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Benchmarking Quality Framework for Mathematics Education in Pre-Tertiary Schools in the Western Region of Ghana: Theoretical Perspective

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Abstract:
Background*: The quality of teaching and learning mathematics has been one of the major challenges and apprehensions of educators and researchers in recent years. The study aimed at theorizing benchmarks for and against achieving quality frameworks for mathematics education in Pre-Tertiary schools in the Western Region of Ghana.*
Materials and Methods*: Document analysis across various countries and by various authors were conducted to unearth quality, tried and tested benchmarks and inhibitors with the view to establishing key factors that suppresses performance and those that improve student mathematics achievement.*
Results*: The literature revealed among others major indicators which on one end of the performance continuum are variables that are deemed to be positively correlated with performance and on the other end are variables that are suggested to be correlated negatively with performance of students in mathematics, the positive correlates include: the mathematics and pedagogical knowledge of teachers; attitude of mathematics teachers; and classroom practices of mathematics teachers. Others include qualification of mathematics teachers; teacher's professional development and teacher's personal experiences. Some others are attitude and beliefs of students; practices of students; home environment; mathematics curriculum and school environment. The negative correlates include: teacher absenteeism; perception of mathematics as difficult; student fear of mathematics; and student inattentiveness.*
Conclusion: *A sequel to this study is ongoing where the identified key indicators are used as benchmarks to conducting situational analysis at Senior High Schools with the view of coming up with quality frameworks for improving upon the mathematics achievements of students in this part of the world.*
Key Word*: Benchmarks; mathematics achievement; mathematics education; mathematics teachers; quality framework.*

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I. Introduction

Quality education has been defined as the kind of education that provides every learner with capacities to become productively useful, economically sound, continuously self-sufficient, and increasingly empowered to succeed in life. The quality of teaching and learning mathematics has been one of the major challenges and concerns of educators in recent times. Good teaching is an interaction between the teacher and student leading to a thorough and lasting acquisition of knowledge, skills and values. Reference [1], opined that knowing the factors affecting mathematics achievement was key to improving upon quality, he outlined three factors which promote quality education. These are the instructional design; teacher competency and motivation.

Reference [2] also noted that quality teachers and their professional development make a difference in students' achievement, he noted that, what students bring on board from their previous educational background did not matter, rather their experiences on a daily basis in interactions with teachers and other students in the classroom is what counts. He argued that since teachers were the most valuable resources available to schools, an investment in teacher professionalism was vital. Further, he asserted that such professionalism could only be achieved by ensuring that teachers were equipped with a repertoire of pedagogical skills that were effective in meeting the developmental and learning needs of all students. [3] reported that prior mathematics achievement was a good predictor of students' achievement.

In[4], the authors underscored three main ingredients to quality mathematics teaching, these are; teacher capacity (that is, the quality of teachers in terms of background training, experience, subject matter qualifications and teacher education), teacher enabling conditions(that is, the quality and amount of professional development in which teachers have engaged over recent years) and school enabling conditions(that is, the quality of the professional community in which teachers work, the philosophy of the work group, opportunities

for mutual work and leadership support). They contended that teacher quality would always be at the heart of the education policy and reform. And that policymakers who want to influence student achievement in mathematics must know that teachers are where the rubber hits the road. It was also worthy to note that student learning takes place in the classroom, not in departments of education. A quantitative analysis performed showed that measures of teacher preparation and certification were by far the strongest correlates of student achievement in reading and mathematics, both before and after controlling for student poverty and language status. State policy surveys and case study data were used to evaluate policies that influenced the overall level of teacher qualifications within and across states. The analysis suggested that policies adopted by states regarding teacher education, licensing, hiring, and professional development may make an important difference in the qualifications and capacities that teachers bring to their work [5]. [6] has also revealed that teacher behavior has a great role to play in school discipline and subsequently student performance.

