

Analysis Of Application And Non-Application Tasks In Two Ghanaian Senior High School Mathematics Textbooks: A Comparative Study

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Abstract

The purpose of this study was to examine and compare the effectiveness of application and non-application mathematical tasks in two Ghanaian mathematics textbooks. A qualitative comparative content analysis model was employed. In this model, eight core Mathematics teachers from two Ghanaian senior high schools in two different municipalities in Ghana were interviewed after which the application and non-application mathematics tasks were simultaneously analysed from the two Ghanaian textbooks. The instruments used for the study were interview guide, content analysis guide and content analysis codebooks. Additionally, inter-rater reliability was determined for percentage agreement to determine the level of agreement between the two raters. It is recommended that textbook authors should incorporate more application tasks in the Ghanaian SHS mathematics textbooks.

Keywords: *Application tasks, non-application tasks, mathematics tasks, mathematics textbooks, raters, content analysis, comparative, codebook.*

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I. Introduction

Background To The Study

Several scientific studies have shown that many students worldwide have great difficulty solving mathematical tasks. (Aforklenu, 2013; Amoah, 2018; Saul, & Vaderlind, 2022; Toh, 2022; Baah-Duodo, Borbye, Someah-Addae, Ennin and Osei-Buabeng, 2022; Aforklenu and Bukari, 2023). These difficulties students have in solving mathematical tasks have been cited by several studies and attributed to a number of factors such as students' inability to understand the language of text which comprises of students' poor problem-solving abilities, teachers' incapacity to use problem-solving as a teaching strategy, and students' incapacity to recognize the various types of mathematical problems (Abdullah, Shin, Kohar, Ali, Samah & Ashari, 2019; Aforklenu & Bukari, 2023).

Furthermore, several scientific studies have indicated that students' failure may stem from teachers' incapacity to successfully instruct students or from their failure to emphasize the necessity for students to have the essential abilities and grasp of the mathematics language. The inappropriate curriculum, the use of inappropriate textbooks, the ineffectiveness of the classroom setting, and the inability to distinguish between application and non-application tasks in the Ghanaian mathematics textbooks were some other possible reasons why students failed (Adu, et al, 2017; Amoah, 2018; Wijers, & de Haan, 2020; Boadu, 2022; Amoah, & Adu-Darko, 2023; Amponsah, 2023). In order to examine the ratios of ATs and NATs in two Ghanaian SHS mathematics textbooks, this study was required.

Additionally, Mereku (2023), who recognizes the difficulties Ghanaian students encounter and promotes the value of completing mathematical tasks in order to lessen these difficulties, claims that Ghana has not fully utilized mathematical tasks found in mathematics textbooks (Essuman & Osei-Poku, 2015; Khanal, 2022). The Education Reform Review Committee recommended that a problem-solving curriculum be incorporated into Ghana's pre-university education (Aforklenu, 2013; Amoah, & Adu-Darko, 2023). According to Aforklenu & Bukari (2023), Ghana's pre-university curriculum currently needs to incorporate a problem-solving mathematics curriculum that requires students to tackle real-world mathematics tasks. Using appropriate mathematical problem-solving strategies in the classroom is one of the key goals of teaching mathematics in Ghana's pre-university institutions in order to assist students in acquiring mathematical problem-solving skills (Baah-Duodo et al., 2019).

Statement Of The Problem

The importance of textbooks in the teaching of mathematics has come to the attention of the international mathematics education community over the last forty years (Guzman Gurat, 2018; Shepherd, 2023). TIMSS, the Third International Mathematics and Science Study, examined curriculum materials and hundreds of textbooks from around fifty (50) different countries. Researchers' interest in textbooks is growing, as evidenced by this large-scale comprehensive study that focused on textbooks as a major research field (Afolabi and Adebawale, 2013; Amoah, 2018). But unlike other areas of mathematics education research, there have been some concerns raised indicating that the amount of research on textbooks is still insufficient; consequently, some scholars have called for more studies on textbooks (Hadar & Tirosh, 2019; Pan, & Zhu, 2022).

Mathematics is a required subject in Ghana's integrated high school curriculum, and emphasis is placed on mathematical tasks. As a result, educators have been encouraged to prioritize the use of mathematical tasks when preparing and delivering lessons (Taley & Adusei, 2020, Kazu & Kuvvetli, 2023). According to Aisyah, Lestari, and Yudhanegara (2023), solving mathematical tasks is important because it can help students become more adept at logical reasoning. Therefore, even if intelligence is the capability to solve issues in daily life, mathematics education will be insufficient if it does not contribute in the development of intelligence and reasoning ability, according to Widiyastuti, Ramadan, Sugihandardji, Gunawan, & Kusuma (2023).

Scholarly studies have further emphasized that Mathematics achievements in Ghana have not been satisfactory (Adu, Mereku, Assuah, & Okpoti, 2017; Babah, Ayamah, Asase, & Odei, 2023; Banson, Bonyah, Boateng, & Owusu, 2023; Mereku, 2023). Results from examinations in Mathematics at all levels of the Ghanaian educational system show that most students fail in the subject (Mills & Mereku, 2016; Tella, 2017; Essuman, Nyarko, & Frimpong, 2021; Awoniyi, & Amponsah, 2023). Additionally, a review of the Chief Examiners' Reports on the Senior High School Certificate Examinations (SSSCE) of the West Africa Examinations Council (WAEC) reveals that student's performance in the mathematics papers has been extremely poor (WAEC, 2008, 2011, 2017; Zalmon & Wonu, 2017; Abreh, Owusu, & Amedahe, 2018; Tetteh, & Agyei, 2022; Kissi, Baidoo-Anu, Anane, & Annan-Brew, 2023). The report made reference to the students' deficiencies, which indicated statements such as "Candidates showed poor skills in computations and seemed to have a knack for solving easy problems in a rather difficult way" (Appiah, 2016; Amoah, 2018; Adu et al., 2017). Moreover, observations revealed that over the past eight years, the average SHS student who sat for the West Africa Senior Secondary Certificate Examinations (WASSCE) did not perform well (Esuong, Owan, Edoho, & Eni, 2023; Gbeleyi, Okebukola, Awaah, Umar, Sanni, Moses, & Adebisi, 2023).

Further observations indicated that students are not able to identify application tasks (AT) and non-application tasks (NAT) in the textbooks they use much more to talk of solving these mathematical tasks (Amoah & Adu-Darko, 2023). Hence, this study was an attempt to determine the AT and NAT that are covered in the Core Mathematics textbooks for Senior High Schools (GACM) and the Enriched Mathematics for Senior High Schools (GECM) textbooks.

Research Objectives

The research objectives were to find out;

1. The proportion of mathematical tasks presented in the GACM textbook(s) that are application and non-application tasks?
2. The proportion of mathematical tasks presented in the GECM textbook(s) that are application and non-application tasks?
3. The differences between the proportions of application and non-application tasks in the GACM textbooks and the GECM textbook(s)

II. Literature Review

The Impact of mathematical tasks

The impact of mathematical tasks on both the content and the pedagogical approach employed in mathematics textbooks has been a widely investigated research domain in recent decades. The nature of the mathematical tasks that students engage in when learning mathematics has emerged as a critical determinant of the extent to which students grasp the concepts and principles conveyed in mathematics textbooks (Lin, & Powell, 2022). It is important to note that mathematical tasks “influences students by directing their attention to particular aspects of content and by specifying ways of processing the information they receive”.

According to Majeed, Hassan, & Hammadi, (2023), the kind of mathematical tasks students solve affect not just the concepts they learn but also how they improve their understanding of, use, and conceptualization of mathematics. When students engage on a series of problem-like tasks in mathematics classes, they develop mathematical thinking rather than simply following the teacher's step-by-step directions.

These tasks are considered to be “conceptually focused” “making “purposeful use of models, representations, or other tools” (Heili, 2023).

Mathematical tasks give students the chance to practice and solve tasks. The resulting learning process is significantly more exciting, compelling, and effective, which results in the lasting assimilation of the material for use in both subsequent mathematics study and a wider range of applications. Cognitively demanding tasks are those that call for students to solve complex tasks. As a result, the nature and function of mathematical tasks involving various forms of cognitive effort are crucial to students’ chances for learning (Greeno, 2021; Van der Bogaart-Agterberg, et al, 2022).

The ability to use activities even when the path to a solution is first unclear allows students to work mathematically. Mathematical tasks also encourage exploration because they are accessible to students with a wide range of abilities. The likelihood that a student will continue studying mathematics increases when they get the chance to work on a variety of mathematical tasks (Greeno, 2022).

The cognitive demands of mathematical tasks indicated that the levels and types of mathematical tasks were primarily at the level of procedures with connections, producing the goal of school mathematics textbooks (Miller, 2020; Toh, 2022; Van der Bogaart-Agterberg, et al, 2022). The mathematical tasks in the textbooks, in my opinion, help students develop conceptual thinking skills, spur connections, and help them concentrate on a single mathematical concept while also giving them a greater understanding of the nature of mathematical concepts, procedures, and relationships. In order to determine the types of mathematical tasks in the mathematics textbooks and provide context, it was helpful to examine the tasks therein.

Studies conducted on Application and Non-application mathematical tasks

Yang, Tseng, & Wang, (2017), in a study analysed geometry problems in four middle-grade mathematics textbook series from Taiwan, Singapore, Finland, and the United States, while exploring the expectations for students’ learning experiences with these problems. An analytical framework developed for mathematics textbook problem analysis had three dimensions: representation forms, contextual features, and response types. Implications of this study’s findings for textbook developers and future research directions are discussed. The results showed that Taiwanese and Singaporean textbooks contained more problems in combined form, whereas Finnish and the American textbooks contained more problems in verbal and visual forms. The problem distribution across various representation forms was more balanced in the Finnish and Singaporean textbooks than in the Taiwanese and American textbooks. Most problems were non-application and close-ended problems compared to other application and open-ended problems. The Taiwanese textbooks contained the lowest proportion of real-world problems, whereas the American textbooks contained the highest proportion of open-ended problems.

