Quest Journals
Journal of Research in Applied Mathematics
Volume 9 ~ Issue 9 (2023) pp: 19-29
ISSN (Online): 2394-0743 ISSN (Print): 2394-0735
www.questjournals.org

Review Paper

Teachers Content Knowledge in Teaching Standard Deviation in Adu- Gyamfi Senior High School in Ghana: The influence on Students' Performance

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Abstract
The focus of the study was to investigate the Content Knowledge and pedagogy of teachers of Mathematics and their impact on students' performance in Adu- Gyamfi Senior High School in Jamasi in the Ashanti Region of Ghana. The study adopted the quantitative approach and made use of purposive and random sampling methods to sample the respondents for the study. Data was gathered through observation and questionnaire. Data was analyzed using SPSS software and the results interpreted on tables and frequencies. The study revealed that, the teachers in the study area are well equipped with content and pedagogical knowledge when it comes to teaching of Standard Deviation topics in Mathematics. And this translates to the level of understanding among the students during teaching and learning situation. The study recommended that, Mathematics teachers in the study area should be well motivated by School management to continue to give off their best. In addition, the students were advised to continue to respect their Mathematics teachers so that, they would have the good heart to teach them.

KEYWORDS
Standard Deviation, Content Knowledge, Teaching, Pedagogy Students' Performance.

***R**eceived 06 Sep., 2023; **R**evised 16 Sep., 2023; **A**ccepted 18 Sep., 2023 © The author(s) 2023.*
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I. Background to the Study

On March 14, 2022, the International Day of Mathematics was celebrated by the Ghana Mathematics Society and the Science Education Unit (National Stem Centre) of the Ghana Education Service (GES). The theme was "Mathematics Unite." The main goal of the celebration was to make people more aware of how essential mathematics is to the growth of humanity. In Ghana, students in the first and second grades celebrate the day by doing hands-on activities, debating mathematics-related motions, competing in mathematics quizzes, and going to a mathematics fair/durbar.

Ghana thinks a good mathematics education for sustainable development should be based on questions (MOE, NaCCA, 2019). So, mathematics education must allow students to broaden, change, improve, and alter how they see the world. It should be based on mathematics teaching and learning methods that put the learner at the center and involve them physically and mentally in learning in a rich and rigorous inquiry-driven environment (Japelj Pavesic et al., 2022; Ministry of Education, 2020). Mathematics, science, and technology are used well in developed and developing countries. Modern societies are getting more complicated, which is happening simultaneously because science and technology are making giant leaps forward. Because of this, how mathematics is taught, learned, and used is also being carefully and thoroughly examined. Marilyn (1987) says that no modern society can live without mathematics ". In other words, the study of mathematics is critical to the work of every organisation.

Mathematics learning is an active process of building knowledge based on the learner's experiences, not just getting it (Principles, 2000). Learners are people who put together information and work as researchers. Teachers act as "facilitators" because they create an environment that helps students build their knowledge on top of what they already know. This makes what they are learning more beneficial and helps them become better critical thinkers and problem solvers (Japelj Pavesic et al., 2022). Ministry of Education, 2020). Two types of mathematics are taught in senior high schools and technical schools across the country. These are Mathematics

(core) and Mathematics (elective). The main reason for the mathematics curriculum is to help all young Ghanaians "acquire the mathematical skills, insights, attitudes, and values they will need to be successful in their chosen careers and daily lives" (MOE, 2010).

In the West African Secondary School Examinations from 2016 to 2020, the Chief Examiners for Mathematics (Core) 2 and Mathematics (Elective) 2 have given many examples of where students did not do well in mathematics. Even though the Chief Examiner for Mathematics (Elective) 2 saw that some candidates were good at figuring out the mean and standard deviation in 2019, those who tried to answer these questions got low marks. These candidates found the report's mean and standard deviation correctly, and only a few got the formula wrong. Part "b" of the same Question 13 had candidates who could not find the age of the person who left, so the standard deviation was poorly calculated, according to the report (WAEC-Ghana, 2019).

Jamasi and its environs are an active farming community. Most people who live in and around there are primarily involved in farming and trade. Because of these things, the people who live there do not see why they should pay much attention to school. In their senior year of high school in the area, students like to spend their time on social media, drugs and other vices. In the end, this is going to hurt their mathematics skills in the future. In the meantime, you can only make significant progress in almost any area of life by knowing science and mathematics.

The Statement of the Problem

In 2016, the Chief Examiners for Mathematics (Core) 2 and Mathematics (Elective) 2 instructed teachers of these two subjects, among other things, to take the steps needed to make mathematics lessons more practical and relevant to real-world problems (WAEC-Ghana, 2016). In 2018, the Chief Examiners for Mathematics said that teachers should give their students enough practice problems for each topic. Also, they said that candidates should be given more help in areas where they are weak by having the concepts explained in detail (WAEC-Ghana, 2018).

Armah et al. (2022) looked into and rated how Ghanaian first-year students in college understood the standard deviation based on what they had learned in core and elective mathematics classes in Ghanaian Senior High Schools (SHS). Based on the main points of the student's answers, it was clear that first-year college students need help understanding what standard deviation is. Little is known or has been researched about how teachers at Adu-Gyamfi Senior High School teach standard deviation and how well their students understand what they are learning. Since studies (Khodarahmi et al., 2022; Shi et al., 2020) have demonstrated that teachers' content knowledge is key in students' conceptual understanding. It is in view of this that this study is carried out to find to determine if mathematics teachers at Adu- Gyamfi SHS have the content knowledge to teach standard deviation; as well as determine if teachers pedagogical content knowledge impact students' academic performance in standard deviation

Research questions

1. Do the mathematics teachers at Adu- Gyamfi Senior High School have the content knowledge to teach standard deviation?

2. Does teacher's pedagogical knowledge impact students' academic performance in standard deviation at Adu- Gyamfi Senior High School ?