The Global Sustainable Development Goal 4 [7] has maintained that by year 2030, every nation must strive to achieve quality education; the world leaders were of the view that obtaining quality education was the foundation for improving people's lives and sustainable development and Ghana cannot sit on the fence and pretend that all is well with our mathematics education. The free Senior High School (SHS) programme that was rolled out in 2017, increased the enrolment figures by more than 50,000. According to the Deputy Minister of Education in charge of pre-tertiary education, the anticipated increase in enrolment in 2018 is 180,000. The increased enrolment figures have compelled the government to introduce the double-track education policy with very good intentions to accommodate the increases and to reduce class sizes among other tangible reasons. As excellent as the policy might be, there are implications to quality mathematics education and student performance in mathematics which educators must not gross over.

When the free SHS logo for Ghana was launched, the theme for the occasion was: Access, equity and quality. The policy was to ensure access to secondary education, equity in the secondary education system and most importantly quality in teaching, learning and assessment. These are wonderful and brilliant variables that should underpin the philosophy of the educational system in Ghana. But the question that arises is, does the manner in which Ghana is implementing the free SHS policy fall in line with these three variables? Achieving quality education is not just a matter of slogan or logo or the introduction of free SHS and the double track system, it is so complicated and lends itself to empirical investigations, and it therefore means that more needs to be done if our focus is to achieve quality education. The Ministry of Education (MoE) and the Ghana Education Service (GES) have certain parameters they use to gauge quality education, which are termed "Quality Inputs". These are; student-teacher ratio, student-trained teacher ratio, student-textbook ratio, student-classroom ratio, student-desk ratio, percentage of qualified teachers, percentage of specialized teachers, class size, survival or repetition rate, expenditure on education, per capita cost and others. These inputs are supposed to be relatively reasonable to achieve quality education. The GES norm is that, student to teacher ratio at the SHS level should be 1: 25. Thus, each 25 students should be handled by a teacher. The national average is around 1:35 or 1:40. Moreover, student to classroom ratio hovers around 46, thus, on the average 46 students must be assigned to one classroom. The implication of this is that, by removing the barriers of accessibility (that is, affordability and infrastructure), the automatic result will be an increase in enrolment. The end result will be an increase in student-teacher ratio, student-classroom ratio, and reduction in per capita among others. The increase in enrolment will have pedagogical implications and can affect teacher-student interaction and instructional processes.

Lessons on the impact of increase in enrolment on quality education as a result of free education from countries such as Uganda, Kenya and Namibia should always be a guide - the revelation was that the free education brought about lower quality in education in Kenya, it also failed to improve upon equity. In Uganda, it brought about decline in the mathematics achievement of students. In Namibia, there was lack of understanding from parents regarding their financial, social, cultural, and political responsibilities towards the education of their children [8].

Other key indicators to quality education follows: Basic infrastructural needs must be provided; management and community support systems must be effective and efficient, moreover, school and classroom environment must be conducive. In addition, curriculum, teaching and learning materials must be readily available; teacher and teacher preparation must be well-balanced; Furthermore, opportunity time (teaching-learning time); classroom practices, processes and learners' assessment must be up to standard; finally, monitoring and supervision must be available and operational. (https://www.scribd.com/presentation/98261904/Quality-Education-Dimension-and-Key-Indicators)

Teacher absenteeism is a hindrance to obtaining quality mathematics education, it is a persistent problem in many countries including Ghana. A World Bank study revealed that in Uganda and Zambia, the shares of teachers who had been absent in the previous week before the visit of researchers were 26% and 17%, respectively [9]. The literature also has it that many educational officials in Ghana who appraise mathematics

teachers, have little or no training in secondary school mathematics teaching or its appraisal, again, one of the major stumbling blocks in the delivery of quality education in the country has been the lack of textbooks.

