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Comparative Content Analysis of Statistical Tasks in Two Selected Ghanaian Senior High School Mathematics Textbooks

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Abstract:- This study analyzed the nature of the statistical contents and task types in two Ghanaian senior high school (SHS) mathematics textbooks The aim of the study was to examine the similarities and differences in the contents and task types in the two Ghanaian SHS mathematics textbooks. Additionally, the study evaluated the mathematics textbooks used in Ghana mainly in terms of standards linked to lifelong learning with learners' in-class experiences and acquired skills as seen in the mathematics textbooks. The study further analyzed how much of the textbooks were devoted to statistical topics, sub-topics and concepts which were embedded in the statistical units of the SHS textbooks. The nature, differences and similarities in the statistical tasks in the two Ghanaian mathematics SHS textbooks and the level of cognitive demand exhibited by the statistical tasks were further analyzed.

I. INTRODUCTION

A. Background

Over the past few decades, there has been a notable surge in the use of Mathematics textbooks within the educational framework of many countries including Ghana, signifying a positive perception of textbook quality (Amoah, 2018; Adarkwah, & Huang, 2023). A significant number of researchers have focused their scholarly pursuits on examining the content and structure of mathematics textbooks (Kwami-Apoenchir, Bedu-Addo, Bornaa, Dabone, Kwarteng-Nantwi, Attah-Gyamfi, &Kissi-Abrokwah, 2023). In accordance with the assertions of Reid O'Connor (2023), the essential components of mathematical proficiency are characterized by five strands, namely 'proficiency in essential mathematical procedures, adeptness in strategic decision-making, adaptive reasoning capabilities, and an inclination towards productive disposition' (Yoseph, 2023). This discourse posits that the implementation of standards and recommendations in mathematics education significantly influences the routine pedagogical practices in the classroom, with textbooks serving as a primary medium for such influence (Amoah, 2018).

Bailey, & McCulloch, (2023), explains that statistics as a field has been recognized as a means of extracting conclusions based on a collection of empirical data, thus earning its recognition as the "Science of Data. " Moreover, it offers various sectors that are distributed across different industries the chance to shed light on their research or commercial inquiries, thereby facilitating the projection of outcomes that are of utmost significance. The application of statistical analysis serves to expedite the process of gathering and comprehending pertinent numerical information as well as dissemination of complex data facilitated by the utilization of various visual aids such as graphic, tabular, and diagrammatic formats. This enables students to efficiently comprehend the information being conveyed thereby providing a precise depiction and improved understanding which encompasses a multitude of instruments and methods, of which some of the more notable ones are mean, which represents the arithmetic average of a set of numerical values, the median and mode, which pertain to the central tendency of a distribution, as well as additional measures of variability, such as range, dispersion, standard deviation, interquartile range, and coefficient of variation.

Kwami Apoenchir, et al, (2023), posit that statistical concepts have gradually trickled down the mathematics curriculum and are currently integrated into the educational standards for basic and SHS in Ghana. McKitrick, Schuurman, & Crooks, (2023) explains that the field of Statistics pertains to the systematic analysis and manipulation of data, encompassing a diverse range of techniques and approaches aimed at gathering, assessing, analyzing, and synthesizing data to generate meaningful inferences and conclusions as the acquisition of statistical knowledge aids in the judicious selection of methodologies for data collection, precision in the execution of analyses, and skilful communication of research findings with a specific emphasis on the classifications of the two fundamental domains: Descriptive statistics and Inferential statistics. Statistics as a field occupies a crucial position in enabling the advancement of mathematics, providing direction for evidence-driven decision-making, and predicting anticipated outcomes. This provides a precise explanation and improved understanding that is intended to assist in the creation of a robust and holistic statistical research plan, with relevance and applicability across a broad range of academic domains. The use of reliability measures serves as a guarantee of the validity of inferences pertaining to population parameters that can be extrapolated from the sample data. The engagement of the statistical tools primarily fulfils the purposes of information retention, probability evaluation, and dissemination of knowledge. Fundamentally, quantitative data facilitates the improvement of our understanding of the world, providing us with accurate numerical insights. The use of statistical analysis is prevalent in everyday activities.

Software applications have also exhibited efficacy when employed for analyzing data sets with substantial sample sizes within a given analytical framework. Numerous statistical methodologies have gained prevalence for measuring comparisons in diverse fields. The F-test, T-test, and regression analysis are among such techniques widely utilized for their practicality and accessibility. Given the inherent significance of statistics, it is pertinent to prioritize the analysis of the statistical contents of two mathematics textbooks in the current discourse.

Watson postulated that a tripartite framework is necessary for the acquisition of statistical literacy (Papamitsiou, Filippakis, Poulou, Sampson, Ifenthaler, & Giannakos, 2021).The aforementioned model encompasses a fundamental understanding of the essential concepts and terminology within statistical discourse, the ability to recognize and comprehend the application of these concepts within social contexts, and the capability to critically analyze claims that are not adequately founded in statistical reasoning (Papamitsiou, et al, 2021). Consequently, there has been insufficient research in the area of statistics to investigate the statistical content presented in Ghanaian Senior high school (SHS) mathematics textbooks (Kwami-Apoenchir, et al, 2023). In light of this, this study is aimed to investigate the statistical content presented in textbooks commonly utilized within the Ghanaian educational context. The study is an attempt to gain insight into the treatment of statistics contents in mathematics textbooks utilized in the context of SHS education across SHS 1-3.

B. Statement of the problem and rationale

It is a frequently observed phenomenon that educators allocate tasks from required textbooks to their students, but often fail to incorporate ancillary tasks into the pedagogical textbooks (Amoah, 2018; Cooper, 2023). Research conducted by Vojíř and Rusek (2022), suggests that the inclusion of a particular concept within a textbook can have a significant impact on a student's ability to acquire knowledge related to that concept. The researcher posits that the most crucial factor influencing students' academic success is the extent to which they have access to educational opportunities. Furthermore, empirical evidence indicates that subjects situated towards the latter portion of the academic tome are more prone to being disregarded in instances of inadequate pedagogical duration. Regrettably, several studies have provided evidence to support the notion that active engagement in complex tasks, such as pattern and trend identification, mathematical concept explanation, and justification of methodological approaches for deriving substantive inferences, can have a favourable impact on students' cognitive development (Alam, 2022; Mcleod, 2022; Wang, Qin, Luo, Yang, &Xin, 2022). According to Bui (2023), the establishment of an effective instructional environment for learners is contingent on the availability of two critical components: the availability of learning opportunities and the application of tasks requiring advanced cognitive abilities. The concept of a learning environment as defined by Brown (2023) encompasses the tangible and intangible aspects of the classroom setting, including the physical space, psychological factors, and instructional practices. There exist four distinct categories of learning environments, each characterized by exclusive constituents (Karmazyn-Raz, & Smith, 2023). Learning environments may adopt a variety of focal points, including those of student or learner, knowledge, assessment, and community-centric perspectives as well as three distinct areas that hold significant importance: the physical, psychological, and instructional settings. The creation of ideal learning environments is facilitated by the demonstration and implementation of social and emotional aptitudes. Inclusive and equitable relationships as well as a heightened comprehension and value of diversity are cultivated within the student body, faculty, and overall school community. According to Brown (2023), the perspective of the student is highly valued and promoting empathy towards others' perspectives is actively encouraged. The advantages of the mathematics syllabus for the student help in effective instructional materials that promote the cultivation of problem-solving skills and the practical application of mathematical principles to daily situations (Mereku, 2023).

It is essential for students to wield mathematical language with precision and proficiency, whilst displaying adequate comprehension of mathematical concepts and procedures that correspond to their developmental stage and cognitive capacity (Suparatulatorn, Jun-on, Hong, Intaros, &Suwannaut, 2023). Moreover, the mathematics curriculum furnished a structured approach to teaching within the realm of education for exceptional students. The content domains encompassed by the instructional curriculum notably comprise numeration, whole numbers, rational numbers, real and complex numbers, calculator proficiency, measurement, geometry, statistics, functions and relations, computer literacy, along with pre-algebra. In contemporary mathematical discourse, statistical analysis has become essential, permeating virtually all facets of the discipline. Central to this integration are various statistical tools, including but not limited to the mean, the arithmetical average of a set of numerical data points, the median and mode for assessing central tendency, the range for quantifying the spread of values, measures of dispersion such as standard deviation, interquartile range, and the coefficient of variation (Suparatulatorn, et al, 2023). Software suites such as SAS and SPSS can be efficaciously implemented in the interpretation of statistical findings for considerable sample sizes.

Given the increasing importance placed on the incorporation of statistical concepts into educational curricula, it is essential to determine whether the designated statistical knowledge is sufficiently reflected in the textbooks utilized by students. The primary objective of mathematics education is to facilitate the development of children's aptitudes for the process of mathematization (Amoah, 2018; Suparatulatorn, et al, 2023). Furthermore, the statistical concepts encompassed a range of topics, which comprised range, variance, and standard deviation. The term "distribution" pertains to the comprehensive configuration of the data, which can be illustrated through various means such as histograms or dot plots, while also encompassing features such as the probability distribution function, skewness, and kurtosis. The newly designed curriculum yields advantages, as it exercises pressure on individual students to exhibit a

keen interest in the workforce (Mereku, 2023). This program further fosters the potentiality for students in navigating and opting for their preferred professional pathways in the domain of mathematics. Graduates who have majored in Mathematics have a diverse range of career prospects, such as pursuing a profession in teaching or engaging in various other interdisciplinary fields. The integration of mathematics with other specialized fields including economics, statistics, computer science, applied mathematics, engineering, and mathematical sciences has the potential to substantially enhance employment opportunities. To affirm the presence of subsequent research, a literature review was undertaken with a specific focus on published studies. However, it is unfortunate that there have not been enough studies to examine the statistical content present in mathematics textbooks used in SHS in Ghana.

Additionally, insufficient exploration within the related literature exists regarding the effectiveness of statistical exercises incorporated within the statistical components of SHS mathematics textbooks in Ghana. The primary aim of this research is to ascertain if the available statistical textbooks offer an adequate number of statistical tasks to ensure that students attain a sufficient level of proficiency in statistical content. Mathematics textbooks offer a plethora of statistical tasks; however, students are frequently challenged with diverse terminology associated with statistics in their everyday encounters. The acquisition of an adept understanding of statistical concepts holds immense importance for the student community, as it furnishes individuals with the ability to proficiently comprehend and analyze quantitative data that they frequently encounter in their daily lives.

It is widely recognized that the attainment of proficiency in statistical skills is crucial for students in order to establish a robust foundation for future professional advancement. This study will assess the extent to which two designated mathematics textbooks, presently implemented in Ghanaian SHS enable the acquire of statistical concepts. The study entails an examination to determine the inherent statistical content ratio in the two Ghanaian mathematics textbooks.

C. Research Objectives

Considering the research questions, a thorough examination was performed to juxtapose the statistical data presented in two mathematics textbooks designed for SHS students. The focus was centered on the identification and comparison of discernible dissimilarities, distinctive attributes, and pedagogical approaches pertaining to the communication of statistical concepts. It is anticipated that examinations conducted on pedagogical resources will reveal divergent cognitive patterns, thus providing implications for the utilization of textbooks. The study was aimed at providing an in-depth analysis of the statistical contents in the two Ghanaian SHS mathematics textbooks. Therefore, the research aims to contribute to the existing body of knowledge by providing empirical evidence and theoretical analysis to gain a better understanding of the statistical contents in the textbooks.

The following objectives were utilized in the current study;

- Analyze the nature of statistical contents in two Ghanaian SHS mathematics textbooks
- Analyze the nature the types of statistical tasks in the two Ghanaian SHS mathematics textbooks.