II. REVIEW OF RELATED LITERATURE

Teacher Licensing in Ghana

In Ghanaian schools such as Junior high schools (Basic Schools) and Senior high schools (Second Cycle schools), teaching and learning mostly occur in the classroom, where a teacher takes students through a subject like Mathematics, English language, Integrated science, social studies, etc. the teachers are often guided by teaching syllabus to prepare a scheme of learning and lesson note. In the Junior High and Senior High School syllabi, the topics are arranged and sectioned into years one, year two, and year three. Each topic in the syllabus has specific objectives to attain at the end of teaching that particular topic.

The teachers handling various subjects in the basic and second cycle schools in Ghana are expected to have gone the requisites training in those fields either from a university or college of education. After going through those years of training, he/she is expected to have acquired the right qualification and certification, such as a Diploma in Education, Bachelor of Education, Bachelor of Art, Bachelor of Science, Master of Education etc., in order to teach in Ghanaian public schools. These days an additional certification is required of the teacher to obtain a Teacher Licence after writing and passing the Teaching Licensure Examination organised by the National Teaching Council (NTC). When prospective teachers pass the Teacher Licensure Examination, he/she is issued a Teacher License renewable every two years. They are then posted to teach in any sixteen regions across the country where there are vacancies in the public schools for his/her subject area. Before 2018,

after successfully completing their programmes of study from either University or the College of Education in Ghana, teachers were posted to schools with vacancies by the Ghana Education Service (GES) under the auspices of the Ministry of Education. Where there are more vacancies to fill, the GES resorts to recruiting untrained teachers to fill those vacancies. The untrained teachers are those with content knowledge about the subject area but no or little knowledge about teaching methodologies, principles and pedagogies. The untrained teachers are sometimes called "non-professional teachers", whereas the trained ones are referred to as "professional teachers".

Mathematics Education in Ghana

As a subject in both junior and senior high schools, mathematics is found to be useful. It complements other subjects such as science, technical, vocational, economics, accounting, etc. the subject serves one of the requirements on which admissions are offered to students to pursue second-cycle education or tertiary-level education. If a candidate fails to pass mathematics to obtain a grade of C6 or better in the West African Secondary Certificate Examinations, the candidate would have to re-sit (re-write) the mathematics paper until the results improve. To qualify for tertiary-level admission, a passing grade in mathematics and all other subjects is between A1 and C6. Any grade apart from any within this required range is considered a failure, and admission will be denied to such prospective students.

Core mathematics syllabus adopted for use in the Ghanaian senior high schools' premise on the rationale that "the mathematics syllabus is focused on attaining one crucial goal: to enable all young Ghanaian persons to acquire the mathematical skills, insights, attitudes and values that they will need to be successful in their chosen careers and daily lives. The new syllabus is based on the premise that all students can learn mathematics and that all need to learn mathematics. The syllabus is, therefore, designed to meet expected standards of mathematics in many parts of the world". Again, it continues to stress the essence "Mathematics at the Senior High school (SHS) in Ghana builds on the knowledge and competencies developed at the Junior High School level. The student is expected at the SHS level to develop the required mathematical competence to be able to use his/her knowledge in solving real-life problems and, secondly, be well equipped to enter into further study and associated vocations in mathematics, science, commerce, industry and a variety of other professions" (Ministry of Education, 2010).

Studies in students' conception of arithmetic means

In Ghana, little has been done in terms of research work on students' conception of arithmetic mean in senior high schools. However, few can be said at the tertiary level in Ghana and outside the country where scholars and researchers tried investigating undergraduate students' conceptions of the arithmetic mean. Other scholars also investigated students' conceptual understanding of both mean and standard deviation. Armah (2018), who employed a case study approach, investigated fresh undergraduates' level of conceptual knowledge and understanding of mean and standard deviation and found a poor show of knowledge and understanding of the subject matter.

III. RESEARCH METHODOLOGY

Research Design

Bloomfield & Fisher, (2019) describe the research design as the blueprint or an outline for conducting the study in such a manner that maximum control will be exercised over factors that could interfere with the validity of the research results

This research was non experimental which means that no experiments or intervention was carried on(Johnson, 2001). It was purely a quantitative survey design which employed the use of face to face administered questionnaires to gather data for the research (Kothari, 2017). Survey research is defined as the process of conducting research by designing series of questions to elicit responses from a sample of respondents (Johnson, 2001). A quantitative research provides a researcher with data that is quantifiable, this is because numbers are assigned to answers so that researchers can objectively measure and compare. It is particularly useful method for collecting data when the sample size is large. The data collected from surveys are normally subjected to statistical analyses to draw meaningful research conclusions(Kothari, 2017). Surveys have demonstrated to be efficacious and trustworthy research methods. Surveys are not only used in academia, but it is the obvious choice for the business community. Cooperate institutions, Political Parties, the media, and even governments now rely on survey research to attain accurate and quality data. Survey research method provides the opportunity for collecting quantitative data for information from a pool of respondents by asking multiple survey questions. Survey research allows for variety of methods to recruit participants, collect data and utilize a plethora of methods of instrumentation(Bishop & Verleger, 2013).