Reference [10] has charged curricula developers to design the school curriculum by the four pillars of the curriculum framework, which are: subject and curriculum knowledge; literacy studies; pedagogic knowledge; and supported teaching in schools. If the mathematics curriculum is designed according to these four pillars, there is no doubt that the rate at which students fail mathematics would be reduced.

My attention at this juncture is to explore the broad concept of mathematics in the light of all the findings made for and against it. Mathematics is a practical application of matter, though the subject appears to be abstract, its application to scientific and technological development in any society cannot be overemphasized. It is a language of pattern and order and has an inherent quality of creating in a person the ability to approach life systematically and orderly. Mathematics also enhances the power of reasoning, creativity, problem solving ability, aesthetic appreciation, communication skills, spatial thinking, and critical thinking. It offers rationality to our thoughts and makes our life simpler and easier. Additionally, mathematics is said to be the framework of all creation; artisans, cooks, engineers, medical doctors, farmers, lawyers, drivers, accountants and all other professionals have need of it [11].

Mathematics is also important as a school subject because not only is it needed for the sciences but also, it provides access to undergraduate courses in engineering, psychology, sciences and social sciences [12]. The main arguments for the importance of mathematics fall into two areas. Firstly, mathematics is a core skill needed by all adults in life, secondly, a mathematically well-educated population will contribute to the country's economic growth and prosperity. Researchers in mathematics education are primarily concerned with the tools, methods and approaches that facilitate practice or the study of practice. [13] has reported that the goal of teacher education is to support prospective teachers to offer students rich mathematical experiences through collaborative lesson planning and enactment of highly demanding problem-solving tasks with students.

The National Teachers Standard for Ghana has also documented three domains that would enhance effective and efficient teaching at the pre- tertiary level. These are the professional values and attitudes, the professional practice, and the professional knowledge of teachers. If every teacher, especially the mathematics teacher, measures up his/her teaching according to these three domains, chances are that student's mathematics achievement will be enhanced.

The Real Challenge

The importance of the subject matter in life situations, culminated in the Ministry of Education making mathematics one of the three core subjects at the West African Senior Secondary Certificate Examination (WASSCE) level. The National Council for Tertiary Education (NCTE) now Ghana Tertiary Education Commission(GTEC) has also made mathematics one of the three core subjects for accessing any tertiary education programme in the country's tertiary education institutions, this is meant to improve mathematical literacy and steer the country towards economic and social growth and development.

Notwithstanding the wide applicability and importance of mathematics, the subject is yet to be decoded by learners, the subject still remains a mystery to some students at all levels of the academic ladder, while some of the students grab the concepts, formulae and processes and forge ahead, others have a negative mindset about the subject. The latter struggle to make meaning of a process, concept or formulae, irrespective of the method of teaching adopted by the facilitator, the subject seems incomprehensible to this latter group.