Zhu & Fan (2006), in a study compared how selected mathematics textbooks from Mainland China and the United States at the lower secondary grade level represent various types of problems for classroom teaching and learning. The examination of problems was carried out based on the classifications of problem types established in the study, including routine problems versus non-routine problems, open-ended problems versus close-ended problems, traditional problems versus non-traditional problems, and application problems versus non-application problems, among others. Both the similarities and differences in the representation of problems in the selected textbooks were analyzed. The results were used to explore the possible influences of those textbooks on students’ different performances in mathematics, as revealed in cross-national comparisons. Discussions about how to improve the representation of problems in mathematics textbooks were provided at the end of the study.

Mailizar & Fan, (2014), examined how the new mathematics textbooks reflect one of the features of the new curriculum, that is, authentic learning. The study focuses on to what extent authentic tasks are presented in the textbooks. For this purpose, we established a framework for analysing the mathematics tasks presented in the textbooks. The year 7 mathematics textbook was selected and the analysis was carried out through two layers. First, all the mathematics tasks were classified into two categories: authentic tasks and non-authentic tasks. Second, the authentic tasks were further categorized into two different levels of authenticity, which are real authentic and semi-authentic. Furthermore, the analysis also compares the authenticity of mathematics tasks between topics of mathematics. The results show that only about 22 percent of the tasks were authentic tasks which comprise 19 percent semi-authentic tasks and 3 percent authentic tasks. The findings of the study suggest that there is room for improvement of the textbook.

Lestiana, Maula, & Winarso, (2023), in a study, compared Pythagorean problems in Indonesian and Singaporean mathematics textbooks based on the cognitive level of Bloom's taxonomy, representation form, contextual feature, and response type. The data were collected through documentation and observation. The research results indicated that on the cognitive level, the C3-C4 level dominated the Pythagorean problems in Indonesian and Singaporean textbooks. Regarding representation form, Pythagorean problems in Indonesian textbooks used visual and combined forms, while Singaporean textbooks applied mostly combined forms. In

contextual feature and response type, Pythagorean problems in Indonesian and Singaporean textbooks used non-application and closed-ended problems. Therefore, the result of this study is expected to contribute to the improvement of high-quality mathematics textbooks, which can compete internationally to support students' learning.

Conceptual Framework

Mathematics tasks framework

The Mathematics Task Framework is a framework that provides a clear differentiation of three distinct phases that mathematical tasks undergo (Feng & Liu, 2023). These phases are tasks that appear in the first place in curricular or instructional materials on the printed pages of textbooks, followed by tasks set up or announced by the teacher; and then followed by tasks that are actually implemented by students in the classroom (Crowley, Ball, & Hiddink, 2019; Giardino, 2023). The significance of these stages was regarded as influential on the acquisition of knowledge among students, given their direct impact on the learning process in some form or another, as depicted by the triangle in Figure 3.1.

Based on Figure 1, it can be established that the first two arrows depicted in the model highlight crucial stages throughout the academic trajectory of mathematical tasks, during which the cognitive demands may experience modulations. The perceived tasks presented in curricular or instructional materials do not consistently align with the tasks assigned by educators, nor do these necessarily parallel the tasks that students execute.

Nevertheless, tasks designed to impose substantial cognitive demands on students' cognitive processing underwent a substantial transformation regarding students' approaches to their execution. Upon acknowledgement of this fact, it provides a practical foundation for the development of students' cognitive processes in mathematics. The researcher of this present study is of the view that it becomes incumbent upon educators to devise tasks that demand students to engage in such cognitive processes.

Two distinct modes of conceptualizing tasks were established, namely the notion of cognitive demand. The researcher posits that diverse tasks necessitate dissimilar levels of cognitive demand or mental processing. Each of these disparate mathematical tasks ostensibly offer diverse prospects for acquiring knowledge, thereby furnishing students with distinct learning experiences. Yang, Cheng, Wang, & Chen, (2023), categorized cognitive task demands into four distinct categories.

Abdullah, Rahman, & Hamzah, (2017), in a study examined Metacognitive skill of Malaysian students in non-routine mathematical problem solving. The study indicated that Metacognitive skills play an important role in solving mathematical problems. However, there is a lack of empirical studies on the role of metacognitive skills in solving mathematical problems, particularly non-routine ones. Results showed that the level of the students' performance in solving non-routine mathematical problems was very low. There was also a significant difference in the metacognitive skills among students with different performance levels in solving non-routine mathematical problems, and we concluded that these metacognitive skills should be emphasised in this process.

Barbosa, Vale, Jablonski, & Ludwig, (2022), in a study on non-routine problem posing and prospective middle school mathematics teachers: an emotional perspective indicated that Problem posing is an indispensable constituent of mathematical thinking, which makes it a requisite ability for students of all grades.

In the context, this study intends to examine prospective middle-school mathematics teachers' performances and emotions in non-routine problem posing, as well as to investigate whether there is any relationship between these two variables. According to the results, the participants were moderately successful in designing non-routine problems. As for emotions, although the participants mostly acknowledged the merit of posing non-application tasks, they found it very demanding as well. Besides, the interplay between performance and emotions in non-routine problem posing was low. The results indicate that prospective teachers have the potential to generate non-routine problems, and are predominantly positive toward this skill.

Categorization of mathematical tasks

In the realm of mathematical education, the categorization of mathematical tasks has been of great interest among researchers and educators. Specifically, the application and non-application mathematical tasks garnered significant attention as a means of understanding the complexity and nature of the tasks presented to students (Barbosa, et al., 2022). For the purposes of simplicity and clarity, this study adopted the term "categorization" to refer to the analysis of two main distinctive types of tasks namely AT and NAT. Table 1 shows the definition of tasks and their codes.

Table 1: Definitions of tasks and their codes

Tasks	Definition of tasks
Application tasks (AT)	This study's application tasks included both hypothetical application tasks (FAT) and real-world application issues (AAT). This task has conditions and data that were made up by the textbook author(s), taken from actual events, or acquired by the students themselves from their daily lives.
Non-application tasks (NAT)	Non-application tasks were tasks that have no practical use in the real world or in daily life.

This study's conceptual framework, which was based on Fan and Zhu's classification, served as an analytical tool to gain a full understanding of the phenomenon under investigation (2006). It was decided that the conceptual framework should be used since it made it possible to identify conceptual variables that were relevant to this investigation. The framework moreover functioned as a visual aid in elucidating the interconnections among these variables that demanded examination and utilization in the current study. With reference to the previously described definition, AT and NAT will be categorized and measured in relation to the GACM and GECM.

III. Methodology

Sharma, (2022), posits that qualitative research employs a phenomenological approach, wherein data analysis centers around one particular phenomenon that the researcher specifically chooses to gain a comprehensive understanding of, irrespective of the number of study sites, participants, or documents involved (Petrov, 2023; Nnindini & Dankwah, 2023). This analysis employed the Qualitative approach, which utilized diverse methodologies including interviews, to yield an extensive array of minutiae concerning the mathematical tasks included in the GACM and GECM mathematics textbooks

Using a qualitative approach, this study sought to improve the quality of the data collected in order to distinguish between application and non-application mathematics activities included in the GACM and GECM SHS textbooks. The phrase "qualitative research" is broad and includes a variety of research designs or approaches, including case studies, ethnographic studies, and phenomenological studies, among others (Zhao, & Detlor, 2023). According to Teti and Abbott (2023), qualitative research involves a wide variety of methodological techniques that are based on different theoretical frameworks and make use of non-quantitative techniques for gathering and analyzing data. The phenomenological approach was chosen from among the different approaches to examine how the two mathematics textbooks use application and non-application mathematical tasks. Gaining a thorough knowledge of the mathematical material from the standpoint of the many kinds of mathematical tasks was the aim of this phenomenological investigation. The phenomenological methodology was applied in this investigation, which employed content analysis techniques and interviews to fully explain the meanings linked with the experiences of humans. The researcher has to gather qualitative data for this study (Ban & Lovari, 2021).

The selection of a qualitative design arises from the consideration that the study's objective is not predetermined or pre-structured by hypotheses and procedures that curtail its breadth or implementation, as in quantitative research where the analysis is predetermined and pre-structured by hypotheses prior to the researcher's arrival in the field (Teti, & Abbott, 2023). Kuckartz, & Rädiker, (2023), posits that Qualitative design is a convenient framework for carrying out extensive and thorough investigative research within specific contexts, thus offering a unique opportunity for uncovering multiple facets of analyzed content. The advantage of utilizing qualitative research resides in the ability to achieve a higher rate of recovery of accurate and reliable data when contrasted with quantitative research's comparatively lower rate of recovery (Erekson, 2020; Persson, & Millner, 2023).

The choice of a qualitative design is similar to quantitative research where the analysis is pre-determined and pre-built by hypotheses, the purpose of the study is pre-determined by assumptions or procedures that limit its breadth or implementation; It arises from the consideration that it is not something that is pre-constructed (Teti and Abbott, 2023). Kuckartz & Rädiker (2023) argue that qualitative design is a practical framework for conducting extensive and in-depth research studies in specific contexts, offering unique opportunities to uncover multiple aspects of the analyzed content. The advantage of using qualitative research is the possibility of achieving higher return rates of accurate and reliable data, in contrast to the relatively low return rates of quantitative studies (Erekson, 2020; Persson & Milner, 2023).

