Teachers' Geometry Vocabulary Competence and Students' Academic Performance in Circle Theorem

Enoch Kabinaa Suglo[1]   Christopher Saaha Bornaa[2]   Abdulai Boare Iddrisu[3*]   Francis Xavier Adams[2]
Stephen Atepor[2]   Hardi Abdul Rahaman[4]

1. Department of Mathematics, Ken Hammer Senior High/Technical School, P. O. Box 149, Goaso, AR, Ghana.
2. Department of Mathematics and ICT Education, School of Science, Mathematics and Technology Education, C. K. Tedam University of Technology and Applied Sciences, Navrongo, UER, Ghana.
3. Department of Mathematics, Kalpohin Senior High School, P. O. Box 137, Tamale, NR, Ghana. Email: abdulaiboare@gmail.com , ORCID: https://orcid.org/0000-0003-2508-6114
4. Department of Mathematics, Tamale Islamic Science Senior High School, P. O. Box 1485, Tamale, NR, Ghana; Email: abdulhardia@gmail.com
Corresponding Author's Email: abdulaiboare@gmail.com
Corresponding Author's ORCID: https://orcid.org/0000-0003-2508-6114

Abstract
Ghana's mathematics curriculum places less emphasis on geometry terminology and vocabulary instruction. Hence each instructor chooses his/her own strategy, some of which may be incorrect, because there are no explicit guidelines in the Ghanaian mathematics curriculum on how students should be introduced to mathematical language and vocabulary. A number of research findings however, have suggested that, mathematics vocabulary education has a big impact on how well students do in geometry in general; but little data is available on the impact of the teacher's language proficiency and vocabulary knowledge on students' performance in Circle Theorem, an area in which students continue to demonstrate inadequate understanding and poor academic performance as reported on several occasions by WAEC Chief Examiners. As a result, it became necessary to carry out further research in the current location to ascertain whether teacher's language proficiency and vocabulary knowledge relates significantly to students' performance in Circles Theorem. This study used a mixed-methods research approach and a sequential explanatory design with 210 students selected through the probability systematic sampling technique. A thorough literature study was conducted in addition to the primary data collection that involved the use of a Questionnaire, an Achievement Test, and an Interview guide. The data that was gathered in the field was analysed using, regression tool, and deductive manual thematic analysis, which was used for only the qualitative data collected from the interviews. The study found a significant relationship between the independent variable teacher's language proficiency and vocabulary knowledge and the dependent variable students' academic performance in Circle's Theorem. This implies that that students' performance in circles theorem depends on the circle theorem language proficiency and vocabulary knowledge of the teacher.Therefore, it is recommended that the Ghana Education Service organise training conferences and workshops aimed at improving teachers' teacher's circle theorem language proficiency and vocabulary knowledge as well as include guidelines in the Mathematics Syllabus as to how students should be introduced to mathematics vocabulary and terminologies.
Keywords: Teacher vocabulary Knowledge, language proficiency, Circle Theorem, Students' Performance
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1.0. Introduction
Education is an important instrument for the grow of society and human development and that is why Free Senior School has been made free for all school-going children in Ghana who qualify to enrol for secondary education. It is also important to indicate that the academic success of these students at the Senior High School is greatly influenced by the teacher's language proficiency and vocabulary knowledge. However Ghana's mathematics curriculum places less emphasis on geometry terminology and vocabulary as compared to the mathematics curriculum in other African countries, such as the South African mathematics syllabus ((IMU), 2014). Each instructor chooses his/her own strategy, some of which may be incorrect, because there are no explicit guidelines in the Ghanaian mathematics curriculum on how students should be introduced to mathematical language and vocabulary. According to a number of research findings, mathematics vocabulary education has a big impact on how well students do in geometry.