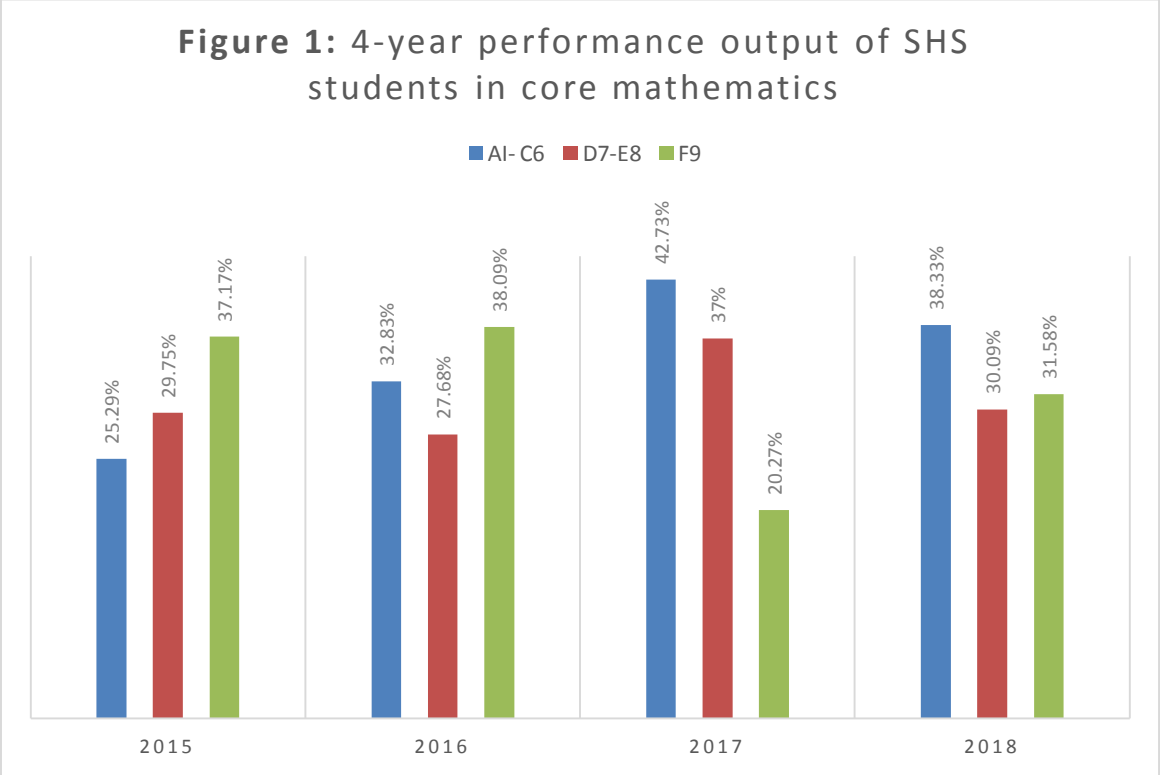
The teaching of mathematics is currently linked to stable and standardized knowledge provided by teachers who are the reservoirs of knowledge. These reservoirs of knowledge appear to be non-examinable, non-retrainable and non-negotiable. Through interviews, teacher tests, and direct observation, some scholars have uncovered problems with teachers' basic mathematical knowledge. Some mathematics teachers are so much glued to the traditional methods of teaching and assessment of students; such as the non-interactive ways of teaching, where the student is more or less a receiver of the knowledge at a level of minimum participation, if not in a non-participative mode. This mode of delivery seems not to serve the learning needs of the students and thus renders most of the students unable to appreciate the subject matter. The mode of assessment also poses additional challenge, no feedback, and no remedial actions. [14] has advocated the use of an alternative teaching method such as active learning and cooperative learning in achieving good results.

Results released year by year by the West African Examinations Councils (WAEC) for Senior High School graduates reveal that majority of the candidates fail mathematics. The trend is alarming and shows clearly that the teaching of mathematics at the pre- tertiary levels has not been effective. The performance of Senior High School (SHS) students for the period 2015 to 2018 is presented as Figure 1, the figure depicts clearly that the percentage of failure in mathematics is unacceptably high. In 2015, 66.92% obtained grades D7, E8 and F9, a grade which disqualifies one from accessing Bachelor degree programmes in the university and other tertiary institutions. In the 2018, 61.62% obtained grades D7, E8 and F9. This trend must stop. It appears that no concrete effort has been made to unearth and mitigate this problem.

The chief examiners report concerning the weaknesses of the students seem not to have had any impact on the subsequent year's results. A sample of the many reports published by the WAEC on their website (waec.org) reads inter alia: In the 2015 core mathematics examination, the weaknesses identified were as follows: students had difficulty:

- recalling and applying circle theorem to solve related problems;
- translating word problem into mathematical statement; and
- using ruler and a pair of compasses only to construct a trapezium.