Furthermore, unlike inductive analytical approaches that test predetermined hypotheses, qualitative researchers apply deductive methods that aim to examine data and test prior theories in deviant scenarios, thereby Generate and reveal unexpected results. As identified by Kumatongo and Muzata (2021), the first step

for qualitative researchers involves collecting data, followed by establishing a conceptual framework before formulating general statements and conclusions.

In this study, qualitative comparative content analysis employed purposive and convenience sampling to intentionally select a diverse group of participants using random sampling techniques commonly used in quantitative research (Zickar & Keith, 2023). To achieve this goal, this study used a qualitative approach that applied an empathetic and objective analysis. The relevance of this methodology to the study encouraged the use of a qualitative approach.

Research Approach

Bogna, Raineri, and Dell (2020), posits that research approaches entail structured plans and methodologies employed in conducting research, encompassing diverse stages extending from preliminary assumptions to explicit techniques for the collection, analysis, and interpretation of data (Bouncken et al, 2021; Saba et al, 2021). The comparative content analysis approach embodies a systematic methodology for examining and evaluating the textual contents of educational textbooks. This task entails a thorough examination and juxtaposition of two academic textbooks, whereby their respective messages and contents are exhaustively evaluated, summarized, quantified, and analyzed with the objective of revealing insightful interpretations from the GACM and the GECM textbooks (Ormiston & Thompson, 2021).

Bogna, Raineri, and Dell (2020) state that a research approach includes various steps for conducting a study, from preliminary assumptions to explicit methods for data collection, analysis, and interpretation. It claims to involve structured plans and methods (Bouncken et al., 2021; Saba et al., 2021). The comparative content analysis approach embodies a systematic methodology for investigating and evaluating the textual content of textbooks. In this work, the two academic textbooks were thoroughly investigated and compared, with the aim of uncovering insightful interpretations from the GACM and GECM textbooks, and the message and content of each is comprehensively evaluated, summarized, quantified and analyzed (Ormiston & Thompson, 2021).

This study used rigorous and unbiased methods to characterize and measure the observed phenomena in order to identify the presence of AT and NAT in textbook data, particularly textual and graphic communication messages presented in GACM and GECM textbooks. Comparative content analysis was used as a method.

Research Paradigm

According to Zhang, Ye, Wang, Lin, Xiong, Hwu & Chen (2020), a paradigm involves widely recognized and adopted perspectives on a particular topic and established conventions that guide research direction and methodology which represents a comprehensive structure involving various aspects such as selecting observable and measurable phenomena such as textbooks, formulating research questions, creating research protocols and codebooks, determining the most appropriate research tools such as interview guides, and content analysis of the codebooks and interpretation of the resulting data.

IV. Epistemology And Ontology Of The Study

Epistemology also examines the methods, criteria, and standards used to evaluate knowledge claims and evaluates the strengths and weaknesses of different approaches to knowledge acquisition and verification. This study adopts a constructivist epistemological framework as its underlying philosophical orientation. Ontology is a philosophical inquiry concerned with the nature of existence and fundamental understanding of reality, presenting a precise and formal depiction of a shared conceptual framework (Azevedo, 2023). Constructivism indicates that researchers recognize social structures as subjective and that students' mathematical abilities depend on their ability to understand and solve mathematical problems and concepts presented in mathematics textbooks. The researcher adopted an ontological perspective consistent with research objectives. The researcher adopted a constructivist perspective and demonstrated a potential link between students' use of mathematics textbooks and their ability to use a variety of mathematics exercises and problem-solving methods. As shown, under certain conditions we perceive social constructs as objective. This study aimed to investigate the approaches of both secondary school teachers in using mathematics textbooks in order to identify the different categories of mathematical task methods present in the SHS mathematics curriculum in Ghana, including constructivism. Ontology further recognizes that individuals have different experiences and perspectives that shape their understanding of the world, thus emphasizing the need for context-specific analyzes of social phenomena.

Interpretivist / Constructivist perspective

The interpretivist / constructivist perspective often uses qualitative research techniques that focus on the study of subjective experience and the meanings that people attach to it. The theoretical basis for this

research is the interpretivist / constructivist paradigm, which states that the methodology chosen must be consistent with the philosophical beliefs and must be grounded in the epistemological point of view that supports the idea that knowledge is built. It has been argued that epistemology biases play an important role in the choice of data collection tools and analysis tools (Nazuri, et al, 2022; Sharofutdinov, 2023).

In the interpretive research method, the researcher recognizes and takes account of the emotional state, personal experience, and perspective of the data under investigation. Researchers prefer interpretivist paradigms over other paradigms because the interpretivist approach allows the researcher to access the unique experience and perspective of the research subjects, thus acknowledging the essential role of the researcher in recognizing the interpretation as a socially constructed reality (Jackson, 2023).

The interpretive school of thought holds that knowledge is “informed” and “built”. The researcher was accessible to all teachers involved in this study at any time, and participants were able to provide objective and subjective opinions on the research findings.

Study Population

Study population of mathematics teachers

A study population is a group of individuals selected on the basis of inclusion and exclusion criteria which relate to the variables being studied (Hunter, Montes, Murray, Sanchez-Franco, Montgomery, Jaramillo & Kimbrough, 2020). The study population in this study constituted all mathematics teachers in the Akuapem-North and Okyere municipalities.

Study population of Mathematics textbooks

The cohort for analysis consisted of Mathematics textbooks. This research elucidated the sample which comprised of five mathematics textbooks utilized by both teachers and students at the SHS level mathematics curriculum within Ghana. The textbooks recommended for SHS mathematics include Core Mathematics for SHS (Akron series) (Sixth Edition) 1, 2, and 3 authored by Hesse (2011); Enriched Mathematics Textbook for SHS 1, 2, and 3 authored by Ampomah, Ansong, and Klagah (2009); Core Mathematics for SHS 1, 2, and 3 (Millenium Edition 5) authored by Asiedu (2016); Core Mathematics for SHS 1, 2, and 3 authored by Opong (2011); and Ultimate Guide for SHS 1, 2, and 3 authored by Murray (2008). The aforementioned encompasses Mathematics textbooks of both the public and private domain. All these textbooks are currently in use by both teachers and students in Ghanaian SHS.

Sampling and Sampling Techniques

The term “sample” refers to a subset of people, objects, or items that are selected from a larger population for the purpose of conducting measurements and analyses, as stated by Bull, Gardner, Gosliga, Rogers, Dervilis, Cross, and Worden (2021). This study further purposively selected two Ghanaian SHS mathematics textbook series that are conventionally utilized by teachers and students in mathematics instruction at the SHS level. This study involved purposive sampling and analysis of GECM textbooks for SHS 1, 2, and 3, and GACM textbooks for SHS 1, 2, and 3. The study was aimed at evaluating the textbooks’ suitability for mathematics education in Ghana and their prevalence in mathematics instruction among both teachers and students. Convenience sampling was utilized in the study to draw a sample of eight (8) core mathematics teachers from two SHS who were subsequently subjected to interviews.

Description of Research Sites

This study was executed in two SHS specifically designated as SHS School 1 and SHS School 2, as indicated in Table 2.

Protection of Participants

The safety of study participants was ensured with thoughtful consideration towards the principles of obtaining informed consent, ensuring privacy, maintaining confidentiality, and preventing potential harm. In order to ensure the safety and integrity of both the researcher and the participating individuals, interviews were carried out with all involved parties by the researcher. In order to avoid potential biases or personal beliefs that could influence the results of the study, explicit disclosure of the researcher’s assumptions was made to the participants during the interview process. Additionally, measures were taken to minimize potential disruptions or distractions during the data collection phase, such as confirming reliable phone connections, organizing appropriate recording equipment, and ensuring participants had fully prepared prior to beginning the interviews. With regard to confidentiality, measures were taken to safeguard the recorded interview data and transcribed information, such as limiting access to my personal computer and securing the data on tapes in a locked location to prevent unauthorized access.

Content analysis and its types

The research methodology of content analysis can be employed in either an inductive or deductive approach (Neuendorf, 2016; Haywood, 2023). The present literature identifies various types of content analysis, which are commonly employed in research such as Inductive and Deductive content analysis. This study employed the Deductive approach within the framework of content analysis. Deductive Content Analysis can be classified as a systematic, structured, and theory-driven research method that aims to identify and analyse patterns and themes in information through a deductive reasoning approach (Amoako, 2023).

According to Duong, et al, (2023), the deductive approach in content analysis serves as a valuable tool in circumstances where the primary objective was to examine a pre-existing theory in a new context or to establish comparisons between categories that exist in a distinct setting. The deductive content analysis approach is an analytical methodology directed towards examining pre-existing categories, concepts, models, theories, or hypotheses, referred to as the theoretical structure in this chapter, in a new context with the incorporation of new data. The research assistant helped in the processes involved in the content analysis. The content analysis process can be delineated into three distinct phases. The aforementioned stages encompass the Preparation phase, Organizing phase, and Reporting phase. as can be seen in Figure 2.

