)	5 (1.6)
MPhil (in science-related fields)	32 (9.8)	MPhil (in mathematics-related fields)	9 (2.9)
Total	325 (100.0)	Total	310 (100.0)

Note. HND = higher national diploma.

Table 4. Distribution of Science and Mathematics Teachers Teaching in Their Areas of Specialization and Out of Subject Area of Specialization.

Subject area	Number of teachers teaching in their area of specialization (*N* [%])	Number of teachers teaching in out of subject area of specialization (*N* [%])	Total (*N* [%])
Science	115 (72.8)	43 (27.2)	158 (100.0)
Mathematics	84 (54.5)	70 (44.5)	154 (100.0)

Table 5. Professional Qualification of Integrated Science and Core Mathematics Teachers in the Selected Senior High Schools.

Professional status	Number of science teachers (*N* [%])	Number of mathematics teachers (*N* [%])
Professional	167 (51.4)	180 (58.1)
Nonprofessional science	158 (48.6)	130 (41.9)
Total	325 (100.0)	310 (100.0)

Besides teachers' academic qualifications, one other criterion that is pertinent and crucial to their job is their professional qualification. In this study, most of the science and mathematics teachers primarily had BEd (science) and BEd (mathematics) degrees, respectively (Table 3). Also, some of the teachers possessed BEd (basic education), MEd (science), MPhil (mathematics education), MPhil (science education), and MPhil (mathematics education), which are professionally higher degree qualifications. The teachers possessed professional education degrees and diplomas, such as diploma in education, MEd (IT), postgraduate degree certificate, diploma in basic education, BEd agriculture, and MPhil agricultural extension. Furthermore, some of the teachers had BEd (technology and mathematics), BSc (computer science), higher national diploma (HND) (statistics), MPhil (actuarial science), and BSc (mathematics education). Table 5 shows the distribution of science and mathematics teachers in the schools sampled concerning their professional status. We found out in this study that relatively few teachers have higher degrees in science and mathematics in secondary schools, and the reason assigned for this, for the most part, was that premium is not placed on teachers' acquisition of higher degrees or qualification. In addition, it was pointed out that there were no incentives for going for higher education because the system of education rarely recognizes these kinds of qualification.

In addition, both teachers and students noted that the science and mathematics syllabi are not completed before they wrote the WASSCE. It was additionally found that the majority of the respondents posited that teachers could complete between 50% and 75% of both the science and mathematics curricula. Respondents were asked to provide reasons for the lack of full completion of the science and mathematics curricula. The outstanding reason respondents gave for the lack of full completion of the science and mathematics curricula was the insufficient duration within which teachers have to implement the curricula. Different reasons were assigned for the insufficient duration for completion of the curricula. Among them was what respondents noted as the delay of first-year students' admission, which made them conclude that students spent less than 3 years at the SHS. In some cases, schools ended up admitting students in the second term of the first year. The reasons are further supported by the argument that the time students write their

final examinations also cut short the duration of the schooling process. Respondents also asserted that there were excessive extracurricular activities, which hindered the completion of the curriculum. There was also the viewpoint by some respondents that the contact hours per week for the teaching of science and mathematics topics were too short.

The second highest theme gathered from the responses of the respondents concerning the inability to complete the science curriculum was the low comprehension level of the science content by students, whereas respondents for mathematics noted that weak foundation of students in mathematics was the second highest reason militating against teachers' ability to complete the mathematics syllabus. Respondents highlighted that most of the students who pursue science and mathematics have a poor understanding of science and mathematics concepts emanating from their weak foundations in the subjects from the junior high schools. Thus, the quality of students pursuing science and mathematics is noted as one of the reasons accounting for the failure on the part of teachers to complete the curricula. Given the fact that some students are academically weak, teachers need to spend more time in explaining concepts, otherwise, students' conceptual understanding would be impaired, and this would ultimately make the teacher teach at a slow pace, which, in turn, lead to the incompletion of the curricula.