*D. Purpose of the Study and Research Questions *

The purpose of the study was to examine the statistical contents of two Ghanaian SHS mathematics textbooks. Of this, the following research questions guided the study;

- What is the nature of the statistical content of the two Ghanaian SHS mathematics textbooks?
- What are the types of statistics tasks in the two Ghanaian SHS mathematics textbooks in use by Ghanaian students?

II. REVIEW OF RELEVANT LITERATURE

According to research on textbooks are subdivided into five aspects, using a selected set of studies (Fan, Zhu, & Miao, 2013; Herrmann, Yoder, Gruneberg, & Payne, 2023). The five aspects of textbook analysis are;

- Mathematics content and topics;
- Cognition and pedagogy;
- Gender, ethnicity, equity, culture and value;
- Comparison of different textbooks; and
- Conceptualization and methodological matters.

It is worth noting that these aspects are often intertwined within the same study. In the context of this study, the textbook analysis was done on mathematics content and topics; and comparison of two different Ghanaian mathematics textbooks. As such this study was a comparative study of statistical contents and tasks in two different mathematics textbooks. In this case, discretion was used by the researchers based on their focus and the need for discussions.

A. Studies Conducted on Mathematics Textbooks

Several researchers have conducted content analysis on mathematics textbooks by focusing on a single concept or idea across multiple texts and subsequently comparing and contrasting the treatment of said concept or idea (Lai, & Ahrens, 2023; Segev, &Fernandes, 2023; Lynch, An, &Mancenido, 2023).

Cheung, Jiang, & Fan, (2023), in textbook research, observed that School textbooks have received increasing attention in the international research community of mathematics education over the last decades. Nevertheless, mathematics textbook research as a field of research was still at an early stage of development, and its philosophical foundations, theoretical frameworks and research methods for disciplined inquiry were still lacking or fundamentally underdeveloped. Fan, (2013), puts forward a conceptual framework which conceptualizes textbooks as an intermediate variable in the context of education and hence defines mathematics textbook research as disciplined inquiry into issues about mathematics textbooks and the relationships between mathematics textbooks and other factors in mathematics education. In my own opinion, there is a need to expand research issues from descriptive analysis such as how

a special topic is treated in textbooks to correlational and causal issues including how they are affected by other factors. For this purpose, the researcher critiques that researchers must also go beyond textbook analysis and textbook usage to a new and shifted paradigm of research that will employ more textbook comparison methods, empirical and experimental research methods as well as viewing more rigorously textbook research as scientific research.

Moru, &Essien, (2023), in a comparative study of two mathematics textbooks from South Africa and Germany on affordances for learning linear functions, indicated that Textbook content can influence mathematical learning. The study compared how linear functions were presented in two textbooks, one of South African and the other of German origin used in different language-based streams in a school in Gauteng, South Africa. A qualitative content analysis performed on how the topic of linear functions was presented in these two textbooks indicated that there was an interaction of procedural and conceptual knowledge, the integration of multiple functional representations, and the created links to other mathematical content domains and the real world. German textbooks were found to contain more content that facilitated the development of conceptual knowledge. This was primarily due to the level of cognitive demand for the tasks included in the textbook chapter analysis. South African textbooks offered a wider range of interactions with different representations of function, while German textbooks contained more connections to the real world. Both textbooks linked 'functions' to other mathematical content areas, although the German textbook included a wider range of linked topics. It was concluded that students from the two streams were thus exposed to different affordances to learn mathematics through their textbooks. However, the researcher in the content of this study, views linear functions as connecting to simple equations, simultaneous equations and quadratic equations as well as polynomials of different kinds and other sub-topics.

Welter, (2023), posited that Chinese math textbooks designed for middle grades evince a higher degree of equilibrium in the problems presented for student practice when compared to American textbooks. Moreover, the author argued that students display better performance on specific problem types when they have received a proper education on said types. Therefore, the research conducted by the aforementioned scholar augments the preceding discoveries made by Youayia, (2023), in regard to the correlation between textbooks congruent with international assessments and the substantial relationship between learners' access to educational resources and academic success. Kavalika, (2023), employed a structured framework to evaluate the potential for cultivating skills in reasoning and proof within a textbook series designed for middle-grade students and funded by the National Science Foundation. The researcher discovered a disparity in the distribution of opportunities within the middle-grade levels of academic units that offer instruction on algebra, geometry, and number theory. According to the findings of (Samar, Akkuş, & Kütük, 2023), the maintenance of coherence in terms of subject matter both within a textbook and across a series of textbooks can significantly enhance students' learning potential.

B. Studies Conducted on Mathematical Tasks

Several studies have indicated that the types of mathematical tasks used in the classroom have an influence on the level of students‟ engagement in textbooks (Hilton, 2018; Cai, & Hwang, 2023; Firmansyah, &Rais, 2023).

Forde, Robinson, Ellis, & Dare, (2023), conducted an examination of students' work and classified it according to academic tasks. This classification subsequently served as the foundation for the Mathematical Tasks Framework utilized by the QUASAR Project team (Cai, & Hwang, 2023; Doyle, Postlewaite, Sadler, & Sonnert, 2023). The tasks were delineated into four distinct categories, namely memory retention, procedural/routine execution, comprehension/understanding and personal viewpoint. The task categorization strategy adopted by the researchers facilitated the exposition of variations in the levels of cognitive demand essential for students to execute particular tasks. Distinct problem-solving approaches may be adopted in different classroom contexts. For instance, in one setting, students may be tasked with computing solutions to well-defined multiplication exercises, while in an alternative environment, they may be expected to determine the appropriate mathematical operation to apply to complex real-world situations. The discernible discrepancy in cognitive requirements between the two aforementioned quandaries is evident. Cai, & Hwang, (2023), used the Mathematical Task Framework which outlines three distinct stages of task implementation that are connected to the learning outcomes of students was used. The initial stage encompasses the curricular content encapsulated within the textbooks, supplementary resources, and analogous instructional materials. The subsequent stage manifests in the pedagogical approach adopted by the educator in presenting the course material. The culminating stage involves the process through which the learners execute the assigned tasks. The mentioned framework delineates four distinct cognitive levels, namely: Level 1 - Low-level cognitive demand primarily involving memorization; Level 2 - Low-level procedures that lack any association with comprehension, meanings, or concepts; Level 3 - High-level procedures that are intrinsically linked to understanding, meaning, or concepts; and Level 4 - High-level engagement in the process of mathematical problem-solving. The significance of appraising the cognitive load imposed on pupils, as it substantially affects their acquisition, was underscored by Hoch, Sidi, Ackerman, Hoogerheide, & Scheiter, (2023). The mathematical tasks in which students are involved have a significant impact, not only on the subject matter they acquire, but also on the manner in which they approach, construct, employ, and comprehend mathematical principles. An essential differentiation in academic discourse is the contrast between activities that involve learners in a surface-level engagement and those that require a more profound level of involvement by necessitating interpretation, adaptability, facilitation of resources, and the establishment of significance.

Mathieu, (2023), focused on real-world tasks and issues in his examination of the characteristics of Mozambican mathematics textbooks vs Japanese textbooks. The study attempted to elucidate the relevant sociocultural characteristics of Mozambican mathematics textbooks (in

comparison to Japanese textbooks) by focusing on how they treat real-world' mathematics. Four points of view were discussed; the Proportion of tasks connected to the real world introduced through the use of fresh learning content; the Proportion of problem-solving exercises connected to the real world; Categorization of the scenario of real-world activities and difficulties; The appearance and content of socially open-ended situations. As a result, the study discovered that few problems in Mozambican mathematics textbooks were directly relevant to the real world. The subject of the real-world issues focused on the tax system and salaries, which meant that kids were given the opportunity to examine and think mathematically about their social structure as early as primary school. In the context of this study, it is worth noting that tasks related to the real world are important; therefore, it is preferable that students tackle a variety of mathematical tasks, including real-world tasks, as they apply their mathematical ideas and concepts and examine the challenges using real-world problems in Ghanaian senior high schools.

In general, to use mathematics for solving real-world tasks, the first step is to construct a mathematical model of the problem. This involved abstraction from the details of the problem and the modeler which had to be careful not to lose essential aspects in translating the original task into a mathematical one. After the task has been solved in the world of mathematics, the solution must be translated back into the context of the original tasks.

In a study for the development of a framework to characterize the openness of mathematical tasks, Yeo (2017) found that educators usually mean different things when they talk about open tasks: some may think of pure-mathematics investigative tasks, while others may think of authentic real-life tasks; some may think of the answer as open, while others may think of an open method. On the other hand, some educators use alternative phrases, such as open and open-ended, to refer to the same concept, but others differentiate between these concepts. What children learn is determined by the kind of tasks assigned to them, and different types of tasks exert varying cognitive demands on students. Thus, the study's objectives were to clarify the different types of mathematical tasks, develop a framework to characterize their openness based on five task variables: goal, method, task complexity, answer, and extension, and discuss how different types of tasks and openness may affect students' learning. The framework's openness can assist teachers in designing or selecting more appropriate tasks to cater for students with varying abilities to develop their various types of mathematical thinking processes, making it easier for researchers to study the interaction between different types of openness and student learning.

In a study, Hughes, Love, & Dill, (2023), used an approach for engaging high school mathematics teachers in an initial review of their teaching in a way that is non-threatening while also effectively supporting the growth of teachers' pedagogical content knowledge. Based on the work of the QUASAR project with middle school mathematics teachers, a group of seven high school mathematics teachers engaged in a set of criteria that can be used to critically analyze mathematical challenges. The study attempted to explore how focusing teachers on critically assessing mathematical challenges affects their thinking about the nature of mathematical tasks as well as their choice of tasks to utilize in their classrooms using qualitative data collecting and analytic methodologies. The study found that teachers' attitudes toward tasks improved and that some teachers changed their patterns of task selection and pedagogical subject understanding. In the context of this research. In the context of this study, only qualitative methods were employed with an emphasis on content analysis and interviews.

C. Studies conducted on the History of Statistics Content in the Curriculum

Several studies have been conducted on the history of statistics content in the curriculum. Estrella, Mendez-Reina, Olfos, & Aguilera, (2022), in a study on early statistics in kindergarten: analysis of an educator's pedagogical content knowledge in lessons promoting informal inferential reasoning posited that the integration of statistical concepts be included in both primary and secondary education curricula. The study aimed to describe the pedagogical content knowledge (PCK) of a kindergarten educator who implements a lesson plan about informal inferential reasoning designed in a lesson study group. To this end, the study analyzed teaching interventions in two kindergarten lessons focused on the playful task of tossing two coins, associated with inferential statistical reasoning. The study highlights the importance of arguing and promoting this reasoning to develop statistical thinking. It is crucial to recognize how early students can be subject to learning experiences that promote a language of uncertainty, assess the evidence provided by the data, and make generalization s. The results reveal that while the educator demonstrated knowledge and skills relevant to the curriculum and conceptual teaching strategies, the understanding of the content by the students and the integration of the PCK components still present a challenge. The lesson study collaborative teaching practices that promote PCK have proven effective for informing the design and implementation of instructional practices supporting the development of early statistical thinking in young children. The study enriches the knowledge regarding the potential of the lesson study (LS) in the professional learning of kindergarten educators. It also contributes to a comprehensive approach based on authentic playful experiences in grade K that supports the development of early statistical thinking in young children. In contrast to the longstanding incorporation of mathematical concepts such as algebra and fractions into academic curricula, the inclusion and prioritization of statistics as an educational focus is a relatively recent development.

In a report published by Jones, Brown, Dunkle, Hixon, Yoder, & Silbernick (2015), conducted a study on the statistical material found in elementary school mathematics textbooks. The study analyzed five U.S. textbook series designed for students in grades 1-5, examining 17,688 pages and coding 7445 statistical activities. The objective was to determine the distribution of statistical topics within the textbooks and the emphasis placed on different phases of the statistical problem-solving process. The findings showed that the different series contained varying distributions of

statistical content. Two of the series had most of the statistical content located towards the end of the text, while the other two had more uniform distributions. The majority of statistical tasks required students to analyze data, with a strong emphasis on reading displays and performing mathematical calculations.