Population

The targeted population was Mathematics teachers of Adu- Gyamfi Senior High Schools in the Sekyere South District in the Ashanti Region of Ghana. The accessible population was Two Hundred and Thirty Five (235).

Sample and Sampling Procedures

Sampling as a procedure is a way to use small number of units of a whole population to make generalization about the population. It has the advantage of reducing cost, saving time and to get a better result for a better conclusion (Etikan & Bala, 2017). A purposive sampling method was applied to select only mathematics teachers for the study. Purposive sampling method is a process whereby researchers use their own judgement to select participants for a study (Kothari, 2017). Purposive sampling according to (Etikan & Bala, 2017) is a form of non-random sample method whereby the researchers use their own judgment in choosing participants for the study..

In this case the study was on teachers' pedagogical content knowledge for teaching Standard deviation, hence the need to select only mathematics teachers.

On the part of the student the form three students were chosen because the researcher believes that they have been taught that topic already and that makes them the best participants for the study. To prevent biases a simple random technique was used to select 200 students for the study. 40 students each were randomly selected from each of the following programs, General Science, Home Economics, Business, General Arts and Visual Art. This is so because there was a chance that every person in the population would be chosen.

However, a census method was used to choose the teachers. Therefore, the study included all 35 mathematics teachers.

Research Instrument

The research work adopted the use of structured questionnaires to elicit responses from the service teachers on standard deviation**.** There were thirty (30) structured question items put under five headings; Section A was on Socio demographic characteristics of the student. Section B was on content knowledge, section C on pedagogical Knowledge, section D on pedagogical content Knowledge and section E on Pedagogical content Knowledge and Academic Performance sought to elicit responses on standard deviation in the teaching with regards to the research questions. The data collected for the study was to help find answers to the research questions. With regards to that a questionnaire was designed for the teachers and students to respond to them. A likert scale was used in order to help the researcher generate quantitative data for a better and formidable analysis, conclusions and recommendations.

Data Analysis

The data obtained was coded and entered in the SPSS Software package and converted to Frequency counts. The results were then summarized in tables for easy reading and understanding.

IV. RESULTS AND DISCUSSION

Table 1 : Socio-Demographics of Teachers

Variables	Category	Frequency (N)	Percent (%)
Gender			
	Male	30	85.7
	Female	5	14.3
Subject Taught			
	Core Mathematics	3	8.6
	Elective Mathematics	3	8.6
	Both	29	82.8
Teaching Experience			
	5 years and below	13	37.1
	6-10 years	7	20.0
	11-15 years	8	22.9
	16-20 years	2	5.7
	21 years and above	5	14.3
Highest Professional Qualification			
	First Degree	30	85.7
	Master's Degree	5	14.3
Area of Study			
	Geography	1	2.9
	Mathematics	34	97.1
Possession of teacher's license			
	No	9	25.7

Yes	26	74.3
Total	**35**	**100.0**

Source: Field Data, 2023

Out of the 35 Mathematics teachers sampled, 85.7% (N=30) were males and 14.3% (N=5) were females. Some of the teachers handled both Core Mathematics and Elective Mathematics (82.8%, N=29) whiles 8.6% (N=3) each taught only Core Mathematics or Elective Mathematics respectively. In terms of teaching experience, 37.1% (N=13) had taught for 5 years or below, 20.0% (N=7) had 6-10 years teaching experience, 22.9% (N=8) had 11-15 years of teaching experience, 5.7% (N=2) had taught for 16-20 years while 14.3% (N=5) had 21 years or above teaching experience.

Moreover, 85.7% (N=30) of the teachers had obtained First Degree as highest Professional Qualification and 14.3% (N=5) had obtained Master's Degree. All teachers (97.1%, N=34) but 2.9% (N=1) had Mathematics as their area of study. The 2.9% (N=1), majored in Geography. On teacher's license, majority of the respondents (74.3%, N=26) had obtained the license with the exception of 25.7% (N=9) who had not.

Content Knowledge of Teachers

To answer research question one of this study on "do mathematics teachers at SHS have the content knowledge to teach standard deviation?" both students and teachers were given a set of questions to answer on teachers' content knowledge on Standard Deviation. Tabel 4.2.1 and Table 4.2.2 present the findings from students and teachers respectively.

Table 2 : Students Responses on Teachers' Content Knowledge

Variable	SD N(%)	D N(%)	Nu N(%)	A N(%)	SA N(%)	Mean (Std Dev)
Mathematics teachers know about various examples of how standard deviation applies in the real world	32(16.0)	28(14.0)	49(24.5)	64(32.0)	27(13.5)	3.13 (1.28)
Mathematics teachers have unique professional knowledge base in mathematics	3(1.5)	4(2.0)	10(5.0)	67(33.5)	116(58.0)	4.45 (0.81)
I often times challenge teacher's concepts explanation on standard deviation	19(9.5)	49(24.5)	43(21.5)	56(28.0)	33(16.5)	3.18 (1.24)
Mathematics teachers demonstrate subject matter knowledge when teaching standard deviation	9(4.5)	9(4.5)	22(11.0)	90(45.0)	70(35.0)	4.01 (1.03)
Mathematics teachers have the ability to explain standard deviation content structure and its significance	2(1.0)	20(10.0)	33(16.5)	86(43.0)	59(29.5)	3.90 (0.97)
Mathematics teachers have knowledge in explaining Mathematics concept	4(2.0)	7(3.5)	14(7.0)	70(35.0)	105(52.5)	4.33 (0.90)
Mathematics teachers have the requisite knowledge in treating standard deviation and selecting relevant examples	9(4.5)	16(8.0)	26(13.0)	89(44.5)	60(30.0)	3.88 (1.07)

