UNIVERSITY OF CAPE COAST

INVESTIGATING THE STATISTICS CONTENT KNOWLEDGE OF PRE-SERVICE TEACHERS IN THE COLLEGES OF EDUCATION IN GHANA

STEPHEN APPIAH

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BY

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Thesis submitted to the Mathematics and I.C.T. Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Mathematics Education

JUNE, 2022

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: …… Date: ……

Name: Stephen Appiah

Supervisors' Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: ……. Date: …….....

Name: Mr. Benjamin Yao Sokpe

ABSTRACT

The study investigated the Statistics content knowledge of College of Education pre-service teachers in Ghana. The explanatory sequential design, quantitative followed by qualitative data, was employed. The quantitative data was gathered via questionnaire containing an achievement test (teacher made) while the qualitative data was collected through an interview. The study used one hundred and ninety-one pre-service teachers for the quantitative phase of the study, out of which eight were purposively chosen for the interview. Findings of the study revealed that participants have an average knowledge level in colleges of education statistics content course. Again, the study showed that significant gender difference exists in these selected pre-service teachers' statistics content knowledge, and it was in favour of the male counterparts. Measures of dispersion was found to be a difficult area for the participating pre-service teachers. Moreover, pre-service teachers in the selected college showed misunderstanding in some statistics topics, especially in calculating the quartile, semi-interquartile range, and finding the 25^{th} percentile and median from frequency distribution table. Among recommendations from the findings was that mathematics tutors at the colleges of education should pay attention to the teaching of topics such as finding mean, median, and percentiles from frequency distribution tables, as well as topics under measures of dispersion.

KEYWORDS

Knowledge

Statistics

Gender

Content knowledge

Statistics knowledge

Statistics content knowledge

Pre-service teachers

College of education

Basic school students

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DEDICATION

To my formative year mates, family and friends.

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CHAPTER ONE

INTRODUCTION

In Ghana, basic school students are reported to have difficulties with certain aspects of statistics (West African Examinations Council [WAEC], 2011, 2012, 2013, 2017, 2019). Several factors known to account for students' academic performance could be looked at, in an attempt to investigating why that weakness in statistics by basic school students. However, literature mentions teacher-related factors and teacher knowledge as key factors which influence students' performance (Wilmot, Yarkwah & Abreh, 2018). This creates the need for investigating statistics knowledge of those trained to become teachers at the basic school, by finding out whether the teachers have the prerequisite knowledge in statistics for teaching. This study, therefore, investigated the statistics content knowledge of Colleges of Education pre-service teachers in Ghana, who are being trained to teach basic school learners in this area of concern, statistics. Pre-service teachers instead of in-service teachers are considered in the study because they are still under the guidance of college mathematics tutors. This is also because in case of any deficiencies found in their statistics content knowledge, they can have remedies provided for them easily. That will also help pre-service teachers get adequate preparation for future teaching of basic school statistics. The chapter is made to include background, statement of the problem and purpose of the study. The research questions and the hypothesis, significance, limitations and delimitations, and the organisation of the study are as well captured in this chapter.

Background to the Study

Teachers' content knowledge in teaching is key to successful learning outcomes (Wilmot et al., 2018). It forms the breath and life of education, and without it teaching and learning is paralyzed (Waseka, Simatwa, & To, 2016). Thus, according to Waseka *et al.* (2016) teachers who are well-versed in their subject area are likely to cause great teaching-learning impact on their students. For that matter, teachers' knowledge is key in any educational enterprise (Wilmot et al., 2018). In relation to that, pre-service teachers' knowledge base in various fields of study has received much attention in the literature (Hine, 2015; Wilmot et al., 2018). Statistics content knowledge is one such field of study (Alghazo & Alghazo, 2017; Gal & Ginsburg, 1994).

Pre-service teachers' statistics content knowledge is investigated at many parts of the globe. In experimenting formative cycle for a particular project using group of 55 prospective teachers, Godino, Batanero, Roa and Wilhelmi (2014) found that these prospective teachers need a better statistics preparation. Also, Warren and Cunnington (2017) found that pre-service teachers have weak performance in statistics knowledge.

In South Africa, Sorto (2010) researched on performance in statistics among Grade six teachers and students; they found low performance among the teachers and the students. In Nigeria, Fajobi and Osiesi (2019) investigated primary school mathematics teachers' knowledge, attitude to, and perception for teaching statistics. The study revealed, among others, teachers having adequate basic school statistics content knowledge, and positive attitude towards statistics.

Researchers have established relationship between certain constructs and content knowledge in general, and statistics content knowledge in particular. Gender is one of such constructs (Ajai & Imoko, 2015; Malinsky, Ross, Pannells, & McJunkin, 2006; Naa, Wilmot, & Ashong, 2018). For instance, a study of female pre-service teachers showed that they exhibit higher anxiety in mathematics than male pre-service teachers (Malinsky *et al.*, 2006; Peker, Halat & Mirasyedioglu, 2010). In the same vein, Fish and Fraser (2001) found gender difference in teaching of mathematics among university professors. Johnson and Kuennen (2016) also found a relationship existing between gender and GPA scores in an introductory statistics course.

Research is replete with difficulties, fears, and anxiety students have in mathematics in general and other mathematics-related courses (Kimani, Njagi, & Kara, 2013). Similar difficulty is reported also in the literature about pre-service teachers and their learning of statistics (Leder, 2016).

Statement of the Problem

The numerous importance of statistics to human life and society as a whole cannot be downplayed (Moore & McCabe, 1993). For instance, the fields of engineering, medicine, economics, geography cannot be complete without the application of statistics. Hence, statistics forms a crucial part of study in the school mathematics curriculum right from the basic school. This is because statistics will, among other things, enhance the student's intelligence in collecting data, studying cases, and drawing conclusions (Arteaga et al., 2015).