Boyd & Ash, (2018) indicated that language represents a crucial and significant pedagogical tool in the teaching and learning of mathematics. Language is crucial to both the teacher and learner of mathematics, claims Aldahdouh et al. (2019), because it makes it easier to teach mathematics to students. That was why Cementina (2019) indicated that vocabulary is crucial to the instruction process in geometry and mathematics. Alex and Mammen (2016), also insinuated that a language's vocabulary consists of all its words, which means that the

language of mathematics includes phrases with precise definitions that convey mathematical ideas. Words are a requirement for understanding information; hence, it is important for learners to comprehend words that express content for improved knowledge and communication, according to Bellamy (2012).The ability to grasp vocabulary, which is the knowledge of words and their meanings, affects all terminologies used in the mathematics classroom(Bosson-Amedenu, 2017b). The use of numerals, words, and symbols, which can occasionally be disconnected and autonomous and sometimes be interrelated and dependent upon one another, is included in the mathematical vocabulary, according to (Chand et al., 2021).

According to Chand et al. (2021), mathematics vocabulary is crucial to the teaching of the subject. The importance of mathematics vocabulary in the learning of mathematics has been amply acknowledged in the research literature (Atebe, 2008). Greefrath et al., 2016 believed that teaching mathematics language will help students better understand mathematical contents(Greefrath et al., 2016). The ability of learners to mathematically communicate needs some level of strengthening so as to enhance their learning of geometry because having the appropriate geometry vocabulary is crucial for understanding mathematical ideas like the circle theorem(Chrysafiadi, Virvou, & Tsihrintzis, 2023).Mathematics vocabulary can positively or negatively influence students understanding and academic performance in circle geometry, which is why Cooperstein and Kocevar-Weidinger (2004)argued that employing mathematics vocabulary in the teaching process is necessary, as students who make good use of it through reading, writing, and understanding of mathematical ideas stand a better chance of understanding mathematics as well as improving their academic performance . Bryman (2017), indicated that the key factor for understanding mathematics is learning the vocabulary; hence, if learners must read, comprehend, and engage in discussion on mathematical concepts, then they must have mastery over mathematical vocabulary. When teachers guide students in learning mathematics vocabulary, it will become easier for the students to understand the mathematical language, which is essential for mathematical learning. In line with this view, Eckhardt and DeVon (2017)indicated that learners' comprehension of mathematical content grows as they acquire and comprehend mathematical terminology, which helps them to solve mathematical problems independently. According to According to Pierce and Fontaine, the ability of a student's mathematical vocabulary to convey mathematical meaning has an influence on the child's performance in mathematics(Sumara, 1998).

The gap this study intended to close was that no study has investigated teachers and students' vocabulary knowledge and language proficiency and senior high school students' academic performance in the circle theorem at Sefwi-Wiawso municipality in the Western North Region. Therefore, the purpose of this study is to determine if students' academic performance in the circle theorem has a significant relationship with the teachers and students' vocabulary knowledge and language proficiency in circle theorem in a Senior High School at Sefwi-Wiawso municipality in the Western North Region.

1.1. Statement of the Problem

The teachers circle geometry vocabulary competence and mathematics language proficiency have the probability of influencing students' vocabulary understanding and academic performance in circle theorem. This is because Nwoke (2020), indicated that teaching mathematics vocabulary helps the students understand mathematical concepts. In his study, Saidat Morenike Adeniji (2018) found that including mathematics vocabulary instruction in the curriculum enhanced test results as well as students' comprehension of mathematical concepts. Bellamy(2012), carried out a study on the manipulative influence of vocabulary instruction on learners' understanding of mathematical concepts and found that learning the meaning of vocabulary did play a vital role in the learners' comprehension of the daily lessons and ability to pass exams.

WAEC, (2013,2014,2018) revealed that students demonstrate perform performance in circle theorem anytime they sit for the West African Secondary School Certificate Examination. The numerous reports from WAEC Chief Examiners about students' inadequate knowledge in circle inspired. Do teachers introduce students to circle theorem terminologies and vocabulary before teaching the concept? How do teachers teach circle theorem? If the circle theorem is well taught, then why do students continue to perform poorly in it? If teachers do introduce students to circle theorem terminologies and vocabulary and the teaching is effective, then why do students perform poorly in the concept? Aiym et al. (2022), indicated that students should acquire and use the knowledge, skills, and attitudes acquired to enable them to act in a way that is consistent with the instruction. There is however a contradiction to the view expressed by Aiym et al. (2022) as far as students' academic performance in circle theorem is concerned. Is the problem therefore lack of teaching or poor teaching techniques employed by teachers in teaching circle theorem? Arthur, (2022) indicated that poor teaching techniques employed by teachers in teaching mathematical concepts, including other factors, are attributable to students' poor achievement in mathematics.