Jones, &Tarr, (2007), conducted an analysis of the levels of cognitive demand required by probability tasks in middle grades mathematics textbooks posits that it is crucial to carry out an international comparative study of mathematics textbooks. This is necessary to identify trends in international mathematics education, create textbooks and enhance the quality of teaching and learning in mathematics. The research examined and contrasted the probability and statistics curricula in high school textbooks of Vietnam and Germany. It emphasized the similarities and differences in the content and the manner in which they are presented, reinforced and broadened in textbooks of the two nations. The probability and statistics curricula in Vietnamese textbooks are significantly less compared to that of German textbooks. While Vietnamese textbooks concentrated on the mathematical content, German textbooks focused on applying the content in real-life situations. Vietnamese textbooks tend to impose probability and statistics knowledge on students, whereas German textbooks encouraged students to explore knowledge. As a result, contexts relating to the content in German textbooks were more comprehensive and natural. German textbooks predominantly used an inductive approach to present the content, while Vietnamese textbooks often used a deductive approach. Furthermore, unlike Vietnamese textbooks, German textbooks always utilize realistic scenarios in exploring the content, promoting cooperative learning, and encouraging statistical reasoning by implementing various project works. They provide an opportunity for practical experience and experimentation by using simulations of probability and statistics situations. The comparison highlights the strengths of probability and statistics content in German textbooks that Vietnamese textbooks can adopt for the development of textbooks in the future.

D. Studies conducted on the Importance of Statistics

In the words of Wells, it has been opined that the proficient application of statistical thinking will eventually be considered a fundamental component of effective citizenship, comparable in importance to the traditional abilities of reading and writing. Subsequently, his prediction has manifested itself after a span of several decades. The acquisition of statistical literacy holds indispensable significance in numerous aspects of our daily lives as individuals, consumers, citizens, and professionals alike. Statistics hold significance in both our physical well-being and emotional contentment. It is necessary to ensure that the scientific methods used in research are valid and reliable in order to produce accurate results. However, the validity and reliability of scientific methods can be affected by external factors such as bias and measurement error. Therefore, it is crucial for researchers to take steps to minimize these factors in order to produce trustworthy and credible research findings. The attainment of statistical literacy is not an immediate or expeditious process, nor is it achieved solely through the completion of a singular statistical course. The findings of the study indicated that the development of statistical skills is an incremental process that necessitates nurturing and expansion during the period of middle school and high school education. In the context of this study, the statistical content in the two Ghanaian SHS mathematics textbooks were analyzed.

E. Studies conducted on Statistical Concepts

The present study aims to investigate the acquisition of statistical concepts among students and the issues associated with their proficiency in statistics. The middle school statistical curriculum comprises various research areas that hold significant relevance, including concepts such as measures of central tendency (mean, median, and mode), measures of dispersion (variation and standard deviation), graphical representations, the integration of technology to augment statistical learning, middles school students' cognitive process associated with learning statistical concepts and identifying and rectifying misconceptions prevalent regarding statistical concepts.

F. Studies conducted on Measures of Central Tendency

Several research studies examined how students think about measures of central tendency, specifically the average (mean), mode, and median (Ringwald, & Wright,2022; Weermeijer, Lafit, Kiekens, Wampers,Eisele, Kasanova, &Myin-Germeys,2022; Kaufmann, Ninaus, Weiss, Gruber, & Wood, 2022). Pitta-Pantazi, Christou, Demosthenous, Pittalis, &Chimoni, (2022), studied the development of children's understanding of arithmetic mean by categorizing its properties. Their study involved 8, 10, 12 and 14-year-old Israeli children and delineated the following properties: the average is located between extreme values (the average value lies between the maximum and minimum of the data), the sum of deviations from the mean (average) is zero, the average is influenced by values other than the average, the average does not necessarily equal one of the values that were summed, the average can be a fraction with no counterpart, in reality, the average is representative of the values that were averaged, when calculating the average take a value of zero into account. The results of the study showed that the idea that the average value lies between the maximum and minimum of the data was understood by all but the 8-year-olds. Similarly, the majority of thirty (30) students solved the tasks associated with the idea that the data values influence the average and the average does not have to equal a datum value. Younger students had difficulty with the tasks associated with the idea that the average can be a fraction with no datum counterpart and the idea that the average is representative of the data. The majority of the students had difficulty with the tasks associated with the idea that when calculating the average a value of zero must be taken into account and that the sum of deviations from the mean is zero.

Koga, (2022), conducted a study on the characteristics of statistical literacy skills from the perspective of critical thinking in teaching statistics. The researcher defined Statistical literacy as the ability to interpret and evaluate statistical information critically. According to the researcher, Statistical literacy refers to the aptitude to analyze and assess statistical data in a discerning manner. The proficiency under

consideration is deemed to be a skill in advanced literacy, encompassing critical analysis and evaluation. Prior research has elucidated the notion of statistical literacy; however, the abilities associated with statistical literacy have yet to receive thorough exploration through the lens of critical thinking scholarship. This study addressed a void in the field by introducing a conceptual framework for enhancing critical thinking aptitudes within the context of statistical literacy. The attributes pertaining to the general aptitude for critical thinking were systematized. Seated on these traits, the investigator culled sentences pertaining to the aforementioned competencies from targeted course materials. Consequently, a total of eight facets pertaining to critical thinking proficiency within the domain of statistical literacy have been delineated.

Kuş, (2022), analzed selected school mathematics textbooks of Australia and Turkey on measures of center found that students had difficulty when given an average value and asked to construct the possible data attached to a particular mean. The study found five different ways students view the mean (average): as mode, as a calculation, as a reasonable value, as the midpoint, and as a point of balance. Engin, & Pusmaz, (2021), suggested that students first have to see the idea of distribution before the students can view mean, median and mode as representing the distribution. The development of students' concept of the mean (average) from the third to the ninth grade and their results supported the earlier finds of (Engin, &Pusmaz, 2021). According to Engin, &Pusmaz, (2021), that children's understanding of arithmetic averages has several properties or categories. Kuş, (2022), suggested that students have multiple conceptions of the average which emerge depending upon the type of task used and students' progress in their understanding of the average from the common vernacular meaning of average to the modal (most frequent) to the midpoint and finally to the idea of an average as "representative" of a data set. Kuş, (2022), postulated a hierarchical four-step conceptual view of the mean (average): as a typical value, as a fair share, as a way to reduce data, and as a "signal amid the noise." A typical value is viewed by the students as the most frequent or most central data value. A fair share is the view most commonly found in elementary school-age children and is the calculated average. From the data reduction viewpoint, there is so much data that a single data value is needed to represent the others. For the "signal amid noise" viewpoint "…each observation (datum value) is an estimate of an unknown but specific value.

Martinisi, & Lugo-Ocando, (2020),postulated that, from a statistician's viewpoint, the "signal amid noise" conceptual view of the mean was the most meaningful when examining two or more sets of data; they recommended that students be first introduced to the mean in the context of comparing data sets. Furthermore, Martinisi, & Lugo-Ocando, (2020), stated that "the notion of an average understood as a central tendency is inseparable from the notion of spread" and students need to view statistics as "the study of noisy processes … that have a signature, or signal".

Taherdoost, (2022), conducted a study on different types of data analysis; data analysis methods and techniques in research projects. The study which concentrated data analysis and the concept of data preparation. Then, the data analysis methods were also discussed. For doing so, the first six main categories were described briefly. Then, the statistical tools of the most commonly used methods including descriptive, explanatory, and inferential analyses are investigated in detail. The study finally focused more on qualitative data analysis to get familiar with the data preparation and strategies in the concept.

G. Studies conducted on Measures of Dispersion.

Despite the linkage between the measures of central tendency and dispersion or variability, research into variability is just beginning. Variability is defined as "the propensity for something to change, whereas variation is a measurement of that change". Research on students' thinking and understanding about variability could focus on variation in data, or on students' conceptions of variability in samples, or on the variability across several distributions of data that are being compared" (Donovan, Semmens, Keck, Brimhall, Busch, Weindling, & Salazar, 2019).. The data set was chosen because it is bimodal, that is, it has two most frequent values. Students were asked to predict how long a wait a tourist would have before Old Faithful erupted again. Most gave single-number answers by calculating the mean or means for each day or for all three days. Students were then asked to graph the data and again predict the wait time. After graphing, students could see the bimodal aspect of the data and some gave a range of values instead of a single value. Examples like these helps to solidify the idea of variation in data so students are not apt to calculate the mean without first examining the data. Another area of difficulty for students is the conflict between the ideas of variability and representativeness (Biswas, Scott, Munir, Renzaho, Rawal, Baxter, & Mamun, 2020). Students with some probability knowledge can predict the most likely outcome for a single trial but have a difficult time predicting likely outcomes for several repeated samplings. Recall that probability and statistics are intertwined like the two faces of the same coin. Probability is involved in predicting a single trial but the concept of repeated samplings falls into the realm of statistics. Students had a difficult time reconciling the two views or the idea of variability within reason around an expected value (confidence interval). Further research by Miao, Bokhove, Reynolds, &Charalambous, (2022), revealed a hierarchy of reasoning for learning variability, consisting of additive (most frequent data values) to proportional (mean or center) and ultimately to distribution centrer and spread). For example, in a jar were 100 candies, with 50% red and 50% a mixture of other colours. Six samples of ten candies each were drawn and students were asked to predict the number of red candies in each of the six samples. Students at the additive level based their answers purely on the number of reds in the mixture (example: number of reds in each sample: 8, 7, 6, 9, 10) while students at the proportional level based their answers upon the means or proportions of reds. Based upon the information that 50% were red, students at the proportional level gave the number of reds in each sample: 5, 5, 5, 5, 5, 5. At the distribution level, students' answers took into account both the centre and spread of the coloured

candies, reflecting a balance between the ideas of representativeness and variability.

H. Studies conducted on Graphical Representations

Several studies have exhibited the efficacy of graphical representations which aid statistical proficiency (Ziatdinov, & Valles Jr, 2022; Santos, Collantes, Ibañez, Ibarra, &Pentang, 2022; Elsayed, &Abdo, 2022; Saili, Samuel, &Mukuka, 2023). Zhu, Zhu, Zhang, Xu, & Kong, (2023), posits that the field of statistics employs various modalities of data representation, resulting in diverse forms of statistical data representation. The study identified several empirical data presentation methods that possess a high degree of reliability and validity. These methods encompass textual and statistical data presentation, measures of dispersion, as well as tabular and graphical data representation. Liu, Luo, & Zhou, (2023), posits that utilizing a graphical data representation is an essential tool towards achieving superior outcomes through effective comparison of disparate data sets and as a means for the systematic analysis of numerical data. The employment of graphical representation functions as a mechanism for scrutinizing numerical data in an academic context illustrated the interconnectedness between data, ideas, information, and concepts. The understanding of this particular concept is distinguished by its level of accessibility and its notable importance as a prominent pedagogical strategy. The categorization of data housed within a particular field of study holds significant influence. Additionally, the importance of the visual representation of statistical data in facilitating aids for comparative analysis constitutes a fundamental element in the research process within an academic setting. The graphical representation of data offers several key benefits. Foremost among these benefits is the enhancement and facilitation of learning. Graphical displays are adept at making complex data sets easily digestible, removing language-related and literacy-related obstacles to comprehension. The comprehension of content and information is expedited through the utilization of visual aids as opposed to textual forms, as evidenced by empirical data.