Despite its importance and so the need for its study, statistics has become one of the areas in mathematics that students fear (Estrella & Mena,

2014; Gal & Ginsburg, 1994). Students are reported in the literature to have weak performance in statistics, and this phenomenon is a worldwide canker and at all levels of education (Perney & Ravid, 1991; Schau & Emmioglu, 2011; Sorto & White, 2004) For instance, Schau and Emmioglu (2011) investigated U.S. students' attitude towards introductory statistics and found that though students had positive attitude towards statistics, they would not do statistics if they realised it was going to be involving. That shows a kind of disinterest students possibly portray in doing statistics. Additionally, Estrella, Olfos, and Mena-Lorca (2015) affirmed adults and children having difficulty in statistics; and in Chile, students find difficulty in constructing, reading and interpreting simple tables. Equally worthy of note is the joint study by International Commission on Mathematical Instruction (ICMI) and International Association for Statistics Education (IASE) which revealed that students do not obtain enough mastery in statistics, and this makes them unable to perform in an information-based society nor pursue statistics to a higher level of education (Arteaga et al., 2015). This situation is not different when pre-service teachers are considered.

According to Rosas and West (2011), although some pre-service teachers are prepared to confidently handle mathematics, pre-service teachers in general, have been found to show low performance in both mathematics and statistics (Gal & Ginsburg, 1994; Narh-kert, 2014; Nsiah-Asante & Mereku, 2012). Li and Kulm (2008) found it a necessity that pre-service teachers should develop sound comprehension of knowledge in mathematics and, for that matter, statistics. Again, there are some weaknesses shown by pre-service teachers in content areas of data analysis (Wilburne & Long, 2010), pre-

service teachers have low performance in statistics (Gal & Ginsburg, 1994), and less pre-service teachers stood ready to teach topics involving statistics (Hine, 2015).

In Africa, similar trends of weak performance in Statistic exist. For instance, in South Africa, students at Grade 6 had weak performance in statistics studies, and that had to do mostly with difficulty in finding median and mean (Sorto, 2010).

In Ghana basic school students are reported to show some difficulties with statistics. Chief Examiner's report (WEAC, 2011, 2012, 2013, 2017, 2019) for instance, mentioned that students who sat for Basic Education Certificate Examination (BECE) had problems finding the mode from frequency table, while the 2017 report indicated that some students reversed the formula for finding the mean, $\frac{\sum f}{\sum fx}$ instead of $\frac{\sum fx}{\sum f}$. Further, it was observed that most students could not make stem-and-leaf plot from a given data; and also a few students drew histogram instead of pie chart according to 2014 and 2013 BECE Chief Examiner's reports. Again, some basic school students had difficulty drawing pie chart because they did not have a fixed centre. These are indicators of the basic school students' weakness in statistics.

Several factors known to account for students' academic performance could be looked at, in an attempt to investigating why that weakness in Statistics by basic school students in Ghana as the Chief Examiners reported in the literature (Butakor & Dziwornu, 2018). For instance, student, parent, school and environmental, and teacher factors (Aniruddha & Mondal, 2014; Butakor & Dziwornu, 2018; Yarkwah, 2020) could be explored. Among these

factors, however, teacher-related factors such as teachers' knowledge for teaching is key (Waseka, Simatwa, & To, 2016) Also, teachers' knowledge is deemed pertinent when quality teaching and students' learning outcomes are thought of (Tella, 2008). Thus, if teachers have weak knowledge for teaching statistics, they could influence the performance of students (Asampana, Nantomah, & Tungosiamu, 2017; Van Damme, Kiwanuka, Noortgate, Anumendem, & Namusisi, 2015). That is, teachers' weak mathematical knowledge regarding the teaching of mathematics could negatively influence the performance of students, since one cannot demonstrate what they don't possess (Ngidi & Ngidi, 2019).

Teachers having more content knowledge in a given subject area could ask, seek and engage in higher level classroom questions and discussions than those with less content knowledge (Hine, 2015). This is to say that well-versed statistics content knowledge is a plus to the teacher to positively influence students' performance or achievements in statistics. This attests to the place of the teacher as key in the educational enterprise (Wilmot et al., 2018). Hence, teachers who teach basic school mathematics in Ghana need to be given attention. One such category of teachers is pre-service teachers at the Colleges of Education. Do Colleges of Education pre-service teachers have the prerequisite knowledge in statistics which then will enhance their statistics teaching?

According to the chief examiner's report in 2020/2021 academic year, pre-service teachers generally performed low in EBS 350 (Statistics and Probability I), a Level 300 semester 2 course (Institute of Education, [IoE] 2021). This was based on the Cape Coast University grading system which is

used to assessed all pre-service teachers in all subject areas, and is given by a letter grade and its corresponding Mark (%) range as follows: (80 – 100) as grade A; (75 – 79) as grade B+; (70 – 74) as grade B; (65 – 69) as grade C+; (60 – 64) as grade C; (55 – 59) as grade D+; (50 – 54) as grade D; and (0 – 49) as grade E. By the chief examiner's report for instance, 827(24.92%) out of 3,318 pre-service teachers had grades from B+ upwards. Pre-service teachers who obtained D+ or D were 879(26.4%) while 353(10.64%) scored grade E (IoE, 2021). This implies that precisely 37% of pre-service teachers who wrote the paper that year had grade E (failed) or had weak of D or D+.

Again, an analysis of the performance of the Third-year pre-service teachers in four colleges within the Eastern region, Ghana, in EBS 350: Statistics and Probability I, for the 2020/2021 Academic Year (Semester two) was done. Table 1 shows the outcome of the analysis.