Ansah et al., (2020) indicated that students' academic performance in circle geometry has been inadequate due to the use of ineffective instructional tactics by teachers during lesson delivery. Chief Examiners commented severally on students' weaknesses and difficulties in solving problems relating to circle theorem

questions (WAEC, 2015, 2016) and most of these reports have highlighted that most candidates usually avoid solving circle theorem questions, and even the minority of candidates that attempted questions relating to circle theorem only demonstrate inadequate content knowledge. To help students understand and apply geometric concepts linked to circle geometry; teachers must demonstrate geometrical vocabulary competence and introduce students to circle theorem vocabulary and terminologies to help the students enhance their vocabulary knowledge and academic performance in circle theorem. Therefore, the purpose of this study was to ascertain how teachers' vocabulary competence and language proficiency can help the students enhance their vocabulary knowledge and academic performance in circle theorem at a senior high school in the Sefwi-Wiawso Municipality of the Western Region of Ghana.

1.2. Objectives of the study
This study was carried out to:
Ascertain whether teachers' geometry vocabulary and language proficiency are predictors of students' academic performance in circle theorem

1.3. Research Hypothesis
H_0: Teachers' geometry vocabulary and language proficiency are not predictors of students' academic performance in circle theorem

2.0. Literature Review
The study's objective was to look into the terminologies and vocabularies associated with the circle theorem and their relationship with students' academic performance .Ismail, Omar, Don, Purnomo, and Kasa (2022) carried out a study to review literature pertinent to difficulties encountered by students in the learning and usage of mathematical terminology and the need to carry out this study arose from the concern of the Kenya National Examinations Council and the general public over the poor annual results in mathematics. Their objective was to investigate the extent to which the meanings of some mathematical terms are understood and/or confused by students for whom English is a second language. They used the constructivist theory of J. Bruner and the cognitive flexibility theory of R. Spiro, P. Heltovitch, and R. Coulson, which advocate teaching learners to construct the meanings of mathematical terms. The findings of their study showed that students have difficulties using mathematical terms and their related concepts. Possible ways of teaching these terms so as to generate more meaning for the learners were then suggested to assist mathematics teachers, curriculum planners, and textbook authors in countering the poor performance in mathematics in Kenya.

Constantinou (2018), conducted a study to find out the impact of language characteristics in mathematics test items on student performance. Regression analyses were conducted to examine relationships between item linguistic characteristics as independent variables and item difficulty as the dependent variable. Language characteristics had moderate effects on item difficulty at 4th grade, dropping to small-to-medium effects at 10th grade. The study indicated that difficult mathematics vocabulary had a consistent effect on performance for all students at all grades. Ervin F. Sparapani (2015), investigated the perception of teachers on geometry vocabulary teaching, how geometry vocabulary was taught, and how the teaching of geometry vocabulary influenced learners' performance in geometry. Van Hiele Theory of geometrical thinking and the constructivist theory of learning guided the study. The study conveniently sampled 250 participants in the Greater Accra Region of Ghana. The study found that geometry vocabulary was not taught and that the most commonly used strategy for teaching geometry was the drawing of 2-D shapes and models of 3-D objects on the board. The study also found that the teaching of geometry vocabulary improved learners' performance in geometry. The study therefore recommended further research to investigate the effect of geometry vocabulary teaching on learners' performance in geometry across all year groups in the primary school.

Carlson et al. (2019), discovered that students' use of the language and comprehension of mathematical terminology grew in tandem with their academic accomplishments in their study to encourage students' understanding and use of the language. Students need to understand mathematics vocabulary in order to grasp the subject's material and apply it in the future, according to a study by B.I et al. (2023).