During the recent high school debate programme aired on Joy news [15], we heard one of the debaters saying "As a prospective lawyer what will SOH, CAH, TOA do for me, what will πr^2 do to my life?" Variations of these questions have echoed in the halls of mathematics classrooms everywhere. Struggling students often become frustrated with mathematics problems and quickly give in to the notion that they will never use mathematics in real life. Their mindset thereafter is blocked from receiving any mathematical concept. The questions that are begging for answers are many, who bears the blame? Can we put the blame at the doorsteps of the teachers of mathematics for failing to adopt best practices? Can we blame it on the fact that some of the mathematics teachers are rusty and needed coaching? Can we also say that some of the teachers do not have in-depth mathematical knowledge and skills to transmit the knowledge hence only scratch the surface? Is it the case that some of the teachers come to the classroom unprepared and thus throw confusion into the learning environment? Do we put the blame on the government for failing to set up a mathematics council to supervise and regulate the activities of the mathematics teacher? Is the National Inspectorate Board living up to their mandate? Can we also say that best practices like continuous professional development for mathematics teachers are not yielding their desired results? Should we put the blame squarely on the students for reasons adduced by [16]? Is the cause of the problem traceable to home environments? Can we attribute it to school factors? "Is there no Balm in Gilead"? Can we not collectively as a nation put our oars together and reduce the failure rate or better still record no failures? These questions together with other undocumented queries have instigated the conduct of this study. I propose to carry out this study by firstly identifying key issues and best practices that have enhanced the quality of mathematics education in other countries, I will also look at some of the bottlenecks to mathematics achievements.



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Theoretical Framework

This section provides statements about the theories that informed the design of the study, and subsequently, shaped decisions about what data to collect and how to analyze them. [17] has noted that the objective of good mathematics teaching should not be to cover the curriculum but to show students how to explore our fascinating and beautiful world through the lens of mathematics. He argued that there was the need

to change our focus in mathematics education from a largely irrelevant and uninteresting set of learning objectives to one of making mathematics relevant and engaging for students. [18] has indicated that mathematical modeling education was a powerful tool for developing students' quantitative reasoning, productive disposition, problem-solving skills, and modeling competencies.

In the spirit of sharing what works, [19] has stated that student achievement starts with a good curriculum. The study revealed that:

- a good mathematics curriculum will help in effective teaching and learning of the subject;
- if one was guided in the formative stages of life, he/she will grow to like mathematics;
- learning mathematics can be easier if it was spiked with games, puzzles and riddles;
- teaching aids like pictures, sketches, diagrams, ICT and other models could as much as possible be used in explaining concepts in mathematics;
- students should be given assignments to practice what has been taught in class in order to master the concepts, develop speed and accuracy in problem solving; and
- teachers should encourage peer teaching among students during class hours.

A study conducted to explore the feasibility of using ICT in teaching mathematics at senior high schools in Ghana showed that mathematics teachers in Ghana do not integrate ICT in their mathematics instruction. The study further revealed that the mathematics teachers lacked knowledge about ways to integrate ICT in lessons, they also lacked training opportunities for ICT integration knowledge acquisition. This position is unaccepted if we are to achieve quality mathematics education.

To demystify the concepts of mathematics, [20] proposed a structure for constructing a mathematics curriculum, they averred that the curriculum must be relevant to the real world. Additionally, [21] documented that the starting point for curriculum planning should be shifted from the abstract mode of setting up behavioral objectives to one of conducting situational analysis; doing realistic appraisal and analysis of the situations as they exist. Reference [22] opined that assessment of students should aim at enhancing mathematics learning and supporting good instructional practices, to this end it was suggested that assessment should provide an opportunity for teachers and students alike to identify areas of strengths and weaknesses, after the identification, teachers were encouraged to make conscious efforts to build on the strengths and seek to transform weaknesses into significant learning outcomes. They further indicated that the time spent in conducting the assessment could contribute to the goal of improving the mathematical learning of students. In [16], the authors identified five major challenges confronting students learning behavior. He averred that those students' lacked initiative, perseverance, retention, skills in understanding word problems and were enthusiastic for formulas as against concepts and reasoning; if these facts were true of Ghanaian high school students, then it behooves mathematics teachers to rise up to the occasion and avert these lackadaisical attitudes of students.