Table 1: Performance of Third-year Pre-service Teachers in EBS 350 for 2020/2021 Academic Year (Semester two)

College	Number of candidates	% that had A to C	% that had D to D+	% that had E
A	111	64.87	29.73	5.41
B	63	63.51	28.58	7.94
C	132	67.79	16.67	15.91
D	216	67.05	22.04	10.73

Source: IoE, 2020/2021 academic year, semester two

According to Table 1, though majority of pre-service teachers (67.79%) scored grades from A to C in College C, as high as 15.91% of the candidates had failed (that is with grade E). Similarly, 32.77% of pre-service

teachers in College D had either weak performance (grades D or D+) or failed (grade E). If 32.77% of pre-service teachers showed weakness or failure in statistics contents, then that could imply that some pre-service teachers show low knowledge in statistics contents.

With the issues raised on statistics performance at the basic school and college of education levels, couple with teachers' weakness in statistics, this study was organised to find out the statistics content knowledge of the Colleges of Education pre-service teachers in Ghana. Pre-service teachers instead of in-service teachers are considered in the study because they are still under the guidance of college mathematics tutors. This is also because in case of any deficiencies found in their statistics content knowledge, they can have remedies provided for them easily. That will also help pre-service teachers get adequate preparation for future teaching of basic school statistics.

Purpose of the Study

The focus of the study was to investigate the statistics content knowledge of pre-service teachers in the Colleges of Education in Ghana.

Research Questions and Hypothesis

Research questions

1. Which statistics content topic(s) do pre-service teachers have difficulty in learning?
2. What is the level of pre-service teachers' statistics content knowledge in the Colleges of Education statistics?

Research hypothesis

H_0: There is no statistically significant difference between female and male pre-service teachers' statistics content knowledge.

Significance of the Study

While at the college, pre-service teachers are instructed in statistics as one of the mathematics courses. The study will be helpful in bringing out the status of pre-service teachers' knowledge in statistics content, and the topics pre-service teachers find difficult in College statistics content course. These will assist Colleges of Education tutors identify which aspect(s) of College statistics content area(s) pre-service teachers may need remedies if found necessary.

It will also guide Teacher Education on which statistics topics to organise workshops, if any, for College tutors in enhancing their teaching of statistics content course at the Colleges.

Delimitations

The study was delimited to pre-service teachers in the third year at the selected College. This is because, first, they may have learned the statistics topics considered for the instrument for the study and, second, they may be preparing to go out for their teaching practice programme where they are likely to teach some basic statistics topics. The topics considered for the achievement test are based more on those statistics topics found in the College mathematics curriculum, and on the basic school mathematics syllabus, since that is what the participants will likely teach when they complete their College programme.

In addition, EBS 350: Statistics and Probability I course contains both statistics and probability topics. However, the study considered statistics topics. This was because, the weak performance of basic school BECE candidates as reported in the literature was on statistics not probability topics

(WAEC, 2011, 2012, 2013, 2014, 2017, 2019). Finally, the study is delimited to the statistics topics: Data collection, measures of dispersion, and measures of central tendency, which are studied by all the pre-service teachers for the research.

Limitations

Using pre-service teachers from only one college to generalise for the many Colleges in the country is problematic. The response of the selected pre-service teachers cannot be used to make general conclusions.

Again, the method used, quantitative followed by qualitative may make it difficult for large coverage area. Participants whose responses showed misunderstanding of some of the concepts were selected for the qualitative data. This was made possible due to the fact that first, the researcher identified respondents by secret codes known to only the researcher and the individual respondents; second, the codes were arranged according to participants' schools for the off-campus teaching practice. The researcher then was able contact the needed respondents for the qualitative data for the study without much difficulty.

Organisation of the study

The study was organised in five chapters. Chapter one takes a look at the background to the study; statement of the problem; purpose the study; research questions and hypotheses; significance of the study; delimitations and limitations, and the organisation of the study. Chapter two consists of the literature review; Chapter three encompasses the methodology – research design; population; sampling procedure; data collection instruments; data collection procedures, and then data processing and analysis. Chapter four

contained results and discussion, and then chapter five was on summary, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter looks at reviewing literature in relation to the focus of the study: investigating the content knowledge in statistics contents in a college of education pre-service teachers in the Eastern region, Ghana. The focus was also on finding out whether pre-service teachers have low, average, or high, content knowledge in statistics; statistics content areas pre-service teachers find difficulty, and whether there is any significant gender difference in pre-service teachers' statistics content knowledge. This chapter is therefore, organised to include discussions on the concept of knowledge, statistics content knowledge, pre-service teachers at the Colleges of Education in Ghana, constituents of basic school and the Colleges of Education statistics contents in Ghana, and knowledge for effective teaching of mathematics. The chapter, again, looks at the theoretical and conceptual frameworks for the study and some related literature in statistics content knowledge which includes pre-service teachers' difficulties in the knowledge of contents in statistics, and gender difference in pre-service teachers' statistics content knowledge.

Concept of Knowledge

Many have come to reflect on what knowledge could mean, and most of the attempts made in defining knowledge have rather turned out to give types and explanations of knowledge (de Jong & Ferguson-Hessler, 1996; Niedderer, 2007). In defining knowledge as task performance, de Jong and Furguson-Hessler (1996) put knowledge into four types: Situational, (about

situations), Conceptual (about application of facts), Procedural (the how of doing an activity), and Strategic knowledge (a more, wider knowledge in problem solving) (p.107). Again, de Jong and Furguson-Hessler, (1996) report on Alexander and Judy (1986) who mentioned declarative, procedural and conditional knowledge as types of domain specific knowledge. Another classification by Niedderer (2007) is tacit (explicit knowledge) and propositional knowledge (knowledge by acquaintance). There is also task knowledge which is explained to mean the understanding of the requirements of a given task (de Jong & Ferguson-Hessler, 1996), and knowledge that is explained as facts (Bolisani & Bratianu, 2018). de Jong and Ferguson-Hessler for instance, viewed knowledge from the angle of "*knowledge-in-use*," – as a task performance, (p.105).