Given (2008), expressed the view that a child's ability to succeed in mathematics is largely determined by their mastery of the appropriate mathematical terminology. For this Hailikari et al. (2008) stated that students need mathematics language proficiency so as to respond to questions on mathematics examinations and comprehend communication between teachers and students. Lack of vocabulary knowledge hinders students' mathematics learning in general and geometry in particular (Herner-Patnode, 2001). The improper use of mathematics vocabulary will have an impact on learners' understanding and proper use of mathematics vocabulary as they progress from one level to the next through to the tertiary level. (Eckhardt & DeVon, 2017; Gatrell, 2009). This means that it is crucial that teachers begin teaching mathematics in the classroom using correct and precise mathematical vocabulary (Hanson, Creswell, Clark, Petska, & Creswell, 2005). There is a lot

of stress placed on students' knowledge of mathematical terminology and their understanding of the subject because, without it, they might not be able to grasp complicated ideas, which would prevent some of them from performing more difficult jobs (Kashefi, Ismail, & Yusof, 2012).The effectiveness of geometry tutoring is diminished by the student's inadequate vocabulary and mathematical knowledge (Kiran & Yildiz FeyzİOĞLu, 2021). More language is needed when teaching geometry than when teaching other mathematics concepts (Meimaris, 2009). This demonstrates how crucially important it is to employ geometry vocabulary when teaching geometry (Laborde, 2006). In order for students to understand circle geometry successfully, teachers must go through geometry language with them before introducing the circle theorem. However, most students lack the necessary vocabulary to explain a figure's distinguishing characteristics or the right theorem to apply in solving geometry problems(R. B. Johnson et al., 2016; Kapenda, 2011; Paul, 2006).Teaching mathematics vocabulary allows pupils to understand mathematical concepts (Yalley et al., 2021). Students with the right mathematical vocabulary could answer questions properly as compared to their counterparts who do not have adequate mathematical vocabulary ideas (Nel, 2012).

3.0. Methodology
The study was carried out using a mixed method approach to investigate Teachers' geometry vocabulary competence and Students' performance in circle theorem. The mixed method approach was chosen to ensure a deeper understanding of the research problem as respondents' perspectives were explored using both qualitative and quantitative data collection procedure. By use of this approach, the researcher had the chance to make use of statistical instruments that precisely assess the correlations between the variables. The sequential explanatory design was employed as a mixed methods research design which allowed the quantitative and qualitative phases to be   carried out separately, followed by the integration of results from both phases to achieve a wider perspective and an in-depth understanding of the research questions and phenomena as said by Funda Aydın-Güç (2021).

3.1 Population
All final year senior high school students in the in Sefwi-Wiawso Senior High School were part of the target population of the study. A total of 440 students were however accessible in the school at the time of data collection, although 4.35% of the target population's members were not available due to ill-health and other factors. The accessible population thus comprised 53% (233) female student and male 47% (207) students.

3.2 Sample and Sampling Procedure
It was not practical to have every member of the population engage in the study due to time, budgetary constraints and other factors, hence, a sample of the population was chosen to provide data for analysis and generalisation of the findings(Gaspard et al., 2019). The study sample was chosen using Bryman (2017)sample determination table. This table showed that the sample size (S=210) corresponds to a research population (N=440). Find attached the sample determination table.

3.3. Data Instruments
Students' Performance in circle theorem was measured using an Achievement Test which was made up of twenty-five (50) multiple-choice questions relating to circle theorems chosen from WAEC past questions. Hence the instrument was valid. A questionnaire of 10 item statements was designed to measure the teachers' geometry vocabulary competence and whether or not students were introduced to circle theorem vocabulary and terminologies during circle theorem instructional activities. Therefore, students' views were explored regarding what happened in their circle theorem classroom during teaching and learning of circle theorem.

An interview phase was implemented as a follow-up to the data collected and analysed from the questionnaire to seek an explanation for unexpected outcomes. A pilot study was conducted to ascertain the reliability of the instrument. A Cronbach's alpha reliability value of 0.848 was gotten from the reliability test statistics. This shows that the instrument was trustworthy and implied having and outstanding performance.