Agawu, (2023), posits that facile comparison of heterogeneous data sets can be achieved by employing a graphical representation of data, which critically contributes to improving the precision of the resultant findings. The utilization of graphical representations confers several benefits, including enhanced time management and the ability to discern anticipatory outcomes from complex datasets (Fosco, Jin, Josephs, &Oliva, 2023). The depiction of information through graphical means renders substantial advantages, particularly in the amelioration and simplification of the educational experience. Graphics possess the capability to effectively facilitate comprehension of quantitative information, thereby reducing the impact of language and literacy hindrances. The augmentation of content comprehension can be elevated by the application of visual elements as opposed to textual ones due to the claim that visuals are more effective in expediting human comprehension (Fosco, Jin, Josephs, &Oliva, 2023).

The existing body of literature suggests that there exist three fundamental tiers of graphical representations, as posited by various scholars (Rees, 2022; Caccamo & Cortoni, 2023, April; Lee, Park, & Hahn, 2022, November). These levels pertain to the ability to engage with graphical representations through different modes of comprehension, ranging from mere observation of graphical data, to identifying overarching trends and patterns, and ultimately making informed conjectures about future or missing data values. Durandt, Blum, and Lindl (2022) reported that there was evident difficulty among students in comprehending line graphs. Similarly, Lian, Yew, and Meng (2022) observed that students encountered challenges when dealing with line plots and histograms. In line with previous research findings (Avogo, Appau, & Attakora-Amaniampong, 2022), it was observed that students exhibited a preference for linear representations of data. Additionally, their focus was primarily directed towards the procedural aspects of graph creation, rather than the intricacies of graph interpretation (Rajabi, Taghaddos, &Zahrai, 2022). The use of specific graph types to address particular questions pertaining to data was also observed. Moreover, it was noted that students tended to disregard the utilization of graphs altogether in instances where real-world applications that aligned with their personal experiences were presented. According to Alm, Beery, Eiblmeier, and Fahmy (2022), incorporating open-ended graph problems and encouraging discussions surrounding the process of graphing may enhance comprehension of graphing.

I. Studies conducted on Technology Enhanced Statistical Learning

Several studies have exhibited the efficacy of suitable technological resources in aiding the procurement of statistical proficiency even in those in the nascent stages of development. Various technological resources and software programs, such as Tinkerplots, Mini Tab, and other technological tools are used in improving the statistical learning of students (Stemock, & Kerns, 2019; Prasad, Prasad, Malleswari, Shetty, & Gupta, 2022; Zohuri, & Rahmani, 2023).

The integration of technology within the educational system has facilitated children's ability to tailor their learning experience to a pace that is best suited to their individual needs. In academic settings, students who require additional time to comprehend a given concept are granted the opportunity to invest extended time in related exercises until they establish complete understanding. Conversely, students possessing a well-developed grasp of the material may proceed without further instruction or support. This practice additionally facilitates instructors to provide personalized assistance to students requiring greater academic support. There are various technological applications utilized for statistical instruction, including but not limited to statistical packages and spreadsheets, web or computer-based tools, graphic calculators, and programming languages. The utilization of calculators and computers has been observed to effectively abate the computational burden, thereby allowing for more comprehensive investigation and examination of statistical concepts. It is possible to infuse vibrancy and captivation into subjects that have been historically deemed

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difficult to comprehend. An extensive corpus of data is gathered, necessitating an aptitude in statistical analysis to comprehend it.

The utilization of technology affords students the opportunity to independently investigate and discern patterns within extensive data sets in a prompt and efficient manner.

Pan, Mason, & Matar, (2022), conducted a study on the Challenges and opportunities of integrating simulation, machine learning and statistics in Data-centric Engineering. The study indicated that in recent times, there has been noteworthy progress in the field of machine learning with the development being accompanied by the emergence of cost-efficient computing solutions, as well as the availability of inexpensive streaming sensors, data storage, and cloud-based technologies. These advancements resulted in a surge of multi-disciplinary research pursuits that have enticed ample interest and investment from commercial stakeholders. In the study, the modelling spectrum comprised of mechanistic models, which are grounded in physical equations, and statistical approaches that solely rely on empirical data. The advent of novel hybrid engineering methods that emphasize a data-centric approach, combining simulation techniques with empirical data, has presented a potent solution with significant transformative potential for the physical sciences. The study delved into an analysis of the bottlenecks in the transnational aspects of the field, as well as the long-term upskilling requirements for both the incumbent workforce and prospective university graduates. The study provided a comprehensive analysis of current research trends and potential applications within the emerging field of integrating simulations, machine learning, and statistics. The study emphasized the prospects that a consolidated perspective can offer and delineated the main impediments that are impeding its achievement.

Zeng, Li, Li, &Luo, (2022), conducted a study on Statistical and machine learning methods for spatially resolved transcriptomics data analysis. The study revealed that the recent progress in spatial transcriptomics technology has facilitated the concurrent analysis of multiple cellular transcriptomes and their respective spatial coordinates. With advancements in experimental technologies that enhance capacity and performance, there arises a growing demand for the formulation of analytical methodologies. Moreover, as sequencing protocols continue to undergo continuous development, it becomes imperative to reassess and revise the fundamental assumptions of existing analytical techniques in order to effectively manage the mounting intricacy of data. The present study aims to provide motivation and support for forthcoming model development by conducting a comprehensive review of the recent advancements in statistical and machine learning methodologies in spatial transcriptomics. Additionally, the researchers aimed to offer a summary of valuable resources and draw attention towards the imminent challenges and opportunities in this domain.

III. METHODOLOGY

A. Textbook selection

The process and implications of selecting appropriate textbooks for educational purposes remain an important aspect of pedagogy as it serves as a fundamental aspect in shaping educational outcomes and effective teaching practices. The choice of textbooks is essential in optimizing the learning process and boosting academic achievement among students. Hence, textbook selection should be approached with a critical and systematic perspective, incorporating a range of factors such as subject matter, clarity, coherence, and suitability to the target audience, among other criteria. The study analyzed two distinct textbook series made up of three textbooks series for each series with a specific emphasis on the Statistical contents of the two Ghanaian mathematics textbooks. The study was conducted to assess the level of statistical content in the two Ghanaian SHS mathematics textbooks. The textbook series comprises two series of three volumes each.

The study revolved around ACM and ECM textbooks. The ACM textbook is a private textbook published by Akiola Publications while the GECM is a public textbook published by CRDD that includes a series of instructional materials. Both textbooks were designed for use by SHS 1, 2 and 3 students. The textbooks were specifically designed for students enrolled in the study of core mathematics at the SHS level. The selection of a textbook series, either ACM or ECM, is contingent upon the discretion of the researchers. This study analyzed the curriculum sequence that was selected, which comprised the inclusion of ACM textbooks 1s1, 2, and 3, as well as ECM textbooks 1, 2, and 3.

The ACM and ECM textbooks have been identified as such for research purposes as commercial or publisher-generated textbook series and are both widely used series of textbooks in Ghana by Ghanaian SHS students studying core mathematics. The textbook series has three key focus areas: building mathematics vocabulary, diversified ways to improve student achievement, and diversified instructional approaches that are aligned with different learning styles.

The ACM textbooks comprise all three years put together into one the following years: year 1, year 2 and year 3 (©2009). The textbook series emphasizes various aspects such as understanding concepts, honing skills, and problem-solving. It is worth noting that this textbook series holds a preeminent position owing to its extensive use within the education sector.

The ECM textbooks comprise the following separate years: year 1 (©2009), year 2 (©2009), and Year 3 (©2009). The textbook series emphasizes various aspects such as understanding concepts, and problem-solving skills. It is worth noting that this textbook series holds a preeminent position owing to its extensive use within the education sector.

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B. Mathematics Task Analysis Framework

The Mathematics Task Framework is a foundational construct that facilitates the identification and differentiation of three distinct phases that characterize the progression of mathematical tasks (Feng & Liu, 2023). The phases in question are initial tasks that are typically presented in educational materials, specifically within textbooks, and are subsequently followed by teacher-assigned tasks, culminating in tasks that are ultimately executed by students during classroom instruction. (Crowley, Ball, & Hiddink, 2019; Giardino, 2023). The import of these stages was deemed to be instrumental in the attainment of erudition among students, owing to their immediate repercussions on the pedagogical progression in some way or the other, as illustrated by the triangle in Figure 1.

The Mathematics Task Framework is a theoretical construct that delineates three distinct phases through which mathematical tasks are known to progress (Feng & Liu, 2023). The aforementioned stages are constituent components that are primarily delineated in the curricular or instructional materials published in textbooks. This is proceeded by task assignments that are explicitly provided by the educator, hence followed by the execution of such tasks by students in the classroom setting (Crowley, Ball, &Hiddink, 2019; Giardino, 2023). The stages under consideration are considered to be of substantial importance in the facilitation of knowledge acquisition among students, owing to their significant influence on the learning process in various ways, as portrayed by the triangle illustrated in Figure 1.

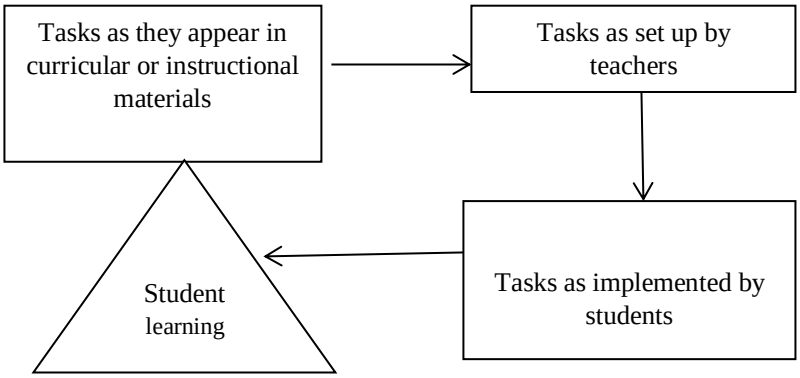

Fig. 1: Progression of Mathematical tasks framework

Drawing upon the insights gleaned from Figure 1, it is possible to discern that the initial two arrows illustrated in the conceptual framework serve as critical junctures along the educational path of mathematical tasks, wherein the cogitative demands may undergo variations. The mathematical exercises have apparent implications for students' procurement of mathematical knowledge, as evidenced by the third indicator in the schematic representation illustrated in Figure 1. The discernable attributes of instructional tasks tend to undergo modifications as they traverse across different stages of the framework. The tasks that are perceived in educational materials and curricula often do not align with the tasks that educators assign or the tasks that students carry out. This lack of consistency raises concerns about the alignment between objectives stated in instructional materials and actual classroom practices. The sequential advancement of tasks from commencement to the implementation phase plays a pivotal role in evaluating students' capacity to tackle intricate, high-level tasks. Despite this, tasks crafted to challenge and tax students' cognitive abilities have undergone significant changes in terms of the students' approaches to carrying them out. Upon recognition of this reality, it establishes a pragmatic basis for cultivating students' cognitive abilities in the field of mathematics. This study endeavors' to analyze the statistical tasks set forth by two pedagogical publications, namely the ACM and ECM textbooks, which function as educational aids for SHSin Ghana.

Table 1 illustrates the position of the statistical chapter of the ACM and ECM textbooks 1, 2 and 3. Table 1 shows that the statistics as to the topic is found in textbook 1 of both the ACM and ECM indicating the sequence of the statistical concepts. Phase 2 focuses on an examination of the lesson narrative, its components and scope. Phase 3 consists of the level of cognitive demand required of the students to complete the exercises, the total number of exercises per statistical concept, and the total of non-statistical exercises. Usually, the opportunity to learn refers to some aspect of what a student has learned as reflected in various assessments. However, because the focus of this study is the "intended curriculum" the definition of the opportunity to learn is slightly different. In this study, the idea is more of a potential opportunity to learn if the concept is present in the textbook.