The several-angle descriptions of knowledge portray a kind of confusion in defining what knowledge is. Thus, the Prologue of the *Ankara Seminar* would mention that "there is ambiguity in terms of what knowledge is" (Kucuradi & Cohen, 1995, p. xviii). The traditional definition of knowledge, "Justified, true, belief" even has some ambiguity (Neidderer, 2007). At the same time, however, according to de Jong and Ferguson-Hessler (1996), whichever way knowledge is described falls into one of cognitive theories, instructional design theories, and epistemological perspective (p.106).

Gagne (1985) was one of those who define knowledge under instructional design theories (cited in de Jong & Ferguson-Hessler, 1996), and describes knowledge to encompass Declarative knowledge, Conceptual knowledge, and Procedural knowledge. For Gagne, declarative knowledge is

more of memory – not only as in to remember, but also one being able to mention ideas in their own words. This, however, may not necessarily be with understanding; and can be linked to knowledge about facts. In Conceptual knowledge, one goes beyond such memory described in declarative knowledge. Conceptual knowledge makes one understand how materials and ideas are organised and categorised; and procedural knowledge is, coming to the understanding of the processes of taking steps to completing a task.

Epistemological perspective (theory of knowledge) puts knowledge into knowledge that, knowledge how, and knowledge by acquaintance (Bolisani & Bratianu, 2018; Dombrowski, Rotenberg & Bick, 2013). 'Knowledge that,' also known as experiential knowledge (Dombrowski, *et al.*, 2013), entails facts one possesses about a place, a person or something (that is, descriptive knowledge). 'Knowledge how' is about knowing how to do something, a skill – and that also is procedural knowledge (Dombrowski *et al*., 2013; Reihenova, 2021); and knowledge by acquaintance is about one being familiar with something, some place or people (Dombrowski *et al*. 2013; Reihenova, 2021).

From the foregoing discourse this study brings out the point that knowledge is about awareness, familiarity of concepts, understanding of facts and the procedure of doing something – skill, for instance. All of that have to do with the mind of the subject who intends to know. Thus, Zagzebski's (1999) definition of knowledge as "the individual's cognitive contact with reality" forms the working definition for this study. In this vein, knowledge is an idea or concept of objects, places, and people that one has in mind. That is to say that knowledge is what forms the memory of the individual, something

the individual interiorizes or possesses. It is a grasp of something by the intellect or the mind; what one forms in the mind by varied means of acquisition. Knowledge, as such, enables people to say something about what they contain or harbour in their mind or memory, come to imitate how something is done, and have the skill of doing something.

Statistics Content Knowledge

Kaba and Ramaiah (2020) mention that in whichever way knowledge may be defined, it is something to be acquired by varied means. That which is to be acquired becomes the object of study. So knowledge could be described as something, the "what of study" students think about (Willingham, 2006). The "what of study" would mean the various topics, ideas or concepts, the theories, generalisations, and skills which school syllabus or curriculum in a country spells out to be studied by students. This "what of study," defined in the syllabus or a curriculum, could be referred to, in the arena of education, as content.

The Mathematics Common Core Programme Curriculum for instance, describes content as strands – the broad areas the mathematics content to be learned (NaCCA, 2019; 2020). Knowledge in "the what of study," knowledge in the contents, knowledge in the constituents of a programme or course to be taught and learned, could be termed content knowledge. As such, content knowledge would be mirrored in the definition by Grossman (1990) as, "the major facts and conceptions within a field and the relationship among them" (p. 6). Content knowledge then could mean the aspect of knowledge to be communicated, the proficiency, the reservoir of the teacher on one hand, and that which is to be learned by the student on the other hand.

As known in education, every subject or programme of study has its contents – general or specific (NaCCA, 2019; 2020). Thus, one could mention English content knowledge, Geography content knowledge, and Economics content knowledge which would mean "the what" to be taught and learned in a given course. This could further be broken down into the various specific branches and, or topics of a course. In mathematics, there is, for instance algebra, calculus and geometry content knowledge.

Drawing from the foregoing exposé, statistics content knowledge could mean the various topics, the nitty-gritty and the constituents of a given statistics course of study; and statistics content knowledge becomes the focus of my study. However, statistics contents differ depending on the group or level of the individuals for whom the course is planned or organised. For example, there is statistics content planned for basic schools (NaCCA, 2019: 2020), secondary schools, and for under graduates at the University and other tertiary institutions. This study, however, focuses on statistics content knowledge of College of Education pre-service teachers in Ghana.

Colleges of Education Pre-service teachers in Ghana

Pre-service teachers are students being trained for teaching at the different levels of education. They could be trained for teaching either at the basic school or secondary school levels. In Ghana, the Universities and the Colleges of Education are where such teachers are trained. Pre-service teachers to teach at the secondary school levels are trained at the Universities, while teachers to teach at the basic or elementary schools are prepared by the Colleges of Education in Ghana. Colleges of Education pre-service teachers form the target of this study.

Pre-service teachers enter the College after their secondary school education. Until 2019, the duration for the programme of study for Colleges of Education pre-service teachers had been three years: they had two years of classroom studies at the College, and spent the last one year outside campus for teaching practice, where they not only practise what is learned so far, but have practical observation of classroom theories and activities. The three-year College programme awarded pre-service teachers with Diploma of Basic Education Certificate which is an upgrade of the former "Certificate A". With the revision of College of Education programme, pre-service teachers are to spend four years, with one year off-campus teaching practice. Also, pre-service teachers, at the end of the programme, will obtain degree in B.Ed (Primary Education) or B.Ed (Junior High School Education) Certificates instead of Diploma. However, the current college pre-service teachers are also trained for the same purpose of teaching at the basic schools in the country.