Many researchers have underscored the importance of a well-planned instructional design which could provide a systematic process and framework for structuring, developing, and enhancing mathematics instruction and achievements. They further adduced that demographic, social, economic and educational factors have some positive influence on the mathematics curriculum. Other factors included, parents' socioeconomic status, student's study skills, social environment and parental support. Additionally, variables like; gender, family structure, parents' educational level, socio-economic status, parent and student attitudes toward school, and parental involvement in wards education were seen to have some amount of effect on students' mathematics achievements [23-29].

Reference [30], was of the view that environmental factors, the teacher factor, home environment, the parent factor, personal interest of student, method of teaching and method of assessment have a great effect on curriculum development, its study and mathematics achievement. The examination of the relationship between concepts and practice of mathematics teachers showed that the teachers' beliefs, views, and preferences about mathematics and its teaching, played a significant role in shaping their instructional behavior [30]. Reference [31] has also documented that the knowledge, belief and attitude of the teacher had a significant effect on his practices.

From the research outcomes documented above, three major factors come out strongly. Firstly, instructional factors (like the mathematics competency of teachers, teachers' beliefs and views, teacher's knowledge, instructional design, mathematics content, school settings and facilities). Secondly, demographic factors (like gender, socio-economic status, social environmental, parental support and educational background of parents). Thirdly, personal factors (like self-motivation, perception of mathematics and learning skills). [20] was of the view that to make mathematics relevant, six basic ways should be incorporated in the pedagogy of mathematics, they advocated that mathematics teachers should:

- incorporate graphs, tables, and charts in their lessons where necessary;
- use video story problems since they are great ways of thinking outside the box;
- conduct performance assessments based on real-life scenarios, so that students would see the application as they work through the situation**;**

- share a real-life context e.g., management of money;
- teach students to ask questions in class or during tutorials; and
- promote problem solving skills

They have observed that facilitators teach mathematics as a series of computations rather than a tool for solving open-ended and interesting problems, they argued that, too little of the mathematics learnt by students was situated in a useful context as a result, the mathematics curriculum was not motivating to students.

The National Council of Teachers of Mathematics [32] offered useful, tried and tested guidelines for achieving quality in the delivery of mathematics education. The council documented that the teacher must:

a. have a deep knowledge of mathematics on which to base their instructional decisions;
b. recognize the importance of what is known about the ways students learn mathematics;
c. know that what students learn is fundamentally connected with how they learn it;
d. know that all students can learn and think mathematically;
e. know that teaching is composed of elements that interacts with one another; and
f. know that no single right way exists to teach all mathematical topics in all situations.

A National statement on mathematics for Australian schools had been put in place by the Australian Education Consultants, the purpose of the document was to provide a framework around which systems and schools could build their mathematics curriculum. This document has become a key reference point for many aspects of Australian mathematics education since it was established in 1990. The Australian Education Council [33]. Reference [34] shed some light on why mathematics instruction in China was more effective than the one in the United States of America, they have identified, teacher professional development, teacher collaboration, mathematics coaching practices and school leadership as key factors that have enabled the success story of the Chinese students, the point here is that the profession of teaching is organized and supported well in China. (https//news.vanderbilt.edu/2013/10/23/math-instruction-china-effective/). New Zealand has developed a document referred to as the mathematics best evidence; this document evaluates, analyses, and synthesizes New Zealand and international research on quality teaching in mathematics

II. Research Method

Document analysis was adopted to categorize all documents consulted for purposes of classification, summarization and tabulation. The content was analyzed on two levels; basic and higher levels.

Content analysis

In arriving at the benchmark presented as Table 1, the following procedures were followed. All the literatures reviewed were read thoroughly making some brief notes in the margin when interesting or relevant information were found. Thereafter, the notes made in the margins were categorized in a way that offered rich feedback for the work at stake.