Figure 1 depicts the three distinct stages of the data analysis process. The first phase pertains to the placement and ordering of the statistical concepts. The second phase of the study centres on a thorough analysis of the pedagogical story, its constituent elements, and its overall range and breadth. The third phase entails an assessment of the cognitive load necessitated for the successful completion of the exercises, as well as the count of exercises per statistical concept and the aggregate quantity of non-statistical exercises. This study centred on the "intended curriculum", and hence, the interpretation of the notion of "opportunity to learn" varies marginally. This investigationcentres around the potential

opportunity for learning provided by the presence of a particular concept in the textbook.

C. Procedures

The analysis of the statistics contents of each textbook series consisted of four areas, namely textbook units or chapters, statistical units or chapters of the textbook and statistical concepts and their corresponding tasks as well as types of statistical tasks After the explanation of the procedures, examples were provided. The established protocols and methodologies used in carrying out a particular task or achieving a specific objective are known as procedures in academic contexts. These procedures are often documented and communicated to various stakeholders. They are typically designed to ensure consistency, efficiency, and accountability throughout the execution of the analysis process. In effect, a description of the procedures used in the study including any adaptations or modifications made throughout the process was indicated. This level of detail is crucial for the reliability and validity of the research findings.

The assessment of the textbook series incorporated three fundamental categories, namely the chapters of the textbooks, the proportion of the textbook devoted to statistics chapters, contents, and concepts as well as the statistical tasks in the textbooks. Following the explication of the methodologies, illustrative instances were furnished. Similarly, all the tasks that corresponded to the statistical sections identified for analysis were included in the analysis. All tasks in the statistical sections that did not pertain to statistical concepts were omitted but the number of tasks that were non-statistical in nature was noted. The researcher planned to use the search feature in the e-book versions to locate statistical concepts. However, although e-books are becoming more readily available, some of the textbook series chosen for this study did not have e-book versions. Thus, to maintain consistency in how the statistical topics for analysis in all the textbooks were determined, the researcher excluded the use of the e-book search feature. From the books used in the pilot study, after going through each textbook page by page and looking for statistical concepts, none of the examples were missing when using the table of contents and index to locate the statistical textbook. All the examples were about statistical concepts which indicated the use of the table of contents and the index to find where the statistical concepts are located.

In simple terms, the entirety of tasks pertinent to the identified statistical sections earmarked for analysis was incorporated into the analysis. Tasks within the statistical sections that were not relevant to statistical concepts were identified if found and excluded, however, a record was kept of the number of exercises that were non-statistical in nature. The researcher as a means of identifying statistical concepts and for the sake of upholding uniformity in determining the statistical themes for analysis in all the textbooks. In the pilot study, a systematic approach was taken to review each textbook utilized. The objective of the review was to identify any statistical concepts presented within the texts. The analysis was conducted on a per-page basis to ensure that all contents were covered. The table of contents and index were referred to in order to locate any relevant statistical content. The aforementioned instances were integrated within statistical segments, with a sole example pertaining to a statistical notion. The topics underlying were centred on statistics. The utilization of the table of contents and index as a means of locating statistical concepts was found to have no missing example resulting in a negligible margin of error tolerable.

D. Excluded Sections of tasks

Since the study was solely on statistical contents in the two Ghanaian mathematics textbooks, the researcher included all mid-chapter exercises that were related to statistics concepts, and chapter tests as those items were considered as part of the assessment according to the aim of the study. The focus of the study was on the textbooks and how the textbooks presented to the average student; therefore, the student handbook was excluded from the study.

E. Textbook Coverage of Statistical Concepts

The first phase of the analysis dealt with the location and total percentage of statistical content, the location of statistical content within the textbook, and the identification of the year levels in which the statistical concept(s) appeared. To determine the percentage of the textbook devoted to statistics, instructional pages were counted and the total number was recorded. Instructional pages are the pages that excluded the preface, glossary, index, selected answers or table of contents pages. These pages do include the page chapters/units, topics expositions, worked examples on topics and topical exercises. Next, within each statistical section, the number of pages devoted to each statistical content was determined. The researcher applied this method of determining the amount of textbook content that was statistically related in the ACM and ECM textbooks, which were made up of SHS 1, 2 and 3 as well as also noting the subsequent location of the chapters and concepts in relation to the entire textbook. The location (page number) of the statistical chapter and concepts in relation to the entire textbook was noted along with the used to examine the textbooks in his study where he denoted what material was new for each SHS year group. For each textbook series, the statistical content of SHS 1, 2 and 3 from the same textbook series was compared, and any statistical concept that was not found in the ACM textbooks and ECM textbooks were classified as different. Similarly, the statistical concepts for SHS were compared in both the ACM and ECM textbooks 1, and 3; Again, any concept not found in SHS textbooks 1, and 3 was considered different.

F. Reliability

In order to ensure the reliability of the study, the coding of the two textbook series was done and their corresponding statistical contents and tasks were conducted by the two researchers. Additionally, upon completion of 75% of the coding process, the researcher executed a recoding procedure for the statistical content from each textbook series in order to rectify coding drift. The researchers both possess a postgraduate degree in mathematics, mathematics education and have gained extensive academic experience teaching in both secondary and tertiary institutions and have collaborated with other experts in the field of mathematics and statistics with a specialization in Mathematics and Statistics pedagogy.

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G. Training of coders

The two instructional materials employed in the pilot study were utilized for instructional intentions. Each coder in the coding process was provided with a comprehensive compilation of statistical terminologies and phrases. They were instructed to use the table of contents and the index to determine the specific sections of the pilot textbooks to be analyzed. Any incongruities or inconsistencies observed in the instructional modules were deliberated upon by the coders until a consensus was reached as to the extent to which the lesson narration incorporated a statistical concept. The coders ascertained the number of pages dedicated to each statistical topic within textbooks. The present study conducted a comparison between the findings related to the statistical contents, topics and concepts, tasks, instructional expositions, instructional exercises and instructional review exercises and their totals, and textbook totals. For further details, please refer to Appendix A, B, C, D, E, F: There was a concordance observed between the sum of numeric values presented in the textbook and the corresponding quantifications put forth throughout the instructional material. Nevertheless, during the process of determining content to incorporate from both the table of contents and index, a structured and scholarly approach was imperative.

Two research questions were examined in this study. The first question centred on the nature of the contents of statistics in the two mathematics textbooks while the second pertained to the nature of types of statistical tasks in the two Ghanaian SHS mathematics textbooks. Subsequently, two coders were provided with the lesson components. The coders were instructed on the mechanisms and standards underlying the coding process. The coders engaged in collaborative coding activities where they were provided with an exemplar coding of a textbook derived from the pilot investigation. Moreover, the justifications underlying every coding decision were comprehensively elucidated. The coders proceeded to code a distinct source from the piloted textbooks with the intent of analyzing the concurrence or discordance in the coding of the identical constituents. A singular incongruity surfaced in regard to the inquiry of whether a solitary sentence present amidst worked examples pertained to the antecedent example or required distinct codes. As a result of its lack of defined terms or illustrative application, the sentence was deemed a continuation of the antecedent worked example. Subsequently, an analysis was conducted on the statistical activity series derived from the preliminary investigation that had been previously encoded. Complementary deliberations followed, primarily concerning the rationale behind the allocation of a specific level of cognitive complexity to each problem presented. A subsequent exercise set derived from the pilot study was subjected to coding for experimental purposes, and an assessment of inter-coder agreement and disagreement percentages was conducted. Discordances were scrutinized and explicatory measures were undertaken to ascertain cognitive proficiency, until a substantial level of concurrence, i.e, 85% or beyond, was attained. Discrepancies refer to inconsistencies or differences observed in a dataset or information, which deviate from the expected trend or pattern. These irregularities can arise due to various reasons, including measurement errors, sampling bias, or random variation in the data. It is crucial to identify and rectify any discrepancies promptly to ensure the accuracy and reliability of the findings. In other words, identifying and reporting discrepancies is a critical aspect of research methodology and data analysis, as they can significantly impact the interpretation and validity of the results. Therefore, researchers exercised diligence in detecting and addressing any discrepancies and documenting their actions transparently.

The study further examined, analyzed, coded and counted all the statistical tasks in the ACM and ECM textbooks 1, 2 and 3 according to the categories of statistical tasks. The coded statistical tasks were enumerated. The two textbooks were re-coded after two weeks and the codes were counted and entered into the content analysis codebook. The categories of statistical tasks and their codes can be found in Table 1. In addition to that, all the statistical tasks in the two mathematics textbooks were coded. Each of the coded statistical tasks in the textbooks was counted twice to check and recheck whether there were no mistakes in the counting according to the types of statistical tasks. The mean, percentage agreements and kappa value of the results from the two coders and ratings for each of the textbooks were calculated and recorded for consistency checks.

H. Categorization of Statistical Tasks

In the field of mathematical education, the classification of statistical tasks has been of great interest among researchers and educators. For the purposes of simplicity and clarity, this study adopted the term "categorization" to refer to a broad range of statistical tasks. In totality, the analysis made use of two sets of distinctive categories of statistical tasks. The task categories included

- Routine statistical tasks (RST) against Non-routine statistical tasks (NRST)
- Application statistical tasks (AST) as against Non-application statistical tasks (NAST).

Table 1 shows the types of statistical tasks, their codes and definitions.

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Table 1: Types of statistical tasks, their codes and definitions

Type of Statistical Tasks	Code	Definition of type of statistical tasks
Routine statistical tasks	RST	Routine statistical tasks are **statistical t**asks that follow certain known algorithm, formulaor procedure to get the solution and that the way to the solution is immediately evident.
Non-routine statistical tasks	NRST	Non-routine statistical tasks are statistical tasks that cannot be resolved by merely applying a standard algorithm, formula, or procedure, which is usually readily available to the problem solver.
Applicational statistical task	AST	Applicational statistical tasks in this study covered both fictitious application tasks and authentic application problems. These statistical tasks are tasks whose conditions and data are fictitiously made by the textbook author(s) or those whose conditions and data are real-life situations or collected by students themselves from their daily life. All were classified under applicational statistical tasks.
Non-applicational statistical tasks	NAST	Non-applicational statistical tasks **a**re statistical tasks that are unrelated to any practical background in everyday life or the real world.

I. Inter-rater reliability

Inter-rater reliability refers to the degree of consistency among raters' assessment decisions or ratings of a particular variable (TAŞDEMİR, 2022; Eser & Aksu, 2022). It is a crucial factor in research as it determines the level of agreement between different observers or assessors, ensuring the validity of the results. Inter-rater reliability is particularly useful when researchers assign codes, ratings, scores, or categories to variables, as it helps to reduce observer bias (Eser & Aksu, 2022). This study employed inter-rater reliability to evaluate the consistency and reliability of the coding and rating system, specifically for mathematics textbooks. High inter-rater reliability indicated that the coders' ratings were consistent, while low reliability indicated inconsistencies between the coders' ratings.

Assessing inter-rater reliability was important in determining the accuracy of the measurement system and its ability to classify mathematical tasks correctly. When the coders frequently disagreed, it was a sign that the measurement system was invalid, resulting in low inter-rater reliability. The inter-rater reliability was also used to measure the level of agreement between the researcher's ratings and those of their assistant. A perfect alignment of the coders' ratings was scored as 1, representing 100 per cent agreement. Inter-rater reliability was used to determine whether the researcher and their assistant employed the same coding system for each of the mathematics textbooks, which differs from intra-rater reliability. The level of agreement between the coders' ratings was measured using inter-rater reliability. Coders with a high inter-rater reliability score were more likely to rate an individual in the same way. One statistical test used to measure inter-rater reliability is the per cent agreement, which calculates the number of times raters agreed on a rating and divides it by the total number of ratings. The present study used this formula to find the per cent agreement between the coders' ratings.