There are in-service basic school teachers who have already completed their college training and are teaching at the basic schools. However, pre-service teachers also go for teaching practice in their final year as part of their training programme, and are likely to handle some mathematics content areas including statistics even before the completion of their College study. Hence, though these pre-service teachers are still undergoing training at the Colleges of Education, the study would like to investigate if they have adequate knowledge with respect to statistics contents. Again, since pre-service teachers are still under the guidance of college mathematics tutors, in case of any deficiencies found in their statistics content knowledge, they can have solutions provided for them easily at the Colleges before they complete their

study. For, if 'maths-phobia' is to be ended, it should be done at the grounds of teacher education institutions (Marie & Bryant, 2009; Mihako, 1978; Wood, 1988). That will also help them get sufficient training for future teaching of basic school statistics.

Basic schools and the Colleges of Education Statistics Contents in Ghana

The basic schools in Ghana (that is primary and Junior high school [J.H.S.] levels), do not study statistics as a full course. Rather, some statistics topics are found as part of the mathematics course to be studied. These statistics topics found within the mathematics syllabus at the primary level include: Data collection and handling of data; data collection methods; displaying, reading and interpreting bar graphs and pictograms (NaCCA, 2019). Also, at the JHS level, the statistics items found in the mathematics syllabus comprise: Selecting, justifying, and use of appropriate methods to collect data; displaying and analysing data (grouped and ungrouped); data presentation in frequency tables; line graphs; pie graphs; bar graphs or pictographs and use of these to solving and, or posing problem (NaCCA, 2020). The syllabus further contains determining the measures of central tendency (mean, median, mode) for a given ungrouped data and the use it to solve problems.

At the Colleges of Education in Ghana, mathematics forms one of the courses pre-service teachers are trained in. The College of Education mathematics curriculum entails content and method courses as done by Universities that train teachers for secondary schools (Agyei & Voogt, 2011; Nsiah-Asante & Mereku, 2012). Among the mathematics content courses is Statistics, under the broad topic Statistics and Probability (EBS 350: Statistics

and Probability I). There is also the method course offers pre-service teachers with "the how" of teaching statistics and forms part of the College mathematics method courses for primary and junior high schools (JHS) (EBS 322: Methods for teaching primary school mathematics; EBS 356J: Methods for teaching junior high school mathematics).

The content course includes ideas in data collection and representation, measures of central tendency and dispersion, and then probability (EBS 350: Statistics and Probability I). Such contents of statistics are meant not only to furnish pre-service teachers with the prerequisite statistics knowledge, but also to make them competent to handle statistics topics and build good foundation of students' knowledge in statistic at the basic school level. It is to present pre-service teachers with the knowledge in statistics content which will enhance their teaching vocabulary and explanations when delivering lessons in statistics.

Consequently, after the statistics course at the College, pre-service teachers should be able not only to handle statistics contents in the basic school mathematics syllabus, but also be able to assist basic school students handle questions on statistics items in the BECE, sample of which are the following:

BECE 2011, Paper 1(questions 32 and 33):

The table below gives the distribution of ages of students in a class.

Use it to answer Questions **32 – 33**

Ages (years)	13	14	15	16	17
Number of students	3	10	6	7	2

32. How many students are in the class?

A. 28

B. 30

C. 45

D. 75

33. What is the modal age?

A. 14

B. 15

C. 16

D. 17

BECE 2012, Paper 2, Question 4:

The marks scored by some students in a Mathematics test are as follows: 3 3 5 6 3 4 7 8 3 4 5 4 7 4 3 7 4 6 4 8 4 5 6 3 8 4 5 6 4 5.

(a) Construct a frequency distribution table for the scores.

(b) Using the table, find for the distribution, the

(i) mode;

(ii) mean, correct to one decimal place.

(iii) median.

BECE, 2019, Paper 1, Question 12:

The numbers 5, $2x$, 4 and 3 have the mean of 5. Find the value of x.

A. 3

B. 4

C. 5

D. 8

Thus, knowledge on College statistics contents serves as a rudiment for pre-service teachers to be able to handle basic school statistics items.

Knowledge for Effective Mathematics Teaching

There is a dichotomy about the type of knowledge pre-service teachers should be trained in so that they become effective teachers in their respective areas of specialisation (Beswick & Goos, 2012, 2018; Hine, 2015). Some scholars grade specific ones over and above others. Some consider "the how" or methods (Beswick *et al*., 2012), while others mention "the what" or contents (da Ponte & Chapman, 2008; Meany & Lange, 2012). The proponents of the 'how' of teaching (Beswick & Goos, 2018; Fernandez, 2014; Shing, Mohd Saat, & Heng Loke, 2015) stress that not just what the teacher teaches, but how the delivery is done is the most important or what matters. In this case, they endorse the process of teaching, the pedagogy and, hence, the need for pedagogical content knowledge (PCK).

Shulman (1986) sees pedagogical content knowledge as the best ways a teacher explains ideas for students to understand easily. Shulman (as in Solis, 2009) describes PCK as the "teacher's interpretation and transformation of subject-matter knowledge in the context of facilitating student learning" (p. 5). PCK, therefore, has to do with most useful manners that mathematics is communicated for easy understanding (Beswick & Goos, 2012; Hine, 2015). Further, PCK becomes important in teaching because, it embodies certain traits a teacher should have (Beswick & Goos, 2012; Beswick & Goos, 2018; Shulman, 1986). PCK embraces "the types of content-specific skills" (Gess-Newsome & Lederman, 2001; Solis, 2009, p. 5).

Nevertheless, PCK cannot stand on its own (Hine, 2015). This is because the "how of teaching" alone does not suffice good teaching (Hine, 2015; Şahin & Soylu, 2017). In other words, pedagogical practices will not be so important if the teacher does not have good mathematical content knowledge (Hine, 2015; Southwell & Penglase, 2005). Accordingly, for some scholars, how to teach or communicate mathematics alone is of little or no use; the "what" of the teacher knowledge, content knowledge is what counts (Hine, 2015; Mcdiarmid & Ball, 2016).