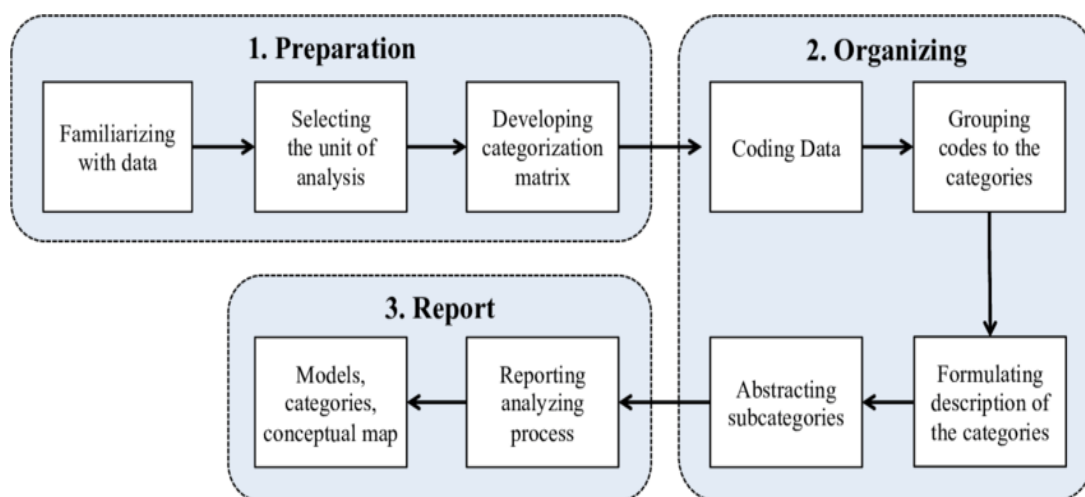


Figure 2: Main phases of the content analysis process

This study focused on the analysis of only the manifest content of the GACM and GECM textbooks. The preparatory phase included developing resources such as content analysis guides, codebooks, and interview guides, Matrix classifications were also developed to identify individual types of mathematical tasks. The codebooks for content analysis were specifically designed to encompass codes representative of AT and NAT. The conceptual framework was assessed on AT against NAT, with all topics in the two textbooks selected as units of analysis.

Husu (2022), described a complete interview that is broad enough to be considered as an integrated entity, yet compact enough to be kept in mind as a contextual framework during the analysis process. This is the selection of the unit of analysis. The preparatory phase also included development work on various resources, including a content analysis guide, a content analysis codebook, Matrix classifications have also been developed to identify individual categories of mathematical tasks performed (refer to Appendix H). The conceptual framework under consideration assessed “AT against NAT”. Although two SHS core mathematics textbooks namely the GACM and the GECM textbooks were sampled, all the topics in the textbooks were selected as units of analysis of these two textbooks.

Organizing Phase of Content Analysis

The researcher developed a content analysis process, focusing on AT and NAT in the two textbooks. The tasks were categorized based on these similarities. The tasks were categorized and grouped into types of tasks. The coding of the tasks was subjected to a content analysis codebook, which recoded the results and determined their frequencies. The outcomes of different AT and NAT were used to verify codes and compare the outcomes of initial and subsequent coding. Descriptive statistics were computed to determine the varieties of AT and NAT presented in GACM and GECM textbooks.

Basic Principle of Counting

This study used the fundamental counting principle to analyze application and non-application tasks in two Ghanaian SHS mathematics textbooks. The counting units were defined by precise measures of task frequency and numerical values. The aim was to assign numerical values to every task found in the textbooks in terms of “AT” and “NAT”. The study used to count in identification of the codes “AT and NAT”, which were used to establish the significance of the research and document the content of the textbook tasks. The interpretivist researchers combined qualitative analysis with counting to ensure the reliability of the research results.

Reporting Phase of the Analysis

From figure 2, the third phase of the analysis process was the Reporting phase. To increase the reliability of the study, the researcher demonstrated the link between the results and the data by finding the mean value and the inter-rater reliability using percent agreement between the two coders or raters. Appendices, Tables and graphs were used to demonstrate links between the data and results. Descriptive statistics such as percentages, frequencies, tables and graphs were used to find out the differences between the “AT and NAT” in the GACM and GECM textbooks (See Appendix L and M).

Triangulation

By employing diverse sampling techniques and data collection methods, the veracity of the research was safeguarded. Data triangulation pertains to the practice of utilizing diverse data sources to yield a more comprehensive and nuanced understanding of the subject of inquiry (Wheeler, 2021). Triangulation aided the researcher to guard against the accusation that the study’s findings were simply an artefact of a single method, a single source or a single investigator’s bias by examining information collected through different methods, corroborated the findings across data sets and thus reduced the impact of potential biases that existed in a single study. As a means of triangulation, a combination of different qualitative research methods such as Content analysis of GACM and GECM textbooks as well as interviews were conducted. The interviews were conducted for teachers who were the users of the textbooks. The combination of methodologies in the study of this phenomenon helped the qualitative researcher to draw upon two sources of evidence to seek for convergence and corroboration through the use of different data sources and methods.

Research Instruments

Considering the nature of research questions, the instruments used for the collection of data were, an interview guide (see Appendix B), Content analysis guide (see Appendix A), Content analysis codebook for GACM textbooks (see Appendix H, H1, H2, H3), Content analysis codebook for GECM textbooks (see Appendix J, J1, J2, J3), general content analysis codebook (see Appendix H, J), Results of the AT and NAT, Percentage agreement and mean values of the GACM textbooks 1, 2 and 3 (See Appendix L, L1, L2 and L3); Results of “AT and NAT” in terms of Percentage agreements and mean values of the GECM textbooks 1, 2 and 3 (See Appendix M, M1, M2, and M3); Coding protocol for “AT and NAT” (see Table 1). Letters for permission to conduct research in the Akuapem-North and Okere municipalities (see Appendix P, and Q); Letters for permission to conduct research in SHS schools 1 and 2 (see Appendix R, and S) and Consent and Assent letters to participants (see Appendix T).

Interview guide for teachers and its development (see Appendix B)

An interview guide is a document that enables researchers to structure the way they conduct interviews (Dzogovic & Bajrami, 2023). The interview guide had two main sections: Section A and B. Section A contained the information on the interviewees whilst section B was on questions on the Ghanaian SHS mathematics textbook usage by the mathematics teachers.

The first question was on the Ghanaian SHS mathematics textbooks that the mathematics teachers used in teaching mathematics. The second question was on why the mathematics teachers used certain specific mathematics textbooks. The third question was on what mathematical tasks were? The fourth question was on how important application and non-application mathematical tasks in mathematics textbooks were. The fifth question was on how important non-application mathematical tasks in mathematics textbooks were. The sixth question was to find out from the mathematics teachers which of the mathematics textbooks was rich in application mathematical tasks. The seventh question was on which of the mathematics textbooks was rich in non-application mathematical tasks? The eighth question was on the proportion of application tasks found in the textbooks the teachers used. The ninth question was on the proportion of non-application tasks found in the textbooks the teachers used. The tenth question was to find out whether there were any differences between the application and non-application task types in the two Ghanaian SHS mathematics textbooks. The interview

sessions were scheduled between the researcher and each of the eight mathematics teachers indicating their convenient place, date and time for the interviews to be conducted.

Development and use the content analysis guide (see Appendix A)

O'Connor & Joffe, (2020), explained that a content analysis guide is a research tool used to determine the presence of certain words, themes, or concepts in some data. Using content analysis guide, the researcher quantified and analyzed the presence, meaning, and relationships of certain words, themes, or concepts. A content analysis guide is a research tool used to determine the presence of certain words, themes, or concepts in certain qualitative data. The content analysis guide includes two main questions based on the research topic. Content analysis guidelines were then used by the researcher to quantify and analyze the presence of meaning of concepts in the textbook.

- Does the SHS mathematics textbook contain application and non-application mathematical tasks?
- Are there differences in the application and non-application mathematical tasks in the SHS mathematics textbooks?

Development and use of content analysis codebooks (see Appendix E, E1, E2, E3)

A content analysis codebook is a research tool used to identify specific words, themes, or concepts in qualitative data. The researcher created a general content analysis codebook and a mean content analysis codebook to collect data from GACM and GECM mathematics textbooks. The sections of the general content analysis codebook included the textbook, chapter of the textbook, worked examples, exercises, review exercises and the total number of tasks and total tasks (see Appendix E). The mean content analysis codebook (see Appendix E) was used to collect data on the application (AT) and non-application tasks (NAT) from the GACM and GECM mathematics textbooks after which the mean of the data from the two raters. Both textbooks were analyzed, coded, and counted for reliability. Data was analyzed, coded and counted using the AT and NAT and their codes and their frequencies recorded in the content analysis codebook. The mean content analysis codebook (see Appendix E) was developed and used in finding the mean of the first and second coded results of the content analysis to ensure that the results from the two raters was reliable.

Data Collection Procedure

All the responses from the interviews of the mathematics teachers were recorded, transcribed, analyzed and reported accordingly.

On the AT and NAT, data was collected by analyzing, coding and counting. The recoding and re-counting were done using the Content analysis guide (see Appendix A), Content analysis codebook (see Appendix H (H1, H2, H3) & (see Appendix J (J1, J2, J3)) and the task analysis guide (see Appendix G) and task analysis codebook (see Appendix K). The Content analysis guide and Content analysis codebook were used in collecting data from the GACM and GECM textbooks.

On the differences, data from research question 3 was analyzed using descriptive statistics. The study examined, analyzed, coded and counted all the AT and NAT in the GACM and GECM textbooks.

Qualitative data analysis of the Interviews

The responses from the interviews were transcribed and analyzed thematically using central themes. These were patterns that run across the data that are important to the study and were closely associated with a specific research question (Larsen, 2023). The three central themes were “proportions of application tasks”, “proportions of non-application tasks” and “differences in application and non-application tasks”. The data collected from the interviews were analyzed manually. Thus the interviews were transcribed verbatim or exactly as the questions were asked and answered. For example, the data corpus included Interviews, and content analysis. After familiarising with the data, the emerging ideas about what was important in answering the research questions were coded manually, using both highlights and abbreviations.

The code (T5Q5) means the response of teacher 5 to question 5. For instance, after coding, some of the themes which emerged were on proportions of “AT” and “NAT”.