Source: Field Data, 2023

About 46.0% (45.5%, N=91) of the students strongly agreed/agreed that Mathematics teachers know about various examples of how standard deviation applies in the real world. Although, 30.0% (N=60) strongly disagreed/disagreed, 24.5% (N=49) remained neutral($Mean = 3.13, Std\ Dev = 1.28$). Also, majority of the students strongly agreed/agreed (91.5%, N=183) that Mathematics teachers have unique professional knowledge base in mathematics($Mean = 4.45, Std\ Dev = 0.81$). As a result, 34.0% (N=68) of the students strongly disagreed/disagreed that they often times challenge teacher's concepts explanation on standard deviation. However, 44.5% (N=89) strongly agreed/agreed whiles 21.5% (N=43) were neutral to the item ($Mean = 3.18, Std\ Dev = 1.24$).

From students' perspective of the level of content knowledge possessed by Mathematics teachers on Standard Deviation, majority of the students strongly agreed/agreed (80.0%, N=160) that Mathematics teachers demonstrate subject matter knowledge when teaching standard deviation ($Mean = 4.01, Std\ Dev = 1.03$), majority further strongly agreed/agreed (72.5%, N=145) that Mathematics teachers have the ability to explain standard deviation content structure and its significance ($Mean = 4.33, Std\ Dev = 0.90$). Whereas 87.5% (N=175) strongly agreed/agreed that Mathematics teachers have knowledge in explaining Mathematics concept, 74.5% (N=149) of the students strongly agreed/agreed that Mathematics teachers have the requisite knowledge in treating standard deviation and selecting relevant examples ($Mean = 3.88, Std\ Dev = 1.07$).

Table 3 : Teachers Responses on Teachers' Content Knowledge

Variable	SD N(%)	D N(%)	Nu N(%)	A N(%)	SA N(%)	Mean (Std Dev)
I know about various examples of how my subject matter applies in the real world	0(0.0)	1(2.9)	4(11.4)	13(37.1)	17(48.6)	4.31 (0.62)
I have unique professional knowledge base in mathematics	0(0.0)	0(0.0)	3(8.6)	14(40.0)	18(51.4)	4.43 (0.23)
My students often times challenge my concepts explanation	2(5.7)	15(42.9)	8(22.9)	8(22.9)	2(5.7)	2.80 (1.43)
I demonstrate subject matter knowledge when teaching	0(0.0)	0(0.0)	1(2.9)	26(74.3)	8(22.9)	4.20 (0.71)
I have the ability to analyse subject content structure and its significance	0(0.0)	2(5.7)	3(8.6)	17(48.6)	13(37.1)	4.17 (0.35)
I have knowledge in explaining standard deviation	0(0.0)	0(0.0)	1(2.9)	21(60.0)	13(37.1)	4.34 (0.60)

Source: Field Data, 2023

On the part of the Mathematics Teachers, 85.7% (N=30) strongly agreed/agreed that they know about various examples of how their subject matter applies in the real world ($Mean = 4.31, Std\ Dev = 0.62$), 91.4% (N=32) strongly agreed/agreed that they have unique professional knowledge base in mathematics ($Mean = 4.43, Std\ Dev = 0.23$) whiles 48.6% (N=17) strongly disagreed/disagreed that their students often times challenge their concepts explanation ($Mean = 2.80, Std\ Dev = 1.43$).

The study further realized that almost all of the teachers strongly agreed/agreed (97.2%, N=34) that they demonstrate subject matter knowledge when teaching ($Mean = 4.20, Std\ Dev = 0.71$), 85.7% (N=30) strongly agreed/agreed that they have the ability to analyse subject content structure and its significance ($Mean = 4.17, Std\ Dev = 0.35$). Majority of the teachers as well, strongly agreed/agreed to having knowledge in explaining standard deviation($Mean = 4.34, Std\ Dev = 0.60$). The tables and the observation below attested to the fact that the teachers have firm content knowledge of the concept and application of Standard Deviation.

So, in computing for the standard deviation we shall apply the same steps but the only difference is the introduction of frequency in our computations where the need be since the (data) information given involved frequencies. See Table 2.6 below:

Table 4 : Calculating standard deviation

Ages (yrs.) (x)	Frequency (f)	fx	x^2	fx^2
14	10	140	196	1960
15	35	525	225	7875
16	7	112	256	1792
17	5	85	289	1445
18	3	54	324	972
	$\sum f = 60$	$\sum fx = 916$		$\sum fx^2 = 14044$

Source: Researcher's compilation (2023)

The variance can be computed as: $variance = \frac{\sum fx^2 - \frac{(\sum fx)^2}{\sum f}}{\sum f - 1} = \frac{14044 - \frac{(916)^2}{60}}{60-1} = 1.0124$. Therefore, the standard deviation can now be computed as $\sqrt{1.0124} = 1.0061$. It further goes on to say that value of the standard deviation is quite minimal thus, 1.0061 which can be used to describe the data as within a normal distribution. Again, where, a grouped data with ranges or intervals are given to compute the mean, variance and standard deviation, the latter approach is applicable, having followed all the steps involved. But, the only addition to the complement the steps aforementioned is to introduce "class mid-points" to represent your $x - values$ in all your computations for the mean, variance and standard deviation. See Table 2.7 below which shows the distribution of ages of patients that visited a local health centre in a day. The range of the ages was: 1 to 10 years, 11 to 20 years, 21 to 30 years, etc.