For that matter some researchers see and applaud content knowledge as an aspect of teaching knowledge that teacher educators should pay attention to (Delaney, Ball, Hill, Schilling, & Zopf, 2008; Hine, 2015). This will not only equip pre-service teachers with the subject matter of the course they are trained in, but will also boost their confidence in their later teaching of the course. Concerning teaching and learning, content knowledge stands out (da Ponte & Chapman, 2008; Meany & Lange, 2012).

Thus, College pre-service teachers, when trained in statistics content knowledge, will have mastery over, and be confident in coming to handle statistics in the classroom. Conversely, pre-service teachers who are not well educated in statistics contents are likely to have inadequate subject matter knowledge in statistics which will not help in teacher education and teaching (Hine & Thai, 2018; Manasia *et al*., 2020; Mcdiarmid & Ball, 2016).

In the US for instance, teachers preparing to teach in the second cycle institutions are to have certificate in Mathematics Content Knowledge (MCK) (Hine, 2015; Wilburne & Long, 2010). Research has established a relation between how well a teacher teaches and their MCK (Hine, 2015; Schmidt,

2002). That is to say that there exists a strong bond between pre-service teachers' statistics content knowledge, and how well they will teach statistics. Moreover, pre-service teachers' narrow knowledge in statistics content could be passed on to their students in the future (Love & Kruger, 2005; Lovett, 2016). That means that pre-service teachers' knowledge of the whole sphere as well as knowledge about vital ideas which form statistics content is key.

Consequently, the need for attention to be paid to statistics content knowledge in the preparation of pre-service teachers cannot be downplayed. This will make the pre-service teacher confident in statistics subject matter. Pre-service teachers, after their College training then, will become competent facilitators in helping their students' statistics learning. This is exactly what Constructivists' Learning theory propounds – that teachers are to moderate students' learning.

Theoretical Framework

Many learning theories exist (Alanazi, 2019; Hein, 1991). Also, each of the theories has their philosophies which spell out how they propose to assist teaching and learning processes. Among such learning theories is Constructivism (Annafo, 2018; Hein, 1991). This section explores Constructivism theory of learning, the proponents and some schools of Constructivism. The section also discusses how Constructivism as a learning model forms the basis for, and fits my study.

Proponents and some schools of Constructivism

Originally linked to Piaget, Constructivism has John Dewey as one of its leading proponents (Hein, 1991). Constructivism encompasses cognitive constructivism, social constructivism, and then radical constructivism

(Alanazi, 2019). According to Alanazi (2019) forerunners from constructivism schools embrace "cognitive development (Piaget, 1964), the zone of proximate development (Vygotsky, 1978), social learning theory (Bandura, 1986), situated cognition (Brown, Collin, & Duguid, 1989), and online collaboration learning (Harasim, 2012)" (p.4).

Constructivism as a learning theory is the philosophical and scientific position that knowledge is acquired through active and dynamic construction (Annafo, 2018; Assuah, Yakubu, Asiedu-Addo, & Arthur, 2017). For the Constructivist, knowledge is built in the mental faculty of the student (Bodner, 2019). Differently put, Constructivism learning theory has it that students are to actively create their own world of knowledge; knowledge happens through students interacting with their environments and experience (Bodner, 2019; Liu & Chen, 2010).

For the learner to be able to create their knowledge, their world of studies, the function of the teacher is paramount (Alanazi, 2019; Liu & Chen, 2010). The teacher serves as a facilitator, a moderator who assists students achieve the required knowledge (Alanazi, 2019). That is to say that in Constructivism, gaining of knowledge happens through students themselves interacting with their environments, but with the assistance of the teacher. If teachers are to play their role as facilitators and to assist students' learning, then their content knowledge is very crucial. For example, the teacher's skill to ask necessary questions to elicit learners' active role in the learning process comes to play. Thus, though students actively create their knowledge in Constructivism, the teacher's role is as well very important. This is to say that

Constructivism theory of learning does not neglect the teacher and their knowledge in contents.

College of Education pre-service teachers will need to actively get involved in the learning of the statistics content course for successful coaching. The category of pre-service teachers for this study is final years, already preparing for their off campus teaching practice programme. Within that period of one-year off campus, the pre-service teachers shall teach mathematics including some statistics topics. A good knowledge in statistics content will provide for pre-service teachers such skills in statistics content which they will need to become facilitators as Constructivism theory proposes. In that case, the pre-service teachers' ability to give relevant examples, ask necessary questions for further clarifications, make proper use of teaching learning materials (TLMs) in statistics, could be enhanced. Also, pre-service teachers' ability to detect errors, making computations and doing necessary applications of concepts in statistics, are all part of pre-service teachers' statistics content knowledge that can influence students' classroom participation and learning. The pre-service teacher needs to select appropriate statistical representations that will pave way for their learners to actively create their world of studies in statistics, and this requires how the pre-service teacher is well versed in the contents of statistics. Thus, Constructivism learning theory is the foundation for my study which seeks to investigate the statistics content knowledge of Colleges of Education pre-service teachers in Ghana.

Conceptual Framework

This segment looks at the frame of concepts, and covers some Mathematical Content Knowledge (MCK) and Statistics Knowledge frameworks, and then discusses the various constructs forming the conceptual frame for the study.

Some Frameworks for Statistics Knowledge

Part of the models for Statistical Knowledge includes Subject Matter Knowledge as well as Pedagogical Content Knowledge (Groth, 2003, 2007; Lovett, 2016). Groth's subject matter knowledge comprises: Common content knowledge, specialised content knowledge, and horizon knowledge (Groth, 2007, 2013; Lovett, 2016). Groth's common content knowledge could mean questions formulation, gathering data, analysing gathered information, and giving interpretation to results, so that one can classify components of common and specialized knowledge for solving statistical problem (Groth, 2013, 2017). This would be used in my study.