Data Analysis

Phenomenological data analysis

This study utilized phenomenological data analysis, a method that examined personal experiences and thoughts (Dodgson, 2023). The researcher employed descriptive phenomenology, which focuses on understanding meanings without assumptions or interpretations, and interpretive phenomenology, also known as existential or psychological phenomenology, which acknowledges the researcher's perspective and background. The data analysis process involved reading, reflecting, and writing, identifying significant statements and analyzing them in relation to the context, purpose, and literature of the study.

Data Analysis of AT and NAT

The data analysis of the GACM and GECM textbooks was carried out in terms of AT and NAT (see Appendix L, L1, L2, L3, L4, L5, L6). The mean of the coded first content analysis data and the coded second content analysis data on the AT and NAT were found by adding the two results and dividing them by two (see Appendix L1, L2, L3, L4, L5, L6). The results were further analyzed using descriptive statistics such as frequencies, percentages, tables, charts and graphs.

Reliability and Validity of Instruments

The concept of reliability pertains to the degree to which the outcomes of research can be reproduced (Amoah, & Adu-Darko, 2023; Bell, Chalmers, & Flora, 2023). According to Amoah (2018) and Amoah & Adu-Darko (2023), reliability is defined as the degree to which data sets remain consistent over time and accurately reflect the total population being studied. In order to address concerns regarding reliability, a triangulation methodology was utilized.

Inter-rater reliability

Inter-rater reliability is a measure of consistency used to evaluate the extent to which different raters agree in their assessment decisions or measures the agreement between subjective ratings by two or more raters (Taşdemir, 2022; Eser, & Aksu, 2022; Amoah, & Adu-Darko, 2023). High inter-rater reliability indicated that the two coders' ratings for the same mathematics textbooks were consistent. In using the inter-rater reliability, the level of agreement between the two coders' measure were found. Results from coders with a high inter-rater reliability score were rated.

Percentage agreement in interrater reliability

One statistical test used to assess inter-rater reliability is percent agreement (Nuriannah & Siwi, 2017; Taşdemir, 2022, Amoah, & Adu-Darko, 2023). The researcher used the percent agreement formula to "calculate the number of times raters agreed on a rating, then divided it by the total number of ratings" in order to determine the percent agreement in this study.

$$\text{Percent Agreement} = ((\text{agreement} / (\text{agreement} + \text{disagreement})) \times 100\%)$$

For every variety of AT and NAT, percentage agreements were computed. Therefore, based on the percentage agreements, the following inter-rater values were employed in this investigation. Table 2 provides an interpretation of the inter-rater agreement, which was measured between -1 and 1. The inter-rater agreement and its interpretations are displayed in Table 2.

Table 2: Description of Percentage of inter-rater 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: Nuriannah & Siwi, 2017; Amoah & Adu-Darko, 2023)

The Kappa statistic or Coefficient Cohen's kappa

The Kappa statistic, sometimes referred to as Cohen's kappa coefficient, is a tool for assessing agreement between two or more raters or judges. It is a measure of inter-rater reliability (Amoah, & Adu-Darko, 2023; Kromidha, Gannon, & Taheri, 2023). One statistical metric used to assess the inter-rater reliability of categorical variables is the Kappa statistic. A score of 0 implied that there is no concordance between the two raters, while a score of 1 indicates complete concordance. Cohen's Kappa (k) is an interval-scaled metric. Values between 0.40 to 0.4075 was a good agreement beyond chance 0.5, whilst 0.40 was interpreted as indicating poor agreement beyond chance. Cohen's kappa coefficient was used in this study to assess inter-rater reliability. Table 3 summarizes the interpretation of the value of k in relation to the level of agreement and the percentage of data analyzed that are 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 Amoah, & Adu-Darko, 2023)

The validation of a specific research tool and its capacity to accurately assess the intended construct was demonstrated by Bartlett & Camba (2023). When a research study effectively assesses the intended construct or phenomenon under inquiry, it has acquired validity. The researcher looked up pertinent textbooks that the students were using and referred to the SHS syllabus in order to verify the authenticity of the measurement tools that were used.

Consent and assent Letters

The consent letters also demonstrated that there were no risks related to the research and that the volunteers were knowledgeable of the AT and NAT present in Ghanaian SHS mathematics textbooks. The agreement and assent letters made it clear that participating in the study would not result in cash or other benefits. The feedback protocols, which specified that the participants received both hard and soft copies of the results for their review, were also included in the consent letters.

Trustworthiness Of The Research

Developing trustworthiness is essential to guaranteeing the validity and reliability of a qualitative study (Azza & Ahmad-Tajuddin, 2013). According to Azza & Ahmad-Tajuddin (2013), the qualitative investigation provided a thorough enough depiction to show that the author's conclusion "makes sense." "Trustworthiness does not mean that the reader has to agree with the researcher; rather, it requires the reader to see how the researcher arrived at the conclusion he or she made," Rowlands and Dangar (2023) reiterated. The researcher includes a comprehensive methodology section in this research report in order to increase trust in the response. According to Lincoln and Guba, the four criteria for judging credibility and trustworthiness that come before internal validity are listed in Table 4.

Table 4: Lincoln and Guba’s (1985) Four Criteria in Establishing Trustworthiness Credibility (in preference to internal validity).

Credibility (in preference to internal validity)	Confidence in the “truth” of findings based on the research design, subjects/informants and context
Transferability (in preference to external validity / generalisability)	Applicability of the findings in other contexts
Dependability (in preference to reliability)	Consistency and replicability of the findings with the same subjects or in a similar context
Confirmability (in preference to objectivity).	Degree of neutrality or the extent to which the findings of a study are shaped by the respondents and not researcher bias, motivation or interests

(Sources: Amoah & Adu-Darko, 2023)

Trustworthiness of the Preparation Phase

During the pilot study, pre-interviews were conducted so as to help to determine whether the interview questions were suitable for obtaining rich data that would answer the proposed research questions. For instance, questions asked included; “Did I manipulate or lead the participant?” and “Did I ask semi-structured questions?” Such evaluation was done for continuous reflection to ensure the trustworthiness of content analysis. In preparing the interview guide, the researcher subjected the interview questions to further evaluation so as to help to construct understandable questions that make better sense of the phenomenon and also ensure that the right questions were asked in the right way so that the data does not become an induced data. The researcher opted for a semi-structured data collection method, so as not to steer the participant’s answers to obtain inductive data. The researcher considered the sampling method used in qualitative content analysis studies which was chosen based on the methodology and topic. Selection of the most appropriate textbooks, units of analysis as well as the method of data collection were essential. The researcher put a lot of thought into how to collect the most suitable data for content analysis. To manage the data, pre-testing of the analysis method was done. When using a deductive content analysis approach, the categorization matrix in a pilot phase was pre-tested. Trial coding was done by the researcher to test tried to look at the difficulties involved and the units of coding interpreted.

Trustworthiness of the Organization phase of the Content analysis

The researcher ensured that the qualitative research process was rich in terms of the collected data and that such data was interpreted and coded in a valid and reliable way. The researcher and the researcher's assistant described how the categories were arrived at, the codes that were used and the description of each of the categories used in the study. Abstraction was done by grouping different types of mathematical tasks together to identify any similarities within and differences between categories.

Reporting the Analysis Process

The researcher reported the Analysis Process with a full description and logical use of concepts, it was impossible to evaluate how the results were gotten and their trustworthiness. The researcher paid much more attention to the descriptions of the analysis, results, and how to evaluate the trustworthiness of this study.

Trustworthiness in the Reporting phase

Reporting phase of the study was linked to transferability, conformability, and credibility. The reporting phase was described in the process of abstraction. Hence, the aim of the study was to identify the types of mathematical tasks by outlining the concepts, their hierarchy, and possible connections where necessary. The researcher, therefore ensured that the structure of results was equivalent and answered the aim and research questions.

Credibility

The credibility criterion involved establishing that the results of the qualitative research are credible, or believable, from the perspective of the participants in the research (Younas, Fàbregues, Durante, Escalante, Inayat, & Ali, 2023). From this perspective, the purpose of the qualitative research was to explain in detail and the phenomena of interest was understandable from the participant's standpoint. The participants were the only ones who can legitimately judge the credibility of the results. In this study, the researcher adopted triangulation to establish credibility.

Transferability

Constructivist emphasizes that students create their own understanding by thinking and analyzing things. It promotes using textbooks and projects to help students learn in this way. The researcher in this study stated how many schools were in the study, where they were located, and who took part. Only eight mathematics teachers took part in the study. Also, the researcher and their assistant coded, counted and wrote down information from the two mathematics textbooks in the analysis codebooks. The researcher calculated the average of the results for both textbooks to find the mean value to make sure the coding results were accurate.

Dependability

The dependability of a study is high if another researcher can readily follow the decision trail used by the initial researcher (Zhu, Yang, & Ren, 2023). To address the dependability issue more directly, the researcher reported the content analysis process and described in detail. The process of analysis was reported in an adequate manner such that the researcher stated the steps used in the research to facilitate detailed descriptions and made use of figures, tables, charts and graphs. The researcher reported the findings of the study especially when explaining the purpose and process of the analysis and structure of concepts. Dependability in this study was further tested based on rater consistency. The raters were two qualified SHS mathematics teachers. These teachers held master's degrees in mathematics, served as counsellors in mathematics guidance groups, knew the curriculum and materials very well and had more than twenty (20) years of teaching experience in JHS (Junior High schools) and SHS education.

Confirmability

Qualitative research shows that each researcher brings a unique perspective to the study (Maxwell, & Levitt, 2023), Confirmability refers to the degree to which the results could be confirmed or corroborated by others (Zhu, Yang, & Ren, 2023). The researcher documented the procedures for checking and rechecking the data throughout the study.