Table 5: Distribution of ages of health centre patients

Ages (yrs.)	1-10	11-20	21-30	31-40	41-50
Frequency	10	35	7	5	3

Source: Researcher's compilation

In the case of Table 2.7, the mean, variance and standard deviation would be computed in the following table, thus, Table 2.8.

Table 6 : Computing standard deviation

Ages (yrs.)	Midpoints (x)	Freq. (f)	fx	x^2	fx^2
1-10	5.5	10	55	30.25	302.50
11-20	15.5	35	542.5	240.25	8408.75
21-30	25.5	7	178.5	650.25	4551.75
31-40	35.5	5	177.5	1260.25	6301.25
41-50	45.5	3	136.5	2070.25	6210.75
		$\sum f = 60$	$\sum fx = 1090$		$\sum fx^2 = 25775$

Therefore, the mean from Table 2.8 can be computed as $\frac{1090}{60} = 18.1666 = 18.2\ years$ and the variance can be computed as: $variance = \frac{\sum fx^2 - \frac{(\sum fx)^2}{\sum f}}{\sum f - 1} = \frac{25775 - \frac{(1090)^2}{60}}{60-1} = 101.2429$. Finally, the standard deviation can now be computed as $\sqrt{101.2429} = 10.0620$.

To be able to master these concepts and teach to the knowledge and understanding of the senior high students, the mathematics teacher ought to prepare adequately in advance, using the immediate surrounding information to craft a scenario or data to elicit students' interest before expanding to relate to other sectors.

The specific objective under the topic and content "standard deviation and variance" of the core mathematics syllabus (2010) enjoins teachers to offer support and encourage students to calculate and interpret standard deviation and variance of ungrouped data. Teachers are also encouraged to aid students in using computers and spreadsheets to draw similar graphs and calculate mode, mean, median, and standard deviation and compare their results. Students are also, according to the syllabus, required to demonstrate competences at the end of the lesson to be able to calculate and interpret standard deviation and variance.

With regards to the elective mathematics syllabus on statistics (measure of dispersion) it goes further on the core mathematics objectives to adopt assumed mean in calculating the standard deviation and variance. Students are to interpret and discuss the values of the standard deviations calculated from various data sets. Both core and elective mathematics treat standard deviation at the same dimension of knowledge and understanding.

Pedagogical Knowledge of Teachers

This section presents the results of research question two on mathematics teachers at SHS possessing the pedagogical knowledge to teach standard deviation. Table 4.3 shows the results from teachers whereas Descriptive Statistics Table 4.3.1 shows the trend of students' responses.

Table 7 : Pedagogical Knowledge of Teachers

Variable	SD N(%)	D N(%)	Nu N(%)	A N(%)	SA N(%)	Mean (Std Dev)
I productively utilise instructional time through the use of various teaching methods	0(0.0)	1(2.9)	2(5.7)	11(31.4)	21(60.0)	4.49 (0.52)
I have knowledge to maximize instructional time through awareness of all classroom activity	0(0.0)	1(2.9)	4(11.4)	17(48.6)	13(37.1)	4.20 (0.69)
I have knowledge of interpreting, evaluating and using research and data to inform teaching and learning process	0(0.0)	2(5.7)	1(2.9)	22(62.9)	10(28.6)	4.14 (0.93)
I have knowledge to improve emotional dispositions of individual students	0(0.0)	2(5.7)	2(5.7)	15(42.9)	16(45.7)	4.29 (0.77)
I have knowledge to assess students understanding in the concept	0(0.0)	0(0.0)	0(0.0)	24(68.6)	11(31.4)	4.31 (0.60)
I use the right teaching methods when teaching	0(0.0)	0(0.0)	0(0.0)	24(68.6)	11(31.4)	4.31 (0.60)
I have knowledge in organising and maintaining classroom management	0(0.0)	0(0.0)	0(0.0)	17(48.6)	18(51.4)	4.51 (0.19)
I have the knowledge to adopt to teaching style to different learners	0(0.0)	0(0.0)	2(5.7)	23(65.7)	10(28.6)	4.23 (0.31)

Source: Field Data, 2023

In ascertaining the pedagogical knowledge of teachers in handling standard deviation, majority of the teachers strongly agreed/agreed (91.4%, N=32) that they productively utilise instructional time through the use of various teaching methods($Mean = 4.49, Std\ Dev = 0.52$). Majority of the teachers also strongly agreed/agreed (85.7%, N=30) that they have knowledge to maximize instructional time through awareness of all

classroom activity($Mean = 4.20, Std\ Dev = 0.69$). The Mathematics Teachers strongly agreed/agreed (91.5%, N=32) that they have knowledge of interpreting, evaluating and using research and data to inform teaching and learning process to buttress their strong pedagogical knowledge($Mean = 4.14, Std\ Dev = 0.93$).