Percent Agreement = ((agreement / (agreement + disagreement) x 100%)

Percentage agreements were calculated for all types of mathematical tasks ((Routine statistical tasks (RST) and Non-routine Statistical tasks (NRST)); (Application Statistical tasks (AST) and Non-application Statistical tasks (NAST)).

Hence in this study, the following inter-rater values were used based on the percentage agreements. The inter-rater agreement took values from − 1 to 1, and was interpreted as in Table 2:

Table 2 shows the inter-rater agreement and its interpretations.

Table 2: Description of Percentage agreement values and their interpretation

Value	Interpretation
➢ 0	No Agreement
0.10 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 0.99	Near-perfect agreement
1.00	Perfect agreement

(Source: Nurjannah & Siwi, 2017)

The Kappa statistic, also known as Cohen's Kappa coefficient, is a measure of inter-rater reliability used to evaluate the agreement between two or more raters or judges. Cohen's Kappa statistic is a statistical measure used to evaluate the reliability of categorical variables between two raters. It determines the level of agreement between the assessments provided by both raters. Cohen's Kappa coefficient (k) is an interval-scaled measure that ranges from 0 to 1. A score of 0 suggests no agreement between the two raters, while a score of 1 indicates full agreement. The author of the study suggested that values equal to or less than 0.40 indicate poor agreement beyond chance, while values ranging from 0.40 to 0.75 suggest good agreement beyond chance. Values greater than or equal to 0.75 indicate exceptional

agreement beyond chance, as noted by Fleiss et al. (2003) and Evans (2022). The criteria for evaluating the concordance between the two raters are presented in Table 2.

In this study, Cohen's kappa coefficient was utilized to assess the level of agreement between the two raters. This measure was preferred over the simple per cent agreement calculation because of its increased robustness. Specifically, Cohen's kappa (k) adjusts for random agreement, offering additional benefits. The interpretation of the kappa coefficient provides information on the reliability and dependability of the data, as shown in Table 4.10. In qualitative research, a Kappa coefficient below 0.4 is considered inferior. A Kappa coefficient of 0 suggests no difference between observers, and any variation in results is due to chance. Kappa values between 0.4 and 0.75 indicate moderate to good agreement, while a Kappa value exceeding 0.75 indicates a high degree of consistency and excellent agreement between the raters.

Table 3 summarizes the interpretation of the value of k in relation to the level of agreement and the percentage of data analyzed that is reliable or dependable.

Table 3: Kappa Coefficient Interpretation)

Value of k	Level of agreement	% of data that are reliable
0 – 0.20	None	0 – 4%
0.21 – 0.39	Minimal	4 – 15%
0.40 – 0.59	Weak	15 – 35%
0.60 – 0.79	Moderate	35 – 63%
0.80 – 0.90	Strong	64 – 81%
Above 0.90	Almost perfect	82 – 99%
1.00	Perfect	100%

(Source: Logical interpretation of kappa from(McHugh 2012)

The concept of validity pertains to the degree to which the research findings can be deemed genuine and trustworthy (Amoah, 2018; Morgan, 2022). Amoah, (2018), illustrates the validation of a particular research tool and its ability to precisely evaluate the intended construct. According to Tanaka, & Ross, (2023), Validity is a metric utilized to evaluate the degree to which research outcomes successfully reflect actual empirical reality, or alternatively, the precision with which researchers' fashioned constructs precisely depict or measure facets of human experience. The validity of a research study is achieved when it successfully measures the intended construct or phenomenon under investigation. In order to establish the validity of the measurement instruments employed, the researcher and their assistant made reference to the SHS syllabus and consulted the relevant textbooks utilized by the students. The objective was to acquire a deeper understanding of the learning objectives of the students in order to tailor the research instruments appropriately.

IV. RESULTS

This study examined the statistical contents of two Ghanaian mathematics textbooks. In an attempt to answer the following research questions:

- What is the nature of the statistical contents in two Ghanaian SHS mathematics textbooks?
- What are the types of statistics tasks in the two Ghanaian mathematics SHS textbooks in SHS 1, 2 and 3?

A. Research question 1

➢ *The nature of the statistical contents in two Ghanaian SHS mathematics textbooks*

The first research question was to find out the statistical contents of the two Ghanaian SHS mathematics textbooks. All the statistical contents were considered with respect to the topics and how they were sequentially presented in the two textbooks. The analysis of the ACM textbook 1 revealed that the textbook had all three years put into one but each had its own demarcations. It was further observed that ACM 1contained thirteen (13) units covering the following topics; “Sets”, ”Real number systems”, “algebraic expression”, “Number bases”, “Plane geometry”, “Linear equations and inequalities”, “Relations and functions”, ”Vectors in a plane”, “Simultaneous linear equations in two variables”, “Rigid motion”, “Statistics”, “Ratio and rates” and “Percentages” with each unit ending with worked examples, and exercises.

The analysis of the ACM textbook 2 indicated that there are also thirteen (13) units covering the following topics; “Modulo Arithmetic”, ”Indices and Logarithms”, “Simultaneous Linear Equations in two Variables”, “Percentages II”, “Variation”, “Statistics II”,“Probability”, “Quadratic functions and Equations”, Mensuration”, “Plane Geometry 2”, ”“Trigonometry 1”, “Sequences and Series”, and “Rigid motion and enlargement” with each unit ending with tasks in worked examples, tasks in exercises and tasks in review exercises.

The examination of the ACM textbook 3 indicated that the textbook contained four (4) units covering the following topics; “Constructions”, “Mensuration II”,” interpretations of Linear and Quadratic Graphs”, “Review Exercise 1”, “Logical Reasoning” and “Trigonometry II”. Textbook 3 also had general review exercises, multiple choice questions and answers to the review exercises. Each chapter had its own chapter summary. The study further found out that there were categories of statistical tasks in the ACM textbooks 1, and 2 such as statistical subtopics (SST), Statistical worked examples (SWEX), statistical exercise (SEXX) and statistical review exercises (SREX).

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➢ *Categories of statistical tasks in the ACM textbooks 1, 2 and 3*

The study identified that Statistics 1 was the tenth topic in the ACM textbook 1. The study indicated that Statistics I comprised of the following sub-topics; Pie chart, Bar charts, Histogram, Cumulative frequency curves, mean, mode and median covered thirty pages with sixty(67) worked examples, eighty-nine (89) exercises and seventeen (17review exercises in the ACM 1. The study further identified that Statistics II covered the subtopics quartiles, percentiles, range, inter-quartile range and standard deviation making up a total of thirty-two pages which further contained fifty-three (53) worked examples, seventy-nine (79) exercises and thirty-one (31) review exercises all under Statistics II. All the statistical tasks in the textbooks were analysed, coded and counted according to the conceptual framework. However, there was no statistical chapter nor statistical tasks in the ACM 3. Table 4 shows the descriptive statistics of the statistical tasks SWEX, SEXX and SREX in the ACM textbooks 1, 2 and 3.

Table 4: Descriptive statistics of the statistical tasks SWEX, SEXX and SREX in the ACM textbooks 1, 2 and 3.

	ACM 1		ACM 2		ACM 3	
TASKS	N	%	N	%	N	%
Statistical Worked Examples (SWEX)	67	39	53	32.5	-	
Statistical Exercises (SEXX)	89	51	79	48.4	-	
Statistical Review Exercises (SREX)	17	10	31	19	-	
Total	**173**	**100**	**163**	**100**	**-**	

Based on the data presented in Table 4, it was noted that ACM 1 encompasses a significantly higher number of tasks compared to the tasks attributed to ACM 2. The study revealed that all three textbooks exhibited a considerable predominance of SEXX over SWEX and SREX, with SEXX surpassing the latter two by more than twice the amount. According to the data presented in Table 4 of the ACM textbook, it was observed that there were sixty-seven (67)SWEX representing 39 % out of 1024 GWEX, while eighty-nine (89) SEXX representing 51% out of the 2863 GEXX and seventeen (17) SREX representing 10% out of 545 GREX of the entire dataset. The data presented in Table3 from the ACM textbook 2 indicated that out of a total of 2754 textbooks, fifty-three (53) were SWEX representing 32.5% out of the 970 tasks in worked examples in the entire textbook GWEX, whilst seventy-nine (79) were SEXX representing 48.4% out of the 1336 tasks in exercises in the entire textbook GEXX. Additionally, out of 443 tasks, 31 were classified as SREX, representing 19%. There were no tasks in the ACM textbook 3. Figure 1 depicts the graphical representation of the various categories of statistical tasks featured in textbooks 1, 2, and 3 of the ACM textbooks.

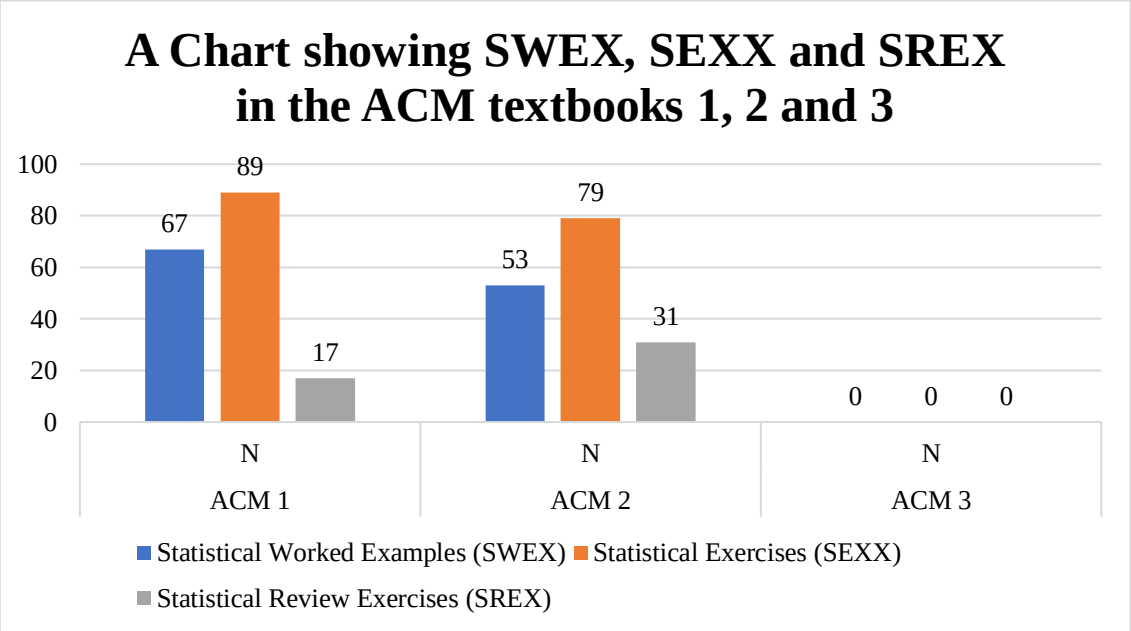

Fig. 2: Bar chart of SWEX, SEXX and SREX in the ACM textbooks 1, 2 and 3.

According to the graphical representation in Figure 2, it was observed that ACM textbook 1 and ACM textbook 2 manifested the tripartite structure of all the statistical tasks. Based on the findings depicted in Figure 1, it can be inferred that the textbooks of ACM 1, and ACM 2, evince a dearth of SREX, while SWEX exhibits the highest frequency of statistical tasks throughout the three years.