Further, the Guidelines for Assessment and Instruction in Statistics Education [GAISE] (2007) model developed in the US for K-12 students (as in Lovett, 2016) classifies statistics knowledge into ranks A, B and C. Rank A consists of low statistics for beginners, B ranks higher, and C contains more advanced content levels (Lovett, 2016). For the GAISE model, statistics contents increase in complexity from A to C (Table 2). Though the GAISE (2007) model was for K-12 level, the definitions within can be for any level of statistics studies (Lovett, 2016) and so it is adapted for my study. Table 2 gives the adapted level and objectives for the GAISE (2007) statistics model.

Table 2: The adapted levels and objectives for the GAISE (2007) statistics model

Level	Objective
A	• Students should have chances to generate questions about a particular context, and determine what data might be collected to answer these questions. • Students' learning of the use of basic statistical tools in analyzing data, and be able to make informal or casual implications in answering the posed questions.
B	• Students become more aware of the statistical question distinction (a question with an answer based on data that vary versus a question with a deterministic answer). • Students make decisions about what variables to measure and how to measure them in order to address the question posed. • Students use and expand the graphical, tabular and numerical summaries introduced at Level A to investigate more sophisticated problems. • Students investigate problems with more emphasis placed on possible associations among two or more variables and understand how a more sophisticated collection of graphical, tabular and numerical summaries is used to address these questions.

Source: Franklin & Kader, 2010; Lovett, 2016.

Table 2 (Cont'd.)

Level	Objective
C	• Students should be able to formulate questions and determine how data can be collected and analyzed to provide an answer. • Students should be able to design and implement a data collection plan for statistical studies, including observational studies, sample surveys, and simple comparative experiments. • Students should be able to summarize numerical and categorical data using tables, graphical displays, and numerical summary statistics such as the mean and standard deviation.

Source: Franklin & Kader, 2010; Lovett, 2016.

The conceptual framework for my study based on the GAISE (2007) and Groth (2007, 2013) statistics knowledge models is shown in Figure 1.

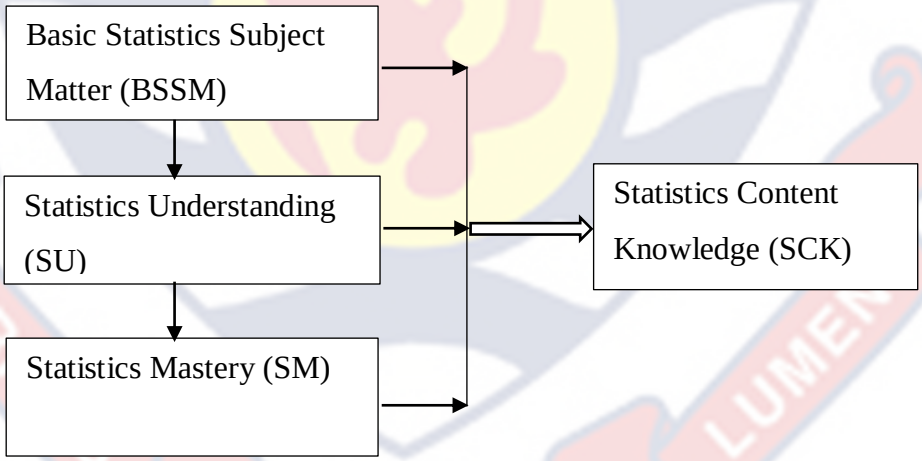


Figure 1: Conceptual framework from GAISE (2007) statistics model

Statistics Content Knowledge (SCK)

Mathematical Content Knowledge (MCK) is seen as understanding fully, the depth, breadth, connectedness, and thoroughness of mathematics (Hine, 2015; Ma, 1999). In that sense, MCK becomes the nitty-gritty of

mathematics which a teacher possesses as knowledge for teaching – the full "measure" of the constituents of mathematics. This definition of MCK serves as yardstick of the scope of Statistics Content Knowledge (SCK).

Statistics Content Knowledge (SCK) could be explained, therefore, to mean knowledge of all the constituents – the 'what' of the statistics course to be taught and studied. SCK will encompass knowledge of the various fragments: the individual topics and subtopics, the full subject matter and concepts of the statistics course, a full knowledge of all statistics contents. SCK shall mean a full knowledge, the nitty-gritty of statistics contents in a given statistics curriculum. The various concepts, generalisations, skills, and the nitty-gritty forming SCK are of various degrees. Such constituents of SCK can be modelled along some statistics frames, one of which is the GAISE (2007) model (Lovette, 2016), in Table 1. Based on the three levels in the adapted GAISE (2007) model which is in Table 2, SCK will be explained to entail three parts: Basic Statistics Subject Matter (BSSM), Statistics Understanding (SU), and Statistics Mastery (SM). In other words, a combination of these three, BSSM, SU, and SM define SCK (Figure 1).

Basic Statistics Subject Matter (BSSM)

The common Content Knowledge (which is the knowledge statistics courses present) according to Groth (2007, 2013) model, coupled with level A of GAISE (2007) model and conceptualisation of content knowledge by Shulman (1986) shall form the theme Basic Statistics Subject Matter (BSSM) in my study. Shulman (1986) used Subject Matter Knowledge synonymously with Content Knowledge of mathematics: all what is to be learnt mathematics. In this sense, BSSM is explained to mean what is to be learnt but limited to the

basic knowledge in a given statistics content regarding concepts, computational skills, procedures, methods and generalisations, and the interrelatedness of all such knowledge, and without an in-depth understanding of concepts. In other words, BSSM refers to a general, but shallow knowledge of the entire statistics content course. One would be able to identify topics and sub-topics of a statistics course. By the GAISE (2007) model, BSSM would be placed within Level A (see Table 2), where one could memorise concepts and definitions, for instance mode or mean formula, but may not necessarily have thorough understanding of such concepts and definitions.