Again, respondents in this study were of the view that the curricula materials, especially for science, that should accompany the curriculum to facilitate their effective implementation were not available. Both teachers and students felt that there was a general lack of teaching and learning materials when it comes to the teaching and learning of science and mathematics. Respondents noted that one of the reasons that affected the completion of the science and mathematics curricula was truancy on the part of both teachers and students. The respondents indicated that some teachers absented themselves from class more often and this affected the completion of the curriculum. Students, however, also tended to absent themselves from classes, which affected the completion of the curricula. Some teacher respondents noted that some students even absented themselves from free extra classes some schools put in place to promote the completion of the curriculum.

Lack of enough teachers, low interest in learning mathematics, poor teaching approach, and laziness on the part of teachers were the other reasons assigned by the respondents as militating against the completion of the science and mathematics curricula. Most respondents indicated that their schools do not have enough teachers to teach the subjects. Some heads indicated that they did not have full complements of staff in science and mathematics. Lack of teachers and its associated issues push the few teachers to teach more than the stipulated number of classes and hours, which ultimately affects how much of the curriculum they can complete because of the heavy workload bestowed on them due to lack of teachers to teach the subject. Respondents also maintained that most of the students tend not to like science and mathematics, and this affects how they learn the subject. Due to such negative attitude toward the subject, the students do not put in much effort to learn, which affects their progress in class and ultimately their performance at WASSCE.

Discussion of Findings

The observable patterns that emerged from the performance of WASSCE candidates in Ghana for the past decade did not establish rising, stalemate, or falling performance. Three relatively outstanding performances of students in mathematics and science were noted in the years 2011, 2012, and 2016. The exceptional performance of the two cohorts of students who experienced a 4-year duration of secondary education in 2011 and 2012 and who also studied core subjects of which mathematics and science were a part needs to be looked at more empirically beyond the kind of trends the bar charts project. For one thing, it was within this period that students were made to study only the four core subjects of mathematics, English language, integrated science, and social studies in the first year. Over the years, the perceived stakeholder performance concerns raised were related to these four core subjects. Another exceptional performance of candidates also emerged in 2016, where there was an enormous improvement of students' density of letter-graded performance vis-à-vis the preceding years of 2013, 2014, and 2015. The cause for improved performance in 2016 needs further scientific analysis, in view of the fact that there was no known intervention that occurred in the period apart from the SEIP intervention, which was only barely a year old, and not enough to have established any known causality on students in their terminal grade. Thus, there is no obvious increasing or decreasing trend in the performance of students in science and mathematics in the WASSCE, although the performance of students in these subjects is generally low. What is obvious, however, is that the performance of students in these subject areas fluctuates.

It is a truism that academic and professional qualifications of teachers are linked to the academic success of students. Research has established the relationship between teacher qualification and student performance (Abe, 2014; Obasi, 2010). Furthermore, advanced academic degrees are positively associated with student achievement in mathematics and science (see Zuzovsky, 2009), although other studies hold a different viewpoint on the matter. For instance, Hill, Sleep, Lewis, and Ball (2007) did not establish direct influence of teachers' advanced degrees (at least in subject areas) on students' improved achievement. The results of this study revealed that most of the science and mathematics teachers

possessed only first university academic and professional qualifications such as BEd (science), BEd (mathematics), BSc (science), and BSc (mathematics), but not advanced academic and professional qualifications like MEd (science), MPhil (science), MPhil (science education), MEd (mathematics), MPhil (mathematics), and MPhil (mathematics education). The teacher characteristics appear to be relatively right on the surface. However, there are a relatively large number of teachers in both mathematics and science who are doing out-of-subject teaching in Ghanaian schools. It is additionally worth noting that more mathematics teachers are teaching out of field than among the science teachers.