III. Result and Discussion

The document analysis across some regions of the world and other authors have revealed several useful factors that have bearing on the pedagogy of mathematics and student performance, these are, the teacher factor, the student factor, parental factor, home environment and the school factor. Others included, the curriculum, the instructional process, cross cutting issues, and supported school teaching. The rest are socio-economic factors, continuous professional development of teachers, professional values and attitude, professional knowledge, professional practices, remuneration and motivation. The summary is in **Table no. 1**.

Parental factor can be realized through such activities like, parents paying school fees promptly, organization of extra classes for ward, buying good textbooks, allocating time for assignments, helping in the doing of assignments, offering guidance and direction, not tasking child to overdo house chores, attending PTAs and getting feedback from the teachers concerning ward. The teacher factor was also reviewed. For a teacher to be tagged as the best mathematics teacher, the teacher must conduct assessment, give timely feedbacks after the assessment and use the outcome of the results to build on the strengths of students and work hard to significantly turn weaknesses into strength. Mathematics teachers need to create an enabling environment in the classroom where team and peer teaching will be highly encouraged. Where the school is situated, policy on discipline, staffing and motivation also have significant influence on mathematics achievement of students.

Table no. 1. Benchmark for factors theorized to be associated with quality and effective teaching of mathematics.

Factor	Effect of factor towards mathematics achievement as suggested by the literature review
Pedagogical knowledge of teacher	The Teacher's mathematics pedagogical knowledge must be deeply rooted. His knowledge about the learning styles of students is also very significant.
Attitude of math teacher	Attitude shapes practice, if teacher believes that every student can succeed in mathematics, then the quality and quantity of time will be balanced for optimum results.
Classroom practices of math teacher	Practices that involve students in the teaching and learning business, use of teaching aids, conduction of performance assessment and using results for building on strengths and transforming weaknesses into significant learning outcomes are very paramount.
Qualification of math teacher	Subject matter qualification is of the essence. Though High-level mathematics qualification has little or no effect on student achievements.
Teacher's professional development	Professional development and continuous mathematics education make a significant difference in student mathematics achievement.
Teacher's Personal experiences	Number of years of teaching, teacher competency and background training of teacher appear not to be associated with teacher effectiveness and mathematics achievement of students.
Attitude and beliefs of student	Most students are lazy and lack intuition, perseverance, retention, and skills in understanding word problems. Students' beliefs about mathematics learning motivates achievement.
Practices of student	Practice makes one perfect. Students must therefore interact with teachers and fellow students.
Home environment	Parent's socio-economic status, involvement towards child's education, educational background and the social environment have significant influences on student's mathematics achievement.
Mathematics curriculum	The instructional material must be developed after conducting situational analysis. Instruction must be customized to optimize the performance of each individual student.
School environment	The school environment supports the opportunity for collegial work. Features like leadership drive. teacher-student ratio, class size, disciplined learning climate and motivation are key.
Mathematics Regulatory Bodies	NCTM, NRC, National statement on mathematics for Australian schools, mathematics best evidence in New Zealand and Chinese mathematics curriculum reforms are all meant to coordinate and regulate mathematics education and enhance achievement
Teacher quality	This affects delivery of good outcome in teaching This affects performance negatively; it demoralizes and kills the enthusiasm of students.
Teacher Absenteeism	This has the tendency of blocking the mind of such students for intellectual discourse.
Student Anxiety	. This has a negative effect on student performance
Student attitude towards attendance to class	Lack of textbooks affects good lesson preparation and teaching.
Lack of requisite Textbooks	

IV. Conclusion

It is concluded and recommended that educators and researchers should conduct situational analysis at the various Senior High School in the Western Region of Ghana along the benchmarks revealed in this study to ascertain current practices and proffer frameworks that would enhance quality mathematics achievement.

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