V. Data Presentation, Analysis And Discussion Of Findings

The results were obtained through Comparative content analysis and interviews. Interpretation and discussion of the results were done to enable understanding of themes emerging from the content analysis with reference to the Ghanaian SHS mathematics textbooks. A discussion of the results in relation to the literature reviewed was presented to address the following research objectives:

1. What proportions of mathematical tasks presented in the GACM textbooks are applicational and non-applicational task types?

2. What proportions of mathematical tasks presented in the GECM textbooks are applicational and non-applicational task types?
3. What differences are there in the proportions of applicational and non-applicational mathematical tasks in the GACM and GECM textbooks?

The qualitative content analysis of the two mathematics textbooks and the oral interviews generated broad themes based on the responses of the participants. The broad themes were discussed under the appropriate research objective. A summary of each research objective is provided and the chapter then ends with concluding remarks. Table 5 presents the themes and sub-themes used in collecting the data.

Table 5: Overview of themes and sub-themes used to explore the interviews and contents of the two Ghanaian SHS mathematics textbooks

Themes	Sub-themes
Summary of information on teacher participants AT and NAT in the Ghanaian SHS mathematics textbooks	<ul style="list-style-type: none"> ➤ Information on teacher participants in the interviews ➤ Types of mathematical tasks <ul style="list-style-type: none"> • AT and NAT in GACM textbooks 1, 2 and 3 • AT and NAT in GECM textbooks 1, 2 and 3
Comparative content analysis on AT and NAT	<ul style="list-style-type: none"> • AT and NAT in GACM and GECM textbooks 1, 2 and 3.

Summary of information on mathematics teachers’ participants in the interviews conducted

Table 6 presents a summary of information on teacher participants in the interviews conducted. The statistics of teacher participants are seen:

Table 6: Summary of information on teacher participants

Name of school of teacher	Status	Sex	Age (Years)	Qualification	Years of experience
SHS school 1	Teacher 1	Female	45	Teacher’s certificate / B.Ed Mathematics / M.A Mathematics	18
SHS school 1	Teacher 2	Male	55	Teachers certificate A/ B.Sc Mathematics	24
SHS school 1	Teacher 3	Male	48	Teachers Certificate A/ B.Sc Mathematics/ Mphil mathematics	20
SHS school 1	Teacher 4	Male	49	Teacher’s Certificate A / B.Ed Mathematics	20
SHS school 2	Teacher 5	Female	49	Teachers Certificate A / B. Ed Mathematics	20
SHS school 2	Teacher 6	Male	43	Teachers Certificate A / B. Ed Mathematics	17
SHS school 2	Teacher 7	Male	46	Teachers Certificate A / B. Ed Mathematics / Mphil Mathematics	20
SHS school 2	Teacher 8	Male	52	Teachers Certificate A / B. Sc Statistics / M.Sc Statistics	19

Table 7: presents a summary of information on mathematics textbooks used in Ghana for the study

Table 7: Summary of information on mathematics textbooks used in Ghana (Field Source)

Mathematics Textbooks used in Ghanaian SHS	Private / Public Textbook	Year of Publication
GECM textbooks for SHS 1, 2 and 3	Public	2009
GACM textbooks for SHS 1, 2 and 3	Private	2016

Analysis of AT and NAT in the GACM textbooks

Analysis of the GACM textbooks 1, 2, and 3, indicated that “AT and NAT”; The data collected were put under themes and sub-themes. Table 8 illustrates the AT and NAT in the GACM textbooks 1, 2 and 3.

Table 8: Analysis of AT and NAT in the GACM textbooks

Textbooks	Book 1		Book 2		Book 3	
	N	%	N	%	N	%
AT	1442	32.3	546	19.9	483	58.1

NAT	3023	67.7	1803	80.1	348	41.9
Total	4465	100	2749	100	831	100

Table 8 reveals that the GACM textbook 1 contained a total of 4,465 mathematical tasks. The results of the analysis revealed that a total of 1,442 tasks, which represents 32.3% of the data, were identified as AT. Conversely, the remaining 3,023 tasks, which accounted for 67.7% of the data, were classified as NAT. According to the findings presented in the GACM textbook 1, the consistency of the raters was ascertained and documented. It was determined that the percent agreement resulting from post-evaluation discussion and revision was 1.00, therefore satisfying the expected percentage range of agreement. Subsequent analysis of the percentage agreement data revealed that the Cohen Kappa coefficient of 1.00 corresponded to a maximal value of 100, thus signifying an ideal degree of concordance between the two raters. This interpretation suggests that the entire set of data gathered by the two raters was characterized by high levels of dependability

The GACM textbook 2 comprised a total of 2,749 mathematical tasks. This study's findings revealed that 546 (19.9%) and 1803 (80.1%) mathematical tasks were identified as AT and NAT, respectively. According to the GACM textbook 2, the ostensible agreement of the raters, as determined by means of consistency scoring, demonstrated that post-discourse and review, the percentage agreement attained was 0.50, which is congruent with the specified range of percentage agreement. Upon conducting a more in-depth analysis, it was determined that the percentage agreement findings yielded a Cohen Kappa value of 0.50, indicative of a weak level of concordance between the two raters. This finding suggests that there was only a modest percentage of dependable data.

The "GACM textbook 3" comprised eight hundred and thirty-one (831) mathematical tasks. Out of the total count, 483 tasks (representing 34.1%) were classified as AT while 271 of the mathematical tasks (accounting for 61.4% of the same) were NAT. The assessment of rater consistency, as evidenced in the GACM textbook 3, revealed a percentage agreement of 1.00 after a process of discussion and revision, which fell within the prescribed range of the required percentage agreement. Upon conducting additional analysis of the percent agreement, it was revealed that the Cohen Kappa value attained a perfect score of 1.00, ultimately indicating a full agreement between the two raters. The resultant interpretation suggests that the entirety of the data collected by both raters is deemed reliable, with a confidence level of 100%.

Figure 3 shows the chart of AT and NAT in the GACM textbooks 1, 2 and 3.

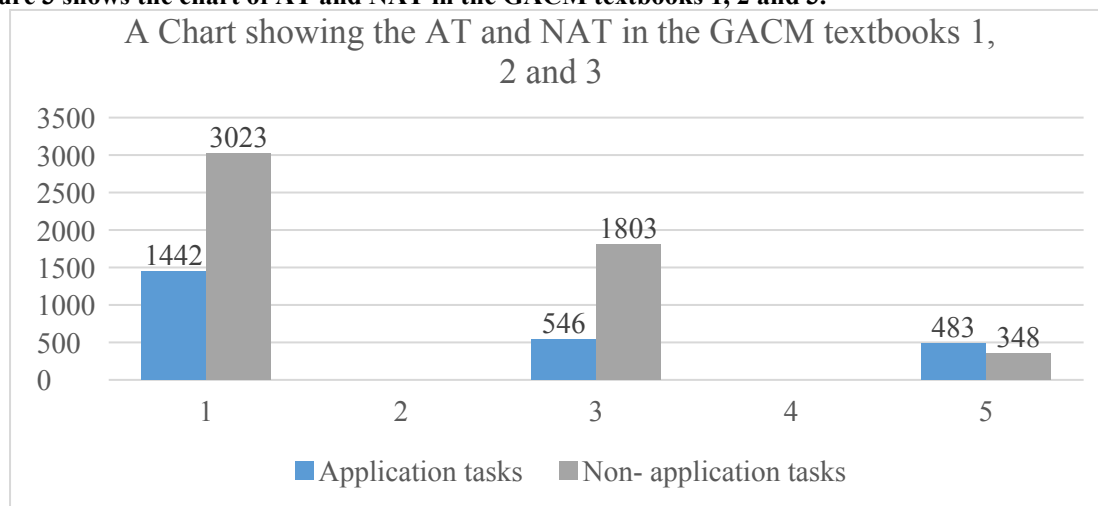


Figure 3: Bar chart of AT and NAT in the GACM textbooks 1, 2 and 3

The findings presented in Figure 3 indicate that majority of the mathematical exercises included in all three textbooks of the GACM were NAT. Whilst there were indeed instances of AT being present, it is noted that NAT were predominant within the GACM textbooks 1, 2, and 3. According to the findings presented in Textbook 1, it was determined that 32.3% of the tasks analysed pertained to AT, whereas the remaining 67.7% were classified as NAT. The findings of the analysis revealed that in relation to mathematical tasks, 19.9% pertained to AT while 80.1% pertained to NAT. According to the findings in Textbook 3, the results revealed that 34.1% of the tasks were categorized as AT while 61.4% of the mathematical tasks lacked applicability. The outcomes obtained from the GACM course materials are in concurrence with the analysis conducted by Alim, Hermita, Wijaya, Putra, Talib, and Fauza (2022), which examined the geometry mathematical textbooks utilized in the primary schools of Malaysia, China, and Indonesia for fifth-grade students.

Alim et al.,'s study found that AT in mathematics textbooks result in a 35% reduction compared to NAT. This is due to students often struggling in national exams despite achieving satisfactory results in tests involving NAT (Mereku, 2023). The use of NAT in textbooks negatively impacts students' confidence in resolving AT, hindering their ability to handle pedagogy requisites for AT proficiency. The study suggests that AT entail heightened cognitive demands, promoting advanced cognitive development and higher-order thinking abilities. The GACM textbook tasks, which focus on NAT, may prolong students' comprehension process in solving AT.

Analysis of AT and NAT in the GECM textbooks 1, 2 and 3.

Table 9 illustrates the frequency of AT and NAT in the GECM textbooks 1, 2 and 3.