➢ *Discussions on the ACM textbooks 1, 2 and 3*

The ACM textbooks included a greater number of categories pertaining to SWEX and SEXX, in comparison to the ACM textbook 2 of the same textbook. The ACM textbook 1 was found to exhibit a noticeable predominance of SEXX in comparison to SWEX and SREX. Whilst ACM textbook 3 displayed no levels, the ratio of SEEX between ACM textbook 1 and ACM textbook 2 was observed to be

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1.4:1. Furthermore, it was observed that the SWEX value presented in the ACM textbook 1 surpassed that of the ACM textbook 2 by a factor greater than one. Similarly, the SREX ratio displayed in the ACM textbook 1 was less than that of the SREX demonstrated in the ACM 2. Additional analysis revealed that ACM 1 contained a greater quantity of statistical exercises (SEXX) in comparison to ACM 2. Upon comparison of the categories of mathematical exercises, it is evident, as depicted in Figure 1, that ACM 1, and ACM 2, exhibited a greater abundance of exercises classified as SEXX, as opposed to SWEX and SREX. This study's findings align with the findings of other research (Amoah, 2019; Murphy, Klymchuk, Evans, Stephens & Thomas, 2022; Earle &Parkes, 2023). This finding suggests that the academic demands placed upon second-year students as far as statistics were concerned were considerably higher than those imposed on first-year students. It is recommended that incoming Form 2 students continue to utilize the ACM2 from their previous academic year, known as ACM 1. This approach is intended to facilitate the establishment of a robust educational groundwork, which will contribute to their success in the forthcoming three-year SHS textbook. Murphy et al. (2022), suggests that the incorporation of three distinct categories of mathematical exercises in the ACM textbooks 1, and 2 encourages students to engage in a comprehensive range of statistical tasks traditionally labelled as the 3 es, leading to a more deliberate and inclusive mode of thinking.

- *Analysis of the ECM textbooks 1, 2 and 3*

A comprehensive analysis of the ECM textbook 1 revealed that it comprises thirteen (13) distinct units that delve into various mathematical topics. The units were as follows: "Sets", "Real Number System", "Algebraic Expressions", "Number Bases", "Plane Geometry", "Linear Equations and Inequalities", "Relations and Functions", "Vectors in a Plane", "Simultaneous Linear Equations in Two Variables", "Rigid Motion", "Statistics", "Ratio and Rates", and "Percentages". Each unit is completed with a set of exercises. The study identified “Statistics” contents as the tenth topic in the ECM textbook 1. Although ECM textbook 1 covered 445 pages, statistics 1 covered only 42 pages of the entire textbook 1. The chapter on Statistics covered sub-topics such as Data, Discrete data, Continuous data, Frequency distribution table, Ungrouped distribution, grouped distribution classes of frequency distribution, Graphical distribution of data, bar charts, pie charts, histograms, measures of central tendencies, mean of a distribution, Grouped data, and estimating the mode from a histogram, Further analysis of the ECM textbook 1 statistical tasks indicated that there were contained twenty-three (23) tasks were SWEX representing 34%, whiles forty-five (45) tasks were SEXX also representing 66% with all review exercises embedded in the review exercises. Textbook 1 contained three review exercises with a total of thirty-two questions. It was however, observed that only one (1) question was SREX.

A detailed analysis of the contents of the ECM textbook 2 revealed the presence of ten (10) units, which encompass the subjects of "Modulo Arithmetic", "Indices and Logarithms", "Surds", "Percentages 2", "Variations", "Quadratic functions/Equations", "Plane Geometry 2", "Mensuration", "Trigonometry 1", and "Probability". Each unit is augmented by a set of exercises to consolidate the learning outcomes. There was however no statistical topic in the ECM textbook 2.

Additional analysis of the ECM textbook 3 revealed that the textbook comprised nine (9) chapters that expound on several topics, including "Sequences and Series," "Bearings," "Constructions," "Statistics II," "Interpretations of Linear and Quadratic Graphs," "Review Exercise 1," "Mensuration," "Logical Reasoning," "Percentages II," "Rigid Motion and Enlargement," "Trigonometry II," and "Review Exercises 2." Each chapter is accompanied by a summary. The study observed that “Statistics II” was identified in the ECM textbook 3 with sub-topics on the following:

Observations and analyses conducted based on the ECM textbooks 1, 2, and 3 demonstrated that each of these textbooks features three distinct exercise areas. The aforementioned tasks comprised worked examples (SWEX), exercises (SEXX), and review exercises (SREX). There were also sixteen (16) tasks as SWEX representing 35.6% and twenty-nine (29) tasks were SEXX representing 64.4%. Details of the statistical contents identified in the ECM textbook 3 indicated that there were thirty-eight (38) pages covering “Statistics II”.

Table 5 presents the descriptive statistics pertaining to the statistical worked examples (SWEX), statistical exercises (SEXX), and statistical review exercises (SREX) in the ECM textbooks 1, 2, and 3.

Table 5: Distribution of categories of statistical tasks in the ECM textbooks 1, 2 and 3

TASKS	ECM 1		ECM 2		ECM 3	
	N	%	N	%	N	%
Statistical Worked Examples (SWEX)	23	33.33			16	35.6
Statistical Exercises (SEXX)	45	65.22			29	64.4
Statistical Review Exercises (SREX)	1	1.45				
Total	69	100			45	100

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From Table 5, it was observed that ECM textbook 1 contained more categories of SWEX and SEXX than ECM 3. In addition to that, the total number of tasks contained in ECM 1 far exceeded the tasks in ECM 3. However, both the ECM textbooks 1 and 3 had more than double of SEXX than SWEX and SREX. Figure 2 shows the categories of statistical tasks presented in the ECM textbooks 1, 2 and 3.

Figure 3 is a chart showing the categories of statistical tasks in the ECM textbooks 1, 2 and 3.

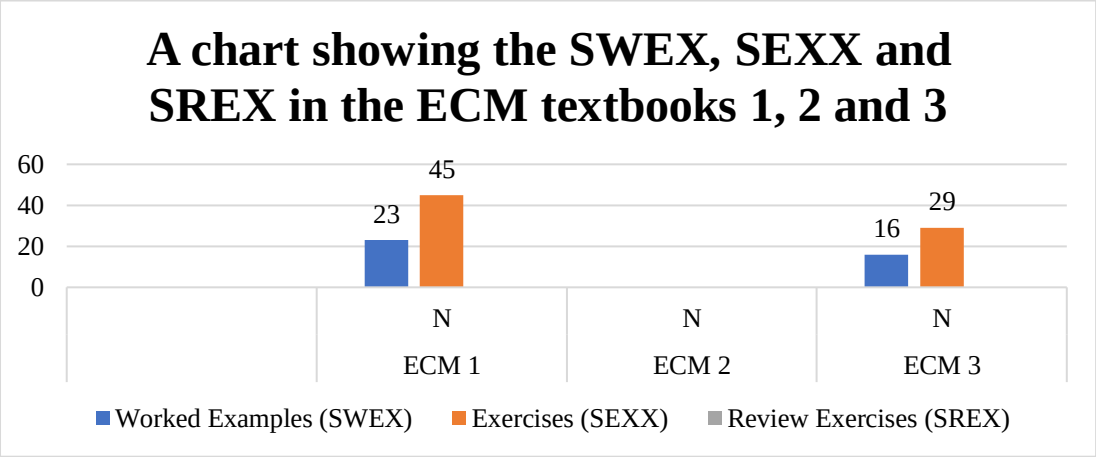

Fig. 3: A chart showing the categories of statistical tasks in the ECM textbooks 1, 2 and 3.

According to the data presented in Figure 3, it can be inferred that ECM textbook 1 possessed a greater number of statistical task categories in comparison with ECM textbook 3, with the sole exception of SREX. The ECM textbooks 1, and 3 were found to comprise three distinct categories of statistical tasks, such as SWEX, SEXX, and SREX. Upon analysis of Figure 2, it was observed that the ECM 1, and ECM 3 textbooks featured SREX over the two-year period. Conversely, SEXX exhibited an increase across all two years of the ECM textbooks. ECM textbook 1 featured a greater number of categories pertaining to SEXX and SWEX as compared to the textbooks, namely ECM textbook3. Although the ECM textbook possessed a lesser degree of SEEX, it is worth stating that the proportion of SEEX in the ECM textbook to that found in the said textbook was ascertained to be 2.12:1. Furthermore, it should be noted that the SWEX in the ECM textbook 2 was twice as large as that of the ECM textbook 3 whereas the SREX portrayed in the ECM textbook 1 was greater than twice that which was found in the ECM textbook 2. Figure 3 delineates the categorization of statistical tasks presented in ECM textbooks 1, and 3. Based on the data presented in Figure 3, it can be observed that ECM textbook 1 presents a comprehensive overview of statistical tasks, encompassing three distinct levels of complexity, as well as a diverse range of strategies that can be employed to successfully solve mathematical tasks. According to the findings presented in Figure 3, it can be ascertained that ECM 1, ECM 2, and ECM 3 reported a lower number of SREX in their respective textbooks. Conversely, SWEX demonstrated the highest frequency of exercises throughout the three-year period under study.

- *Discussions on statistical tasks in the ECM textbooks 1, 2 and 3*

Based on the results, it is worth stating that the academic demands imposed on students in the first year were considerably heavier in comparison to students in SHS 3. Furthermore, it is advisable for first-year students to utilize ECM textbook 1 in order to establish a comprehensive framework for the entirety of their three-year SHS program. The present study's findings are in line with prior research conducted by Amoah (2019), Murphy, Klymchuk, Evans, Stephens, and Thomas (2022), and Earle &Parkes (2023). This observation suggests that the academic demands placed on students in the first year of senior high education were considerably greater in comparison to those in the third year. Additionally, it is recommended that first-year students progressing to the second year should persist in utilizing the ECM textbook 1 in order to establish a sturdy groundwork for the subsequent two years' SHS textbooks. Murphy et al, (2022) highlighted that the utilization of the three distinct categories of statistics in the ECM textbooks 1, and 3 prompts students to engage with all categories of statistical tasks referred to as the 3e's, thereby facilitating a more purposeful and comprehensive approach to problem-solving.

C. Research question 2

- *Types of statistics tasks in the two Ghanaian mathematics SHS textbooks in SHS 1, 2 and 3*
- *Types of statistical tasks in the ACM textbooks 1, 2, and 3*

The second question posed was to identify the types of statistical tasks in the ACM textbooks 1, 2, and 3. To achieve this, all textbook statistical tasks were analyzed, and coded according to the concepts outlined and the results recorded.

- *RST and NRST in the ACM textbooks 1, 2 and 3.*

The tasks in textbooks 1, 2 and 3 were classified based on the categorization of tasks and their codes; "RST against NRST"; "AST" against "NAST";. The data collected were put under themes and sub-themes. Table 6 illustrates the number of RST and NRST in the ACM textbooks 1, 2 and 3.

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Table 6: Number of Routine statistical tasks (RST) and Non-routine statistical tasks (NRST) in the ACM textbooks 1, 2 and 3.

Textbooks	**ACM 1**		**ACM 2**		**ACM 3**	
Tasks	**N**	**%**	**N**	**%**	**N**	**%**
Routine statistical tasks (RST)	161	93	146	89.5	-	
Non-routine statistical tasks (NRST)	12	7	17	10.5	-	
Total	**173**	100	**163**	100	-	

From Table 6, ACM textbook 1 had 173statistical tasks. The analysis revealed that 161 (93%) were RST and 12 (7%) were NRST. Furthermore, the researcher used illustrations, charts, figures and tables when reporting the results of the research, especially when explaining the purpose and process of analyzing and building concepts. Rater consistency, coded from the ACM textbook 1, showed a concordance rate of 1.00, indicating a perfect concordance within the required concordance range. Further analysis indicated that the interpretation was gleaned from the data of the two raters.

ACM textbook 2 contained a total of 163statistical tasks. Analysis revealed that there were 146 (89.5%) and17 (10.5%) statistical tasks for RST and NRST respectively. Rater consistency, coded from the ACM textbook 2, indicated a post-discussion agreement rate of 1, indicating perfect agreement within the required agreement rate. Further analysis of the concordance revealed that Cohen's kappa value of 1. This indicated a perfect agreement between the two raters.