The low proportion of teachers with higher professional and academic qualification teaching science and mathematics in Ghanaian SHSs can be a significant factor affecting the performance of students in the WASSCE. This finding is intriguing and perplexing, in that, one is justified to query the sort of science and mathematics these teachers are teaching the students. It is, therefore, not surprising that there seems to be a high failure rate in these subjects because there is growing evidence of the relationship between teachers' content knowledge, pedagogical content knowledge, and the effect of this on instructional practices across subject areas at different grade levels (Liakopoulou, 2011; Walshaw, 2012), suggesting that if teachers have the requisite subject content knowledge without the professional training (pedagogical content knowledge) needed to impart effectively in classrooms, students' learning outcomes would be affected. This study concedes that there are myriads of other factors beyond the teacher characteristics that can potentially affect students' performance outcomes. These other factors need to work hand-in-hand with other necessary factors outlined in this article, to achieve better results than those shown in the trends in students' performance in WASSCE for the past decade.

The current situation where teachers are not able to complete the science and mathematics curricula is very worrying and has implications for performance. Also, the state of incompletion of the syllabus tends to impair students' current and future learning opportunities. It is a known principle in assessment that assessors seek to have content validity. Thus, if teachers are not able to complete the curriculum, then definitely there will be questions that their students may not be able to answer. Besides the inability to respond to certain questions, students who can progress to the higher level will have learning deficits because some concepts at the secondary level serve as the foundation for advanced concepts at the tertiary level. The reasons assigned to teachers' inability to complete the curricula are alarming, which need urgent attention to address them. Issues of limited time to enact the curriculum, lack of teaching and learning materials, inappropriate teaching approaches, among others, are important factors that affect student learning outcomes. Given the volume of content to be covered, the time for completion of the program currently appeared to be relatively short. Also, it has been observed that first-year students virtually have no meaningful lessons in the first term of their admission because of the lateness of their admission, coupled with the early completion of the program in their third year, all affect their performance negatively and makes it absolutely impossible for students to have conclusively 3 years of curricula and teaching activities. With the advent of free secondary education for Ghanaians, government has taken steps to ensure that students' qualification exam results are released early enough to enable those who qualify enter on time to enjoy full 3 years of schooling.

Conclusion

The trends established regarding the performance of WASSCE candidates in Ghana from 2007 to 2016 do not provide a definitive pattern of performance. For instance, apart from 2011, 2012, and 2016, when the performance seemed to be outstanding, the performance in the rest of the years could be described only as reasonably satisfactory. The reasons for the exceptional performance in the 2011 and 2012 largely related to 4 years these cohorts had to spend in school plus the fact that the students studied only four core courses in first year including mathematics and science, affording them more time to master the school mathematics and science syllabus before taking WASSCE. However, the cause for improved performance in 2016 needs further scientific analysis because no known systemic occurrence was known to have occurred in the period apart from the SEIP intervention, which was only barely a year old, and not enough to have established any known causality.

This study has offered, although to a limited extent, possible reasons for the trends as established. For instance, the academic and professional qualification of teachers across schools was identified not to be uniform. Also, the perception of science and mathematics curricula as not utterly relevant to the needs of Ghanaian society and development tends to affect teaching and learning broadly and performance in specific terms. This study has, thus, explained in explicit terms that maintenance of improved trends in performance is dependent on the factors including those discussed in this article. This research has shown that for a diagnosis of school-level as well as system-level performance analysis, there is the need to engage in other possible factors to identify potential hotspots that ought to be given attention.

Recommendations

The Ministry of Education and the Ghana Education Service should ensure that teachers are recruited to teach only in their areas of specialization to ensure maximum output in their fields of profession. In view of the finding that there is little to no recognition for higher degrees, it is recommended

that the Ministry of Education should take steps to recognize higher degrees and qualification with, for instance, marking the salary differentials based on teacher level of qualification and work output. The 3 years duration of secondary education on paper is less in comparison with actual period of schooling as indicated in the findings; hence, we recommend that there should be a systemic change in school practices, so that 3 years of schooling actually means 3 years of academic work. This may not necessarily mean increasing the length of years of schooling from 3 to some years higher than that but making sure that the stipulated instructional time is maximized for teaching and learning purposes. Thus, although this study primarily targeted students' performance in a regional examination by candidates taking the examination from the Ghanaian nation, the findings have implications for global secondary education and practice because mathematics and science achievement is of global concern.

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