Table 9: Analysis of AT and NAT in the GECM textbooks 1, 2 and 3

Textbooks	Book 1		Book 2		Book 3	
Tasks	N	%	N	%	N	%
AT	192	11	119	18	338	61
NAT	1573	89	549	82	216	39
Total	1765	100	668	100	554	100

According to Table 9 in the GECM textbook 1, a total of one thousand, seven hundred and sixty-five (1765) mathematical tasks were documented. The analysis revealed that a total of 192 tasks, comprising 11% of the sample, were categorized as AT, whereas the majority of 1573 tasks, accounting for 89% of the sample, were classified as NAT. Based on the reliability measures recorded in the GECM textbook 1, the level of consistency among raters was revealed to be 0.50 in terms of percent agreement. Further analysis of the percentage agreement revealed that the Cohen Kappa coefficient of 0.50 fell within the 0.40-0.59 range, signifying a moderate level of agreement (*Evidenced by Table 4.9, 4.10, and Appendix M2*).

The GECM textbook 2 consisted of a total of 668 mathematical tasks. The results of the analysis demonstrated that a total of 119 items, constituting approximately 18%, were categorized as AT, whereas the remaining 82% (549 items) were labelled as NAT. According to the GECM textbook 2, the rater consistency was encoded and recorded as having a degree of 1.00 percent agreement. Additional analysis of the percentage agreement data revealed that the Cohen Kappa score registered at 1.00, signifying complete uniformity in agreement with a corresponding assumption of 100% dependability of the collected data

The GECM textbook 3 comprised a total of 554 mathematical tasks. According to the analysis, out of the total number, 338 tasks (61%) were identified as AT, whereas the remaining 216 tasks (39%) were categorized as NAT. According to the GECM textbook 3, the rater consistency was encoded with a percent agreement of 0.50. An additional examination of the percent agreement revealed that the Cohen Kappa coefficient, which measured the degree of agreement between observers, attained a value of 0.50, placing it within the bracket of moderate agreement corresponding to a range of 0.40 to 0.59. The resulting interpretation suggests that there was a moderate agreement between the two raters.

Figure 4 is a display of bar chart showing AT and NAT in the GECM mathematics textbooks 1, 2 and 3.

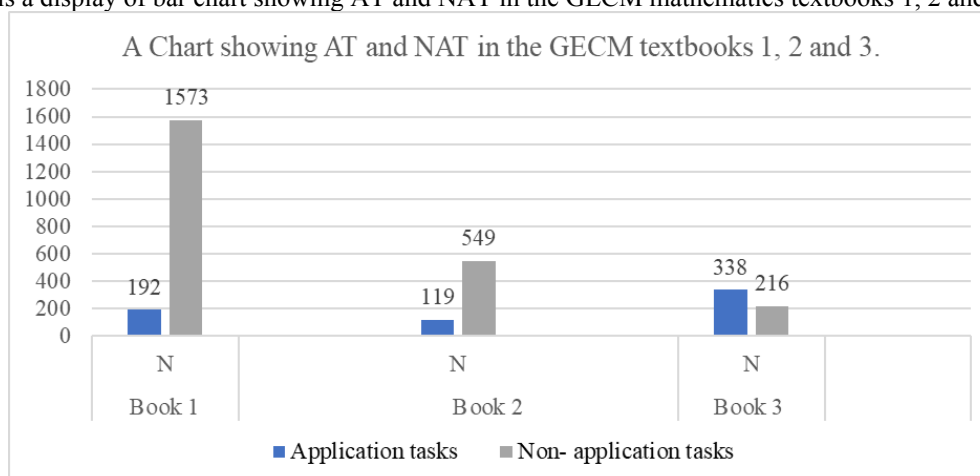


Figure 4: Bar chart of AT and NAT in the GECM mathematics textbooks 1, 2 and 3

The results depicted in Figure 4, evinced that a majority of the mathematical tasks contained in the three textbooks analysed were NAT. The study found that a majority of mathematical tasks in three GECM textbooks were classified as National Assessment Theory (NAT). In textbooks 1 and 2, NAT was more prevalent than AT, while in textbook 3, it was less prevalent. In textbook 1, 11% of tasks were categorized as AT, while 89% were NAT. In textbook 2, 18% and 82% were NAT and AT, respectively. In textbook 3, 61% of tasks were AT, and 39% were NAT. This suggests a lower frequency of NAT in GECM textbooks. The study supports previous research that highlights the lack of AT in mathematics textbooks and its impact on students' performance in national examinations. The study also suggests that the majority of students are not proficient in problem-solving skills due to their familiarity with tasks lacking practical applications. The analysis suggests that the majority of students are not proficient in AT due to their familiarity with tasks that lack practical applications (Alim et al., 2022).

Ghanaian SHS mathematics textbook usage by mathematics teachers

In order to establish the prevalence of mathematics textbook usage among participating mathematics educators, interview data indicated that one out of the eight teachers reported utilizing three distinct textbooks for instructional purposes, four teachers reported utilizing two different textbooks, while the remaining three teachers expressed a preference for implementing four different textbook resources. Several responses were received, among which were:

“There are several mathematics textbooks used in teaching mathematics but I use GCSCM, GACM and the GECM.” T1Q1

“Teaching mathematics without a textbook is difficult hence I use the GACM and the GECM.” T2Q1

“I love to teach mathematics so I use two textbooks. Thus I use the two mathematics textbooks. The GCSCM and the GECM.” T3Q1

“Working with textbooks is paramount as far as teaching mathematics is concerned hence, I use two mathematics textbooks. These are GACM and the GECM.” T4Q1

“Four core mathematics textbooks are key to teaching mathematics depending on the concept that am teaching. These are GACM, GECM, GMS, GASM.” T5Q1

“I love to use two textbooks most of the time. The GMS and the GACM.” T6Q1

“I use four mathematics textbooks depending on the topic am teaching. These are GCSCM, GA^{}SM, GACM and GECM.” T7Q1*

“I use four mathematics textbooks depending on the mathematics concept am teaching. These are GASM; GCSCM; GECM; GACM.” T8Q1

Table 10 gives a summary of the mathematics textbook usage by the eight mathematics teachers in the SHS.

Table 10: Summary of number of mathematics textbook usage by mathematics teachers

Teachers Interview Question 1	Teachers Response to interview question 1 on textbook usage	Number of mathematics textbooks
<i>T1Q1</i>	<i>GCSCM; GACM; GECM</i>	3
<i>T2Q1</i>	<i>GACM; GECM</i>	2
<i>T3Q1</i>	<i>GA[*]SM; GECM</i>	2
<i>T4Q1</i>	<i>GCSCM; GECM</i>	2
<i>T5Q1</i>	<i>GACM; GECM; GMS; GASM;</i>	4
<i>T6Q1</i>	<i>GA[*]SM; GACM</i>	2
<i>T7Q1</i>	<i>GSM; GA[*]SM; GACM; GECM</i>	4
<i>T8Q1</i>	<i>GASM; GCSCM; GECM; GACM</i>	4

Based on the findings in Table 10, a subsequent analysis revealed that the majority of the teachers in the field of mathematics employed either two, three, or four textbooks in their pedagogical approach. This particular circumstance provided an advantageous benefit for teachers, in that no individual teacher was restricted to utilizing solely one mathematics textbook.

Figure 5 shows a chart of the summary of the mathematics teachers' responses to interview question 1 on the use of mathematics textbooks

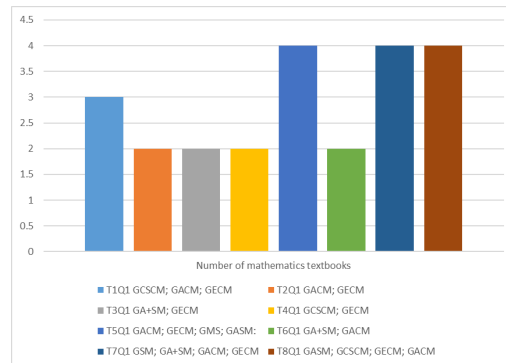


Figure 5: Summary of the mathematics teachers' responses to interview question 1 on the use of mathematics textbooks (Field source)

According to the information presented in Figure 5, a comprehensive overview was provided regarding the frequency of mathematics textbooks being utilized by teachers as per the data extracted from interviews. This finding suggests that the presence of two or more mathematics textbooks provides substantial support to mathematics teachers, thereby minimizing the likelihood of encountering pedagogical challenges. Moreover, it is acknowledged by both the researcher and the researcher's assistant that the utilization of mathematics textbooks affords flexibility, as teachers may choose to adhere to the prescribed content in order to avoid conveying incorrect information to students.

Tables 10 and 11 shows a summary of the number of teachers who use each of the mathematics textbooks from the interviews.

Richness of mathematical tasks in SHS Mathematics textbooks

The study in question which involved interviewing mathematics teachers to assess the disparities in mathematical tasks found in the GACM and GECM textbooks. Specifically, the responses gathered from interview question six (Q6) was analyzed to determine which textbook contained a more comprehensive collection of mathematical tasks. According to the eight mathematics teachers who were interviewed, the GACM textbooks were comparatively more comprehensive and superior to other textbooks. The feedback provided by the three teachers are stated below;

"I believe that GACM for SHS is rich in mathematical tasks than all other textbooks". (T5Q6)

"In terms of richness in mathematical tasks I think GACM for SHS has that". (T1Q6)

"All the textbooks I use are somehow rich in mathematical tasks but GACM has a richer mathematical tasks base". (T2Q6)

One teacher respondent indicated that the GA+SM textbook was rich in mathematical tasks.

"As for me I am very strong on the GA+SM for SHS as being very rich in mathematical tasks; yes". (T6Q6)

Three additional teacher respondents reported on the academic significance (richness of mathematical tasks) of mathematical tasks derived from the usage of the textbooks, asserted that:

"I think the GECM for SHS has very rich mathematical tasks". (T3Q6)

"GECM for SHS". (T7Q6)

"This is a very difficult question but I think the GECM for SHS is very rich in mathematical tasks". (T4Q6)

Another teacher respondent to the interview also indicated that the GCSCM textbook was rich in mathematical tasks.