The teachers further indicated their possession of pedagogical knowledge by strongly agreeing/agreeing (88.6%, N=31) they have knowledge to improve emotional dispositions of individual students($Mean = 4.29, Std\ Dev = 0.77$). I have knowledge to assess students understanding in the concept was strongly agreed/agreed (100%, N=35) by all of the teachers($Mean = 4.31, Std\ Dev = 0.60$). All of the teachers strongly agreed/agreed (100%, N=35) to I use the right teaching methods when teaching ($Mean = 4.31, Std\ Dev = 0.60$) and I have knowledge in organising and maintaining classroom management($Mean = 4.51, Std\ Dev = 0.19$). More than 94% (94.3%, N=33) strongly agreed/agreed that they have the knowledge to adapt to teaching style to different learners, only 5.7% (2) were neutral($Mean = 4.23, Std\ Dev = 0.31$).

Table 8 : Descriptive Statistics of Students Responses on Pedagogical Knowledge of Teachers

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Mathematics teachers productively utilise instructional time through the use of various teaching methods	200	1	5	3.68	1.23
Mathematics teachers have knowledge to maximize instructional time through awareness of all classroom activity	200	1	5	3.68	0.94
Mathematics teachers have knowledge to improve emotional dispositions of individual students	200	1	5	2.88	1.34
Mathematics teachers assess students after mathematics lessons	200	1	5	4.02	1.09
Mathematics teachers use the right teaching methods when teaching	200	1	5	4.18	0.93
Mathematics teachers have knowledge in organising and maintaining classroom management	200	1	5	3.74	1.20
Mathematics teachers have the knowledge to adopt to teaching style of different learners	200	1	5	3.67	1.14

Source: Field Data, 2023

Table 4.3.1 shows that Mathematics teachers productively utilise instructional time through the use of various teaching methods ($Mean = 3.68, Std\ Dev = 1.23$). Also, Mathematics teachers have knowledge to maximize instructional time through awareness of all classroom activities($Mean = 3.68, Std\ Dev = 0.94$). Majority of the students further concurred that Mathematics teachers have knowledge to improve emotional dispositions of individual students($Mean = 2.88, Std\ Dev = 1.34$).

On possession of pedagogical knowledge by teachers, the study realized that Mathematics teachers assess students after mathematics lessons ($Mean = 4.02, Std\ Dev = 1.09$). Majority of the students expressed that Mathematics teachers use the right teaching methods when teaching ($Mean = 4.18, Std\ Dev = 1.20$), Mathematics teachers have knowledge in organising and maintaining classroom management ($Mean = 3.74, Std\ Dev = 1.20$) as well as Mathematics teachers have the knowledge to adopt to teaching style of different learners ($Mean = 3.67, Std\ Dev = 1.14$). These responses buttress the affirmation of teachers' responses on possession of the required pedagogical knowledge to teach standard deviation.

Impact of Teachers' Pedagogical Content Knowledge on Students' Academic Performance

To assess the impact of Teachers' Pedagogical Content Knowledge on Students' Academic Performance in Standard Deviation, teachers were asked series of questions bordering on their pedagogical content knowledge whereas students were made to either agree or disagree on the impact of teachers' pedagogical content knowledge on their academic performance in standard deviation. Table 9 and 10 below show the responses respectively.

Table 9: Teachers' Pedagogical Content Knowledge

Variable	SD N(%)	D N(%)	Nu N(%)	A N(%)	SA N(%)	Mean (Std Dev)
I can select effective teaching approaches to guide student thinking and learning in mathematics	0(0.0)	0(0.0)	2(5.7)	17(48.6)	16(45.7)	4.40 (0.82)
I am able to deliver standard deviation through classroom interaction with multiple dynamics	0(0.0)	3(8.6)	1(2.9)	20(57.1)	11(31.4)	4.11 (1.00)
I can make good presentation of standard deviation based on the knowledge I have about the students	0(0.0)	1(2.9)	2(5.7)	20(57.1)	12(34.3)	4.23 (0.63)
I can distinguish between correct and incorrect problem-solving attempt by students within my class	0(0.0)	2(5.7)	2(5.7)	16(45.7)	15(42.9)	4.26 (0.70)

I can effectively select teaching approaches to guide students thinking and learning of standard deviation	0(0.0)	0(0.0)	5(14.3)	19(54.3)	11(31.4	4.17 (0.87)
I can produce lesson plan with a good understanding of standard deviation	0(0.0)	0(0.0)	0(0.0)	18(51.4)	17(48.6)	4.49 (0.49)
I can anticipate likely students‟ misconception of standard deviation	0(0.0)	0(0.0)	2(5.7)	22(62.9)	11(31.4	4.26 (0.58)
I have the knowledge base to combine wide range of teaching approaches and correct concepts of standard deviation	0(0.0)	2(5.7)	5(14.3)	19(54.3)	9(25.7)	4.00 (0.91)

Source: Field Data, 2023

More than 94% (94.3%, N=33) of the teachers strongly agreed/agreed to the item "I can select effective teaching approaches to guide students thinking and learning in mathematics as a measure of their pedagogical content knowledge ($Mean = 4.40, Std\ Dev = 0.82$). Furthermore, majority of the respondents strongly agreed/agreed (88.5%, 31) that they were able to deliver standard deviation through classroom interaction with multiple dynamics ($Mean = 4.11, Std\ Dev = 1.00$) whiles majority of the teachers strongly agreed/agreed (91.4%, 32) that they can make good presentation of standard deviation based on the knowledge they have about the students ($Mean = 4.23, Std\ Dev = 0.63$)

Teachers moreover, strongly agreed/agreed (88.6%, N=31) that they can distinguish between correct and incorrect problem-solving attempt by students within their classes ($Mean = 4.23, Std\ Dev = 0.63$), majority strongly agreed/agreed (88.6%, N=31) to been effective in selecting teaching approaches to guide students thinking and learning of standard deviation ($Mean = 4.17, Std\ Dev = 0.87$) and all teachers (100.0%, N=35) strongly agreed/agreed that they can produce lesson plan with a good understanding of standard deviation ($Mean = 4.49, Std\ Dev = 0.49$).