The ACM textbook 3 had no statistical tasks.

- *AST and NAST in the ACM textbooks 1, 2 and 3.*

Table 7 illustrates the number of AST and NAST in the ACM textbooks 1, 2 and 3.

Table 7: Number of AST and NAST in the ACM textbooks 1, 2 and 3.

Textbooks	**ACM 1**		**ACM 2**		**ACM 3**	
Tasks	**N**	**%**	**N**	**%**	**N**	**%**
Applicational statistical tasks (AST)	52	30	68	42		
Non-applicational statistical tasks (NAST)	121	70	95	58		
Total	**173**	100	**163**	100	-	

From Table 7, ACM textbook 1 had 173 statistical tasks. The analysis revealed that 52 (30%) were AST and 121 (70%) were NAST. Furthermore, the researchers used illustrations, charts, figures and tables when reporting the results of the research, especially when explaining the purpose and process of analyzing and building concepts. Rater consistency, coded from the ACM textbook 1, showed a concordance rate of 1.00, indicating a perfect concordance within the required concordance range. Further analysis indicated that the interpretation was gleaned from the data of the two raters.

ACM textbook 2 contained a total of 163 statistical tasks. Analysis revealed that there were 68 (42%) and 65 (58%) statistical tasks for AST and NAST respectively. Rater consistency, coded from the ACM textbook 2, indicated a post-discussion agreement rate of 1, indicating perfect agreement within the required agreement rate. Further analysis of the concordance revealed that Cohen's kappa value of 1. This indicated a perfect agreement between the two raters.

- *Types of statistical tasks in the ECM textbooks 1, 2, and 3*

- *RST against NRST in the ECM textbooks 1, 2 and 3.*

Table 8 illustrates the number of RST and NRST in the ECM textbooks 1, 2 and 3.

Table 8: Number of RST and NRST in the ECM textbooks 1, 2 and 3.

Textbooks	**ECM 1**		**ECM 2**		**ECM 3**	
Tasks	**N**	**%**	**N**	**%**	**N**	**%**
Routine statistical tasks (RST)	60	87			32	71
Non-routine statistical tasks (NRST)	9	13			13	29
Total	**69**	100			45	100

From Table 8, ECM textbook 1 had 69 statistical tasks. The analysis revealed that 60 (87%) were rST and 9 (13%) were NRST. Rater consistency, coded from the ECM textbook 1, showed a concordance rate of 1.00, indicating perfect concordance within the required concordance range. Further analysis indicated that the interpretation was gleaned from the data of the two raters.

ECM textbook 2 had no statistical tasks.

ECM textbook 3 contained a total of 45 statistical tasks. Analysis revealed that there were 32(71%) and 13 (29%) statistical tasks for RST and NRST respectively. Rater consistency, coded from the ECM textbook 3, indicated a post-discussion agreement rate of 1, indicating perfect agreement within the required agreement rate. Further analysis of the concordance revealed that Cohen's kappa value of 1. This indicated a perfect agreement between the two raters. Table 9: Number of applicational statistical tasks (AST) and Non-application statistical tasks in the ECM textbooks 1, 2 and 3.

- *AST against NAST in the ECM textbooks 1, 2 and 3.*

Table 9 illustrates the number of AST and NAST in the ECM textbooks 1, 2 and 3.

Table 9: Number of AST and NAST in the ECM textbooks 1, 2 and 3.

Textbooks	**ECM 1**		**ECM 2**		**ECM 3**	
Tasks	**N**	**%**	**N**	**%**	**N**	**%**
Applicational statistical tasks (AST)	11	16			33	73
Non-applicational statistical tasks (NAST)	58	84			12	27
Total	**69**	100			45	100

From Table 9, ECM textbook 1 had 69 statistical tasks. The analysis revealed that 11 (16%) were AST and 58 (84%) were NAST. Rater consistency, coded from the ECM textbook 1, showed a concordance rate of 1.00, indicating perfect concordance within the required concordance range. Further analysis indicated that the interpretation was gleaned from the data of the two raters.

ECM textbook 2 had no statistical tasks

ECM textbook 3 contained a total of 45 statistical tasks. Analysis revealed that there were 33 (73%) and 12 (27%) statistical tasks for AST and NAST respectively. Rater consistency, coded from the ECM textbook 3, indicated a post-discussion agreement rate of 1, indicating perfect agreement within the required agreement rate. Further analysis of the concordance revealed that Cohen's kappa value of 1. This indicated a perfect agreement between the two raters.

- *Differences between statistical tasks across the ACM and ECM textbooks 1, 2 and 3*

Further analysis indicated that there were differences of statistical tasks across the ACM and ECM textbooks 1, 2 and 3.Table 10 shows the number of RST, NRST, AST and NAST between the ACM and ECM textbooks 1, 2 and 3.

Table 10: Number of RST, NRST, AST and NAST in the ACM and ECM textbooks 1, 2 and 3

Types of statistical tasks	**RST**	**NRST**	**AST**	**NAST**
ACM 1	161	12	52	121
ECM 1	60	9	11	58
ACM 2	146	17	68	95
ECM 2	-	-	-	-
ACM 3	-	-	-	-
ECM 3	32	13	33	12

From Table 10, the ACM and the ECM textbooks both showed that there were more RST and NAST. From Table 9, it was observed that textbook 1 was very loaded with much more tasks than textbooks 2 and 3. All the ACM and ECM textbooks 1, 2 & 3 indicate that there was much more RST than NRST, AST and NAST. The analysis of the results indicated that the categories of RST in the ACM textbook 1 were far higher than that of the ECM textbook 1. The study observed that ACM textbook 1 had more RST, NRST AST and NAST, than ECM textbook 1.In addition to that they stated that there were more RSTs in both textbooks than all other task types. The observed frequencies in the task types of RST and NAST in the ACM textbook 2 were far higher than that of the NRST and AST in both textbooks as well. The analysis of the results indicated that ACM textbook 1 had much more task types than all other tasks (RST, NRST, AST and NAST) than ACM 2, ECM 1 and ECM textbook 3. The study observed that there were no tasks in ACM 3 and ECM 2. However, both textbooks labelled the statistics as "Statistics II". Tasks in the ECM textbook 3 were far higher than the categories of steps in mathematical tasks in the ECM textbook 3.

V. DISCUSSIONS

NRST and AST are of high-quality statistical tasks which shows that asking the right questions requires more than substitution into formulas; signifying authentic, intricate, interesting and powerful solutions employing multi-step procedures, appealing to the interest of a large number of students and offering multiple means of solutions (Kumar, Kumar, & Kumar, (Eds.) (2023). The domain of statistics is so ordered that it is propitious for unsupervised learning since it is easy to check an answer by using different methods hence finding solutions to statistical tasks is for the zealous which brings about an intrinsic reward (Coleman, Boit, Butterworth, La Paro, Ricks, Hestenes, & Aal-Anubia, 2023). This may be

especially relevant to the statisticians as experts as this is why parallels between types of statistical tasks were identified.

VI. CONCLUSION

The usefulness of the nature of statistical tasks and the types of statistical tasks in ACM and ECM textbooks, especially those suggested in the literature, determines why some teachers seem to have an impact on task selection in textbooks (Amoah, 2018; Coleman, et al, 2023; Yidana, & Arthur, 2023). Arthur, & Partey, (2023), explains that when students have time with mathematics textbooks, it is important to guide them to understand the type of statistical tasks they are dealing with and the type of thinking going on in their heads (Atta, & Bonyah, 2023). Statistical task types indicate the type of concept being introduced and analyzed according to the statistical task types in the two textbook series. Furthermore, the textbook examples presented should be sufficient and useful to develop students' problem-solving abilities, followed by students' ability to solve other types of statistical tasks (Owusu, Bonyah, & Arthur, 2023). The researchers recommend that the statistical tasks take the nature of the occasional statistical tasks and apply them in all Ghanaian textbooks. This was indicative of the fact that more than 70% of the SHS textbooks displayed the profile dimension of knowledge from the SHS syllabus. The results of the study is consistent with the expectations of the syllabus in terms of the profile dimension which outlines two main components (Knowledge and understanding (30%) and Application of knowledge (70%)) (Amoah, 2018; Tekpor, 2019).

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APPENDIX A

ACM TEXTBOOK 1

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Sets and operations on sets	64	175	60
2	Real Number System	82	419	30
3	Algebraic expression	113	437	22
4	Surds	59	40	17
5	Number Bases	60	338	46
6	Relations & Functions	90	173	35
7	Plane Geometry	72	242	42
8	Formulas, Linear Equations and inequalities	113	512	125
9	Bearings & Vectors in a Plane	138	88	46
10	Statistics 1	67	89	17
11	Rigid Motion 1	27	30	9
12	Ratio & Rates	97	133	44
13	Percentages	75	187	49
	TOTAL	**1057**	**2863**	**545**

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APPENDIX B

ACM TEXTBOOK 2

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Modular Arithmetic	92	74	32
2	Indices & Logarithms	215	226	55
3	Simultaneous Linear Equations in two Variables	27	70	41
4	Percentages II	61	77	32
5	Variation	45	61	33
6	Statistics 2	53	79	31
7	Probability	90	68	30
8	Quadratic Functions & Equations	88	136	30
9	Mensuration	74	157	70
10	Plane Geometry 2 (circle theorems)	27	56	6
11	Trigonometry 1	60	198	27
12	Sequences & Series	47	99	29
13	Rigid motion and enlargement	91	35	27
	TOTAL	**970**	**1336**	**443**

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APPENDIX C

ACM TEXTBOOK 3

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Construction	36	66	35
2	Mensuration 11	199	210	58
3	Logical reasoning	15	47	14
4	Trigonometry II	32		6
5	General review exercises			113
6	Multiple choice questions			
	Answers to review exercises			
	TOTAL	**282**	**323**	**226**

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APPENDIX D

ECM TEXTBOOK 1

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Sets	14	59	
2	Real Number System	52	83	
3	Algebraic Expressions	89	175	
4	Number bases	38	64	
	Review Exercises 1			10
5	Plane Geometry	28	80	
6	Linear Equations/ Inequalities	38	83	
7	Linear Equations/ Inequalities	42	106	
8	Vectors in a Plane	17	79	
9	Simultaneous Linear Equations and Two Variables	9	43	
	Review Exercise 2			10
10	Rigid Motion	19	94	
11	Statistics	23	45	
12	Ratio & Rates	29	39	
13	Percentages	16	76	
	Review Questions 3			9
	TOTAL	**414**	**1026**	**29**

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APPENDIX E

ECM TEXTBOOK 2

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Modulo Arithmetic	23	53	
2	Indices and Logarithms	69	129	
3	Surds	27	60	
4	Percentages 2	11	14	
5	Variations	14	41	
	Review Exercise			15
6	Quadratic functions / Equation	17	50	
7	Plane Geometry 2	22	51	
8	Mensuration	30	30	
9	Trigonometry 1	29	55	
				15
10	Probability			
	TOTAL	**242**	**483**	**30**

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APPENDIX F

ECM TEXTBOOK 3

UNIT	TOPIC	WORKED EXAMPLES	EXERCISES	REVIEW EXERCISES
1	Sequences & Series	25	51	
2	Bearings	28	56	
3	Constructions	8	60	
4	Statistics 2	16	29	
5	Interpretation of Linear and Quadratic Graphs	7	37	
	Review Exercise 1			15
6	Mensuration	22	56	
7	Logical Reasoning	19	41	
8	Percentages 3	10	19	
9	Rigid Motion & Enlargement	12	49	
10	Trigonometry	4	8	
	Review Exercise 2			15
	TOTAL	**151**	**406**	**30**