"If it comes to the richness of the mathematics textbook, I am of the view that GCSCM for SHS is rich in mathematical tasks". (T8Q6)

The findings from the teachers' responses indicated that there exists no predetermined framework with respect to the instruction of various mathematical tasks presented in textbooks. As previously stated, a section of mathematics teachers elucidated that they primarily utilized textbooks for instructional purposes. According to a number of researchers the fact that many students encounter difficulties with diverse mathematical tasks has created lots of attention in the teaching of mathematics by teachers (Awoniyi, & Amponsah, 2023). Recent research indicated that Ghanaian students' inadequacy in comprehending diverse mathematical concepts, although a common phenomenon also generates a disheartening academic performance due to their inability to differentiate between varying mathematical tasks presented in different mathematics textbooks causing a considerable proportion of students to experience difficulty in the domain of mathematics (Boadu, Arthur, & Bonyah, 2023; Awoniyi & Amponsah, 2023). It is imperative for educators and mathematics teachers to

acknowledge the significance of utilizing diverse types of mathematics tasks within the curriculum for optimal student success (Boadu et al., 2023). The study reveals that there is no predetermined framework for teaching various mathematical tasks in textbooks. Many teachers primarily use textbooks for instructional purposes, but many students struggle with diverse mathematical concepts. This inability to differentiate between tasks in different textbooks leads to poor academic performance. It is crucial for educators and teachers to incorporate diverse types of tasks for optimal student success (Aforklenu & Bukari, 2023; Boadu, Arthur, & Bonyah, 2023; Awoniyi & Amponsah, 2023). However, some teachers may lack assertiveness or provide inaccurate information, resulting in divergent responses. This lack of definitive responses may be the root cause of students' inability to grasp mathematical language. Insufficient reference to mathematical tasks in textbooks during instructional sessions can result in inadequate acquisition of mathematical language, especially for AT.

AT requires ingenuity or creativity to solve, and consistent exposure to AT and application-based assignments is essential for students to grasp the intricacies of mathematics. Despite the mandatory inclusion of mathematics coursework and Ghanaian-authored textbooks in students' curricula, there is a decline in the degree to which textbook-based learning translates into mastery of mathematical skills. The use of AT and NAT in mathematics instruction has been shown to diminish the need for traditional, pen-and-paper techniques and essential mathematical proficiencies. Restricting the use of NAT in textbooks used in mathematics classrooms may foster the development of rudimentary mathematical proficiencies, positively influencing students' competence in executing the day-to-day mathematical tasks.

VI. Findings, Conclusions And Recommendations

The results of this study, which looked into AT and NAT in two Ghanaian SHS mathematics textbooks, are summarized under four primary research headings. The remaining questions that were identified while doing this research led to suggestions for additional investigation. After discussing the study's limitations and providing recommendations, the summaries of the study's main findings were identified.

Summary Of Main Findings

The main findings are presented under the four main research questions.

The following research questions guided the study;

1. Proportion of mathematical tasks presented in the GACM textbook(s) that are application and non-application tasks?
2. Proportion of mathematical tasks presented in the GECM textbook(s) that are application and non-application tasks?
3. Differences between the proportions of application and non-application tasks in the GACM textbooks and the GECM textbook(s)

Proportion of AT and NAT presented in the GACM textbook(s)

The primary objective of this analysis was to determine the proportion of AT and NAT contained in the GACM and GECM textbooks.

AT against NAT in the GACM textbooks 1, 2 and 3

The study found that NAT was the predominant task in GACM textbooks 1, 2, and 3, accounting for 67.7%, 80.1%, and 61.4% of the total. Although there were AT, the textbooks primarily focused on NAT. The study also highlighted the importance of incorporating both applied and non-applied tasks in mathematics textbooks. The inter-rater agreement percentages were 1.00, 0.50, and 1.00, respectively.

AT against NAT in the GECM textbooks 1 and 2

The study revealed that NAT is the most frequently used task in GECM textbooks 1 and 2, with 89% and 82% of the tasks, respectively. The rater consistency encoded from the GECM textbooks 1, 2 and 3 by the two coders indicated that the per cent agreement between the two raters was 0.50, 1.00 and 0.50 respectively. Thus AT should be designed to actively engage students in mathematical thinking, fostering critical and creative thinking, deep conceptual understanding, and interpretation (Zhang, 2022).

Summary of teachers' responses on AT and NAT

Teachers struggled with clear definitions for mathematical tasks and a systematic approach to teaching and identifying AT from NAT. According to the teachers, many students struggle with different mathematical tasks due to the lack of comprehensive teaching methods. Teachers often provide unclear answers, leading to confusion and off-gear. Solving AT requires creativity and original thinking to solve, and regular confrontations of these tasks can help students become better problem-solvers. The Ghanaian SHS mathematics textbooks have various levels of tasks, indicating a wide range of mathematical tasks. Regularly tackling different types of

mathematical tasks can help students become better problem-solvers and demonstrate their understanding of math concepts in real-life situations.

Differences between AT and NAT in the GACM and GECM textbooks

This analysis aimed to identify differences in numerical quantity between AT and NAT in the two mathematics textbooks. Despite the mandatory inclusion and use of Ghanaian-authored mathematics textbooks for SHS students, there is a decline in the mastery of mathematical skills. Multiple reasons can explain students' failure to grasp basic mathematical concepts due to textbook use. Teachers' interview responses suggest that using AT in mathematics textbooks is an effective technique to help students understand various ways AT can be applied. However, there is an insufficiency of exact responses to some questions, and some teachers exhibited evasive demeanor when asked about AT. Insufficient reference to AT in textbooks may result in inadequate mathematical language acquisition among students. Consistent exposure to NAT is essential for students to grasp the intricacies of mathematics. Emphasizing AT in mathematics textbooks in fundamental classrooms may foster the advancement of rudimentary mathematical proficiencies and positively influence students' competence in executing day-to-day mathematical tasks.

Recommendations to Curriculum developers and policymakers

Curriculum developers and policymakers should review SHS mathematics textbooks to integrate AT into the mainstream mathematics curriculum. The majority of textbooks show an elevated presentation of NAT which suggests the need to incorporate a higher degree of ATs in mathematics instruction to stimulate students' mathematical reasoning and improve their understanding of mathematical principles.

The study revealed that core mathematics is uniformly taught in all SHS in Ghana, but the usage of mathematics textbooks is not consistent among students. The importance of employing SHS mathematics textbooks in teaching and enhancing students' comprehension, proficiency, and performance in mathematics is emphasized. Teachers are advised to proactively identify and select appropriate mathematical tasks to boost students' competence in solving mathematical tasks related to various topics.

The study suggests that mathematics textbooks in Ghana should emphasize and integrate AT as a major aspect in all three levels, from SHS 1 to SHS 3, to facilitate pedagogy. The textbooks should accommodate the development of students' capacity to categorize mathematical tasks based on progressive levels of difficulty and complexity. Additionally, the GES and MOESS should provide a comprehensive catalogue of mathematical tasks to cultivate problem-solving capabilities, procedural knowledge, and critical thinking capacities.

Recommendation to textbook developers and teachers

The study suggests that Ghana's SHS core mathematics textbooks should be reformed to include much more AT's from SHS 1 to SHS 3. This information should be compiled into a compendium for uniform curriculum application. The study aims to provide pedagogical guidance on using AT and NAT in the SHS textbooks to facilitate effective implementation. Further research is needed to determine the optimal approach for AT and NAT pedagogy, aiming to achieve advanced competency levels in diverse mathematical tasks.

Limitations

This study, conducted in two secondary educational institutions in Ghana's Eastern Region, focused on the classification of mathematical tasks in two academic textbooks. The findings, though not universally applicable, offer valuable insights for educators in mathematics education. However, the study's limitations include the use of content analysis techniques for only two textbooks and the limited number of SHS core mathematics educators interviewed. These limitations may affect the generalizability of the study's findings, as they were confined to the Eastern region and not applicable to all textbooks in Ghana.

Conclusion

The study highlights the importance of recognizing and defining AT and NAT in Ghanaian SHS mathematics textbooks. It emphasizes the need for teachers to teach students AT and NAT to foster exceptional aptitude, potential, and inventiveness in the field of mathematics education and found that the two Ghanaian SHS mathematics textbooks failed to specify AT and NAT proficiencies resulting in persistent student difficulties in mathematical task instruction.

The study also identified several challenges that can result in academic underachievement in mathematics. It is crucial for educators to incorporate discussions about AT and NAT in relevant Ghanaian mathematics textbook to facilitate a deeper understanding of these concepts among students and prepare them for real-life applications of the content. The dominant types of mathematical tasks used in GACM and GECM

mathematics textbooks were NAT. Further exploration is needed to address these new questions and provide a foundation for addressing the challenges faced by students in tackling mathematical conundrums.

Areas For Further Research

This research forms a useful platform for future research in the following areas: It would be of much benefit to see further research studies

- a. undertaken on other types of mathematical tasks such as traditional and non-traditional tasks, routine and non-routine tasks in other Ghanaian SHS core mathematics textbooks and the results compared with each other.
- a. undertaken on Application and Non-application tasks on two other Ghanaian SHS core mathematics textbooks and the results compared with each other.
- b. undertaken on traditional and non-traditional tasks, routine and non-routine tasks in other Ghanaian SHS core mathematics textbooks and the results compared with each other.
- c. undertaken on routine and non-routine tasks in other Ghanaian SHS core mathematics textbooks and the results compared with each other.

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