An introduction and ethical evaluation clearance letters were presented to the managers of the school that participated in the study. The management, after reviewing these letters, granted permission for the data collection to be carried out. The study's goal was explicitly communicated to the participants during the contact that took place before the questionnaire was given to them, and it was made obvious to them that the research was intended for academic purposes. The participants verbally agreed after an assurance was given that any information they provided would be treated with complete confidentiality. The examination was the initial step in the data collection process. The questionnaire was implemented after the examination, and an interview was held based on cases that were observed from the quantitative results. The results for both quantitative and qualitative phases after the analysis were discussed side-by-side to enhance understanding.

3.4 Study Area

According to the Ghana Statistical Service (2014), there are 139 200 people living in the Sefwi Wiawso Municipality, with men and women making up respectively 50.1% and 49.9% of the population. With 41.2% of the population under 15, the Municipality has a young population. 65 and older people make up 5.2 percent of the population. The gender ratio in urban regions is 94.2, while it is 104.1 in rural areas, indicating that while there are more men in rural areas, women predominate in urban areas**.**71.5 percent of people aged 11 and over are literate, compared to 28.5 percent who are illiterate in any language. Males are more likely than females to be literate (78.5%). In comparison to their female counterparts, 72.1 percent of men are literate in both English and a Ghanaian language, as opposed to 66.3 percent of women. The majority of people aged three and older who are currently enrolled in school (47.2%) are in primary education, while 1.6 percent are in post-secondary or university education. While there are currently more males at tertiary institutions, there are currently more females in post-middle and post-secondary institutions**.** About 67 percent of those aged 15 and older work for themselves without hiring any help, 3.0 percent have employees working for them, and 13.2 percent are contributing family members. Employees make up 12.5% of the population, with men making up nearly three times as many as women. More women work for themselves as independent contractors, provide for their families, and are apprentices.89.0 percent of the population is working in the private informal sector, whereas just 4.8 and 5.7 percent of the population, respectively, are worked in the public and private official sectors.

4.0. Results

Inferential statistics was used to analyse the quantitative data. The responses from the respondents were compiled and entered using SPSS. The association between the main variable and the outcome variable was determined using this. Table 1 presents the outcomes.

4.1 Hypothesis Testing

H_0: **In the circle theorem, vocabulary and language proficiency are not predictors of students' academic performance**.

In order to determine rejection or acceptance of the null hypothesis, the study performed a regression analysis on students' views regarding the teacher's circle geometry vocabulary competence   and the students' circle theorem achievement test scores. The results are shown in the table below.

Table 1: Results of circle theorem vocabulary and language proficiency as or not a predictor of students' academic performance in circle theorem

Std. error	df	R^2	B	Beta (standardized slope)	f	t	Sig.
2.255	1	0.001	-.05	-.038	0.302	7.564	< 0.001

Source: field data, 2023

The manual deductive thematic analysis method was used to explore the data collected from students via qualitative interviews. This method was ideal because the study had pre-determined codes that guided the qualitative data collection. This method was also used because the study intended to obtain explanations and clarifications from students on unexpected results that emanated from the quantitative data. There was a summary of key recurring meanings of the data to organise themes, which were mapped against the complete data set. The table below shows the qualitative interview information.

Table 2: Showing qualitative data analysis on pedagogical content knowledge and students' academic performance in the circle theorem

Codes	Organising Theme
Vocabulary and language knowledge and students' academic achievement in circle theorem	
• Familiar with circle theorem vocabulary • Competent teaching circle theorem vocabulary • Introduced to geometry vocabulary • Availability of circle theorem vocabulary guide in Mathematics Syllabus.	• Introducing and teaching vocabulary and language knowledge to students can impact their learning and academic achievement in circle theorem
• Mastery knowledge of circle theorem vocabulary	• The vocabulary knowledge proficiency of the teacher in teaching circle theorem influences students' understanding and academic performance
• Approachable • Not approachable • Engagement of students in hands-on activities	• When teachers are not sociable, it affects students' participation in teaching and learning activities
• Moves fast when teaching • Easily get angry • Competent • Incompetent	• The pace at which teachers teach influences students' academic achievement in circle theorem

Source: field data, 2023.