It is observed from Table 4.4 that majority of the teachers strongly agree/agree (94.3%, N=33) to "I can anticipate likely students‟ misconception of standard deviation ($Mean = 4.26, Std\ Dev = 0.58$. Also, 80.0% (N=28) strongly agreed that they have the knowledge base to combine wide range of teaching approaches and correct concepts of standard deviation ($Mean = 4.00, Std\ Dev = 0.91$. Only 5.7% (N=2) disagreed whiles 14.3% (N=5) were neutral.

Table: 10 Impact of Teachers' Pedagogical Content Knowledge on Students' Academic Performance

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
I perform well in instructional assessment when Mathematics teachers have subject matter knowledge and uses good teaching approach	200	1	5	4.48	0.85
I perform well in standard test when subject matter is delivered through classroom interaction and multiple dynamics	200	1	5	4.16	1.00
I perform well in end of term exam when lesson plan is taught with a good understanding of the topic	200	1	5	4.30	0.95
I perform well in class participation when students' misconception is anticipated between various concepts through the teaching of standard deviation	200	1	5	3.92	1.06
I perform well in external exams when wide range of teaching methods is combined with correct concept	200	1	5	4.22	0.89
I perform well in mid-term exam when good presentation of standard deviation is made based on teacher's knowledge about the students	200	1	5	4.19	0.98
I perform well in past examination when teachers effectively select teaching approaches to guide my thinking and learning in standard deviation	200	1	5	4.29	0.91

Source: Field Data, 2023

In terms of impact of teachers' pedagogical content knowledge on students' academic performance, Table 4.4.1 shows that students perform well in instructional assessment when Mathematics teachers have subject matter knowledge and uses good teaching approach ($Mean = 4.48, Std\ Dev = 0.85$). Also, majority of the students perform well in standard deviation test when subject matter is delivered through classroom interaction and multiple dynamics ($Mean = 4.16, Std\ Dev = 1.00$). It could be ascertained further that students perform well in end of term exam when lesson plan is taught with a good understanding of the topic ($Mean = 4.30, Std\ Dev = 0.95$).

Moreover, students concurred that they perform well in class participation when students' misconception is anticipated between various concepts through the teaching of standard deviation($Mean =$

$3.92, Std\ Dev = 1.06$), a prerequisite of teachers' pedagogical content knowledge. Students perform well in external exams when wide range of teaching methods is combined with correct concept ($Mean = 4.22, Std\ Dev = 0.89$). The positive impact of teachers' pedagogical content knowledge on student's results in students performing well in mid-term exam when good presentation of standard deviation is made based on teacher's knowledge about the students($Mean = 4.19, Std\ Dev = 0.98$). Consequently, students perform well in past examination when teachers effectively select teaching approaches to guide their thinking and learning in standard deviation ($Mean = 4.29, Std\ Dev = 0.91$)

V. FINDINDS OF THE STUDY

Content Knowledge of Teachers

Responses gathered from both students and teachers indicate that mathematics teachers in Senior High Schools possess the needed content knowledge to teach Standard Deviations. For instance, the students agreed that Mathematics teachers know about various examples of how standard deviation applies in the real world ($Mean = 3.13, Std\ Dev = 1.28$), Mathematics teachers demonstrate subject matter knowledge when teaching standard deviation ($Mean = 4.01, Std\ Dev = 1.03$), Mathematics teachers have the ability to explain standard deviation content structure and its significance ($Mean = 4.33, Std\ Dev = 0.90$) and Mathematics teachers have the requisite knowledge in treating standard deviation and selecting relevant examples ($Mean = 3.88, Std\ Dev = 1.07$).

The Mathematics Teachers also affirmed by strongly agreeing that they know about various examples of how their subject matter applies in the real world ($Mean = 4.31, Std\ Dev = 0.62$), they demonstrate subject matter knowledge when teaching ($Mean = 4.20, Std\ Dev = 0.71$), they have the ability to analyse subject content structure and its significance ($Mean = 4.17, Std\ Dev = 0.35$) as well as having knowledge in explaining standard deviation ($Mean = 4.34, Std\ Dev = 0.60$).

Similarly, Kumi & Wonu (2021) found that Senior High students gave the indication that their Mathematics teachers know the content they teach. The findings of this study are in agreement with earlier findings of which established that teachers who have high self-efficacy can be effective in pedagogical content knowledge thereby creating a positive perception in the mind of students (Podell & Soodak 1993; Peterson et al., 2000; Ball et al., 2008; Ampadu 2012; Kumi & Wonu, 2021).

Pedagogical Knowledge of Teachers

The study ascertained that Mathematics teachers in the study area had the requisite pedagogical knowledge to handle standard deviation in the Senior High Schools. This was affirmed through the responses gathered from both teachers and students. Thus, the teachers strongly agreed that they productively utilize instructional time through the use of various teaching methods ($Mean = 4.49, Std\ Dev = 0.52$), they have knowledge to maximize instructional time through awareness of all classroom activity ($Mean = 4.20, Std\ Dev = 0.69$), they have knowledge of interpreting, evaluating and using research and data to inform teaching and learning process ($Mean = 4.14, Std\ Dev = 0.93$), they have knowledge to improve emotional dispositions of individual students ($Mean = 4.29, Std\ Dev = 0.77$), they have knowledge to assess students understanding in the concept ($Mean = 4.31, Std\ Dev = 0.60$), they use the right teaching methods when teaching ($Mean = 4.31, Std\ Dev = 0.60$), they have knowledge in organising and maintaining classroom management ($Mean = 4.51, Std\ Dev = 0.19$) and they have the knowledge to adopt to teaching style to different ($Mean = 4.23, Std\ Dev = 0.31$).