Findings as expressed by the views of students indicate that there is an influence of the teacher's pedagogical content knowledge on students' academic achievement

5.0. Discussion

The results of the study from the results in table 1 above showed that circle theorem vocabulary/language proficiency are significant predictors of students' academic performance in circle theorem as indicated by the views of 210 sampled students (N= 210). The analysed results revealed a significant relationship between circle theorem vocabulary/language proficiency and students' academic performance in circle theorem, b = (-.04), t (210) = 7.56, B= (-.05), p (<0.001). There was therefore enough evidence to reject the null hypothesis that circle theorem vocabulary/language proficiency has no significant relationship with students' academic performance in circle theorem. Also, the unstandardised coefficient (B= -.05) is negative indicating that the independent variable, circle theorem vocabulary/language proficiency has a significant but negative relationship with the dependent variable, students' academic performance in circle theorem. This suggests that if the circle theorem vocabulary/language proficiency changes upwards by one unit, the academic performance of students will shift downwards by -.05 units. This significant found by the study is in line with so many other research findings. During the qualitative interview, a follow up question was put to the students interviewed to clarification as to why 102 (48.6%) of the students expressed the views that their teacher did not introduce them to circle theorem vocabulary and terminologies before/when teaching it. Below are the words of one respondent:

> Please, the truth is that I didn't even understand what circle theorem vocabulary means until you explain it to us. The only thing I remember is that when we started circle theorem, out teacher gave us notes on the properties of circle theorem and we solved some questions in class and that ended it. And the truth is that I never understood that circle theorem thing and I don't like it. Can you make a recommendation to the government to remove it from the WASSCE syllabus?

The above response from the student during the interview obviously confirms the 48.6% of the students who expressed their views in the questionnaire that their teacher did not introduce them to circle theorem vocabulary and terminology during circle theorem lessons. In fact, the student was bold to ask whether circle theorem can be removed from the WASSCE topics. This finding as expressed in the quantitative data and affirmed by the qualitative interview data is in line with so many other research findings and literature. For instance, a study carried out by Ansah and Quansah on the impact of teaching mathematics language, the researchers noted that mathematics language will help students better understand mathematical contents which can result in improved academic performance in mathematics(Ansah et al., 2020). Clearly, this finding also suggests that a change in circle theorem vocabulary proficiency can influence students understanding and academic performance in circle geometry positively or negatively, which is why (Alex & Mammen, 2016;

Bailey, 2013)argued that employing mathematics vocabulary in the teaching process is necessary as students who make good use of it through reading, writing, and understanding of mathematical ideas stand a chance to understand mathematics better as well as improve their academic performance . This study's finding is also in line with Greefrath et al. (2016)view that the key factor for understanding mathematics is learning the vocabulary. This means that if learners must read, comprehend, and engage in discussion on mathematical concepts then they must have mastery over mathematical vocabulary.

During the qualitative interview session, the interviewer enquired to find out the whether or not their teacher was approachable and engages them during the teaching and learning activities. Below are the words of one of the respondents:

> Please, as for being sociable, our teacher is good. He is friendly and he give us the opportunity to talk in class and take part in the topic. Our teacher is friendly. I can go to him or any of my friends can go to him with any problem and he will address it. As for me i do not have any problem with him and I feel free to learn when he is teaching.

Deducing from the student's expression, it is very clear that the teacher has a very positive attitude and relation with the students. It is also clear that the teacher allows the students to contribute in the classroom during teaching and learning activities which is commendable because when teachers are sociable, it influences students' participation in teaching and learning activities in the classroom.

6.0. Conclusion
The study concluded based on the findings that, teachers' circle geometry vocabulary competence and students' introduction to circle theorem vocabulary can significantly predict students' academic performance in the circle theorem. This means that a poor teacher vocabulary knowledge and lack of introducing students to circle theorem vocabulary can negatively affect the academic performance of students in circle theorem

7.0. Recommendation
Teachers should attend conferences and workshops that are aimed at improving Teachers' geometry vocabulary competence. The Ghana Education Service should ensure that there is a clear guideline in the mathematics syllabus as to how students must introduce to mathematical vocabulary so as to enhance students' vocabulary knowledge and academic achievement for students, as found by this study.

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