The students alike, agreed that teachers productively utilise instructional time through the use of various teaching methods ($Mean = 3.68, Std\ Dev = 1.23$), Mathematics teachers have knowledge to maximize instructional time through awareness of all classroom activities ($Mean = 3.68, Std\ Dev = 0.94$), Mathematics teachers have knowledge to improve emotional dispositions of individual students ($Mean = 2.88, Std\ Dev = 1.34$), Mathematics teachers assess students after mathematics lessons ($Mean = 4.02, Std\ Dev = 1.09$), Mathematics teachers use the right teaching methods when teaching ($Mean = 4.18, Std\ Dev = 1.20$), Mathematics teachers have knowledge in organising and maintaining classroom management ($Mean = 3.74, Std\ Dev = 1.20$) as well as Mathematics teachers have the knowledge to adopt to teaching style of different learners ($Mean = 3.67, Std\ Dev = 1.14$).

These findings corroborate with Kumi & Wonu (2021) who found that the general perception of students about their Mathematics teachers' pedagogical content knowledge was good and positive. Thus, the students' perceptions about teacher teaching ability, their pedagogical content knowledge was encouraging as observed in this study. Alshehri and Youssef (2022) found that mathematics teachers showed high confidence in their mathematics knowledge, skills, and teaching practices. Likewise, Gasteiger et al., (2019), found that mathematics teachers rated themselves higher in mathematical teaching than in mathematical knowledge and skills, which supports the idea that teachers are more confident in their practical knowledge than theoretical ones.

Impact of Teachers' Pedagogical Content Knowledge on Students' Academic Performance

To assess the impact of Teachers' Pedagogical Content Knowledge on Students' Academic Performance in standard deviation, teachers pedagogical content knowledge was assessed. The study realized that teachers could select effective teaching approaches to guide students thinking and learning in mathematics as a measure of their pedagogical content knowledge($Mean = 4.40, Std\ Dev = 0.82$). Furthermore, teachers were able to deliver standard deviation through classroom interaction with multiple dynamics ($Mean = 4.11, Std\ Dev = 1.00$), teachers could make good presentation of standard deviation based on the knowledge they have about the students ($Mean = 4.23, Std\ Dev = 0.63$), teachers could distinguish between correct and incorrect problem-solving attempt by students within their classes ($Mean = 4.23, Std\ Dev = 0.63$), teachers had been effective in selecting teaching approaches to guide students thinking and learning of standard deviation ($Mean = 4.17, Std\ Dev = 0.87$), teachers could produce lesson plan with a good understanding of standard deviation ($Mean = 4.49, Std\ Dev = 0.49$), they could anticipate likely students; misconception of standard deviation ($Mean = 4.26, Std\ Dev = 0.58$) and teachers had the knowledge base to combine wide range of teaching approaches and correct concepts of standard deviation ($Mean = 4.00, Std\ Dev = 0.91$).

Teachers' possession of pedagogical content knowledge impact either positively or negatively on students' performance in standard deviation. Thus, the students agreed that they perform well in instructional assessment when Mathematics teachers have subject matter knowledge and uses good teaching approach ($Mean = 4.48, Std\ Dev = 0.85$). Also, the students perform well in standard deviation test when subject matter is delivered through classroom interaction and multiple dynamics ($Mean = 4.16, Std\ Dev = 1.00$). It could be ascertained further that students perform well in end of term exam when lesson plan is taught with a good understanding of the topic ($Mean = 4.30, Std\ Dev = 0.95$).

Moreover, students concurred that they perform well in class participation when students' misconception is anticipated between various concepts through the teaching of standard deviation ($Mean = 3.92, Std\ Dev = 1.06$). Students perform well in external exams when wide range of teaching methods are combined with correct concept ($Mean = 4.22, Std\ Dev = 0.89$). Also, the students perform well in mid-term exams when good presentation of standard deviation is made based on teacher's knowledge about the students ($Mean = 4.19, Std\ Dev = 0.98$) and students perform well in past examination when teachers effectively select teaching approaches to guide their thinking and learning in standard deviation ($Mean = 4.29, Std\ Dev = 0.91$)

The findings sit well with the theoretical underpinning of this study. The Constructivism promotes that teachers take on the role of guides or coaches, promoting learning by creating surroundings and activities that are encouraging to students while building on their prior knowledge.

VI. CONCLUSION

The study concluded with the majority of the respondents confirming that, the teachers who handle mathematics at Adu- Gyamfi Senior High School, are well equipped with the requisite professional and Academic Qualification and skills. And also, their content Knowledge delivery methods impact so much on the students during teaching and learning.

VII. RECOMMENDATIONS

1. The management of Adu-Gyamfi Senior High School should find a way of motivating the mathematics teachers in the School so that they continue to give off their best.
2. Discipline should be maintain among the students to give due respect to their mathematics teachers.
3. Mathematics teachers in Adu- Gyamfi Senior High School should find innovative way to deliver their topics so that students would acquire easier and better understanding.

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