Statistics Understanding (SU)

Mathematics Understanding, according to Heaton (as in Wilburne & Long, 2010) is, "the dynamic, constructed, and reconstructed process of sense making by the learner" and "learning to represent or communicate mathematical ideas or interpret mathematical representations through the use of language, diagrams, pictures, manipulatives, and other tools" (p. 2). Understanding then goes beyond memorisation of definitions and formulas. Similarly, by SU, the pre-service teacher goes beyond BSSM. Pre-service teachers in addition to identifying formulas and definitions, may understand each variable in a given formula and the procedures to follow through to arrive at a conclusion. SU would mean pre-service teachers will able to identify the why behind a statistical activity taken. For instance, the pre-service teacher would both memorise a formula and will likewise be able to understand each variable in that formula, and how to manipulate the variables with an in-depth understanding. By the GAISE model, SU would be within Level B (Table 2).

Statistics Mastery (SM)

From Benjamin Bloom's theory in Mastery Learning, one could see mastery as that possessed by the teacher which enables them to display variations in teaching (Shafie & Jaya, 2010). Mastery is that which erupts the various teacher's and student's thinking processes to act based on what they have in their reservoir of knowledge in contents. So, SM would mean one having both BSSM and SU regarding how solutions are presented and applied in a more in-depth manner. One then, would have the ability to use achieved statistical ideas to apply, analyse, synthesise, and evaluate and present solutions. SM becomes the comprehensive knowledge in a given area of statistics, making the teacher and the student alike have maximum control or strength, a total command, over a course or subject, with less difficulty. By SM, College of Education pre-service teachers will have BSSM and SU, and will as well be able to integrate the two and to have the flexibility of skills regarding problem-solving and data analysis in statistics content topics, without much difficulty. By the GAISE (2007) model, SM would be within the level C (Table 2).

In sum, the conceptual framework drew statistics content knowledge from Mathematical Content Knowledge (MCK), explored some frameworks in MCK and in statistics knowledge, and drew the various constructs making the basis of the conceptual frame for the study.

Works on Content Knowledge and Statistics Content Knowledge

Content knowledge and pre-service teachers have diversely been researched (Agyei & Mensah, 2018; Agyei & Voogt, 2012; Hein, 1991; Shulman, 1986, 1987; Wilmot, 2015: Wilmot et al., 2018). However, not

much could be said as regards pre-service teachers and their statistics content knowledge (Bursal & Paznokas, 2006; Heeralal & Bayaga, 2011; Mensah, 2017; Wolf, 2018; Agyei & Voogt, 2012; Narh-Kert 2014). For instance, Hill *et al*., (2005) studied teachers' mathematics knowledge and its influence on students' achievements. More than a year's mathematics achievement gains of first and third graders were selected from within teachers in selected schools, and analysed using linear mixed-model. The results showed that teachers' mathematical knowledge and students' achievement gains had significant relationship in first and then third grades. However, their work concentrated on elementary in-service teachers, not elementary pre-service teachers. Also, their work was not on pre-service teachers' statistics knowledge; neither did it mention anything about any relationship with respect to pre-service teachers' content knowledge according to sex.

Again, a research by Guler and Celik (2018) investigated pre-service mathematics teachers' Algebraic Teaching Knowledge – pedagogical content knowledge – at the elementary level. Their study used 20 questions based on MacCrory (2012) conceptual framework for algebraic teaching knowledge, and involved 101 sampled final year pre-service teachers at the university. The data was interpreted by Rasch analysis. The result revealed that pre-service teachers had weak pedagogical content knowledge. The study, however, was done in algebra not statistics content knowledge. Moreover, it was done outside Africa and for that matter Ghana to be specific. This study seeks to investigate what statistics content knowledge basic pre-service teachers in Ghana have.

Hine and Thai (2018) employed survey-generated data with semi-structured qualitative interviews to investigate how ready secondary school pre-service teachers were as regards mathematics teaching, the content and pedagogical content knowledge they had. The participants were students of three different programmes, from two universities. The study which was to find out how these pre-service teachers sensed their first-time teaching of mathematics, argued that there was the need for further training of pre-service teachers in content and pedagogical content knowledge. The semi-structured interview added to the survey-generated data could give detailed explanations and, for that matter, solid conclusion to the study. However, the work considered secondary school pre-service teachers other than basic school pre-service teachers. Also, the work was not done in contents of statistics, but on perception of how ready the participating teachers would be in handling mathematics lessons. This study, thus, considers basic school College teachers, and the state of their knowledge in statistics contents.

There was a research into mathematical content knowledge (MCK) but among elementary pre-service teachers and how and when their different categories of MCK get developed during their schooling (Livy, Vale, & Herbert 2016). The study was considered and carved from a larger study, and two pre-service teachers formed the participants, while four-year longitudinal mixed-method, a method developed by 17 Australian pre-service teachers, was used. The study found that variables such as detailed programme structure, and the quality of pre-service teachers' learning experiences, among other factors, enabled pre-service teachers form their MCK. However, here again,

the research was not about pre-service teachers' knowledge in statistics content.

Similarly, a research was organised on pre-service teachers for the middle school level regarding how they perceived their knowledge preparation and mathematics knowledge with respect to division of fractions (Li & Kulm, 2008). Among the findings, pre-service teachers for the middle school level did not show appreciable confidence and perception in their mathematics knowledge for teaching division of fractions. The study, however, was not in statistics, and the pre-service teachers involved were for middle schools, not basic schools. The study was silent on the issue of gender in relation to the variables investigated about those sampled pre-service teachers. These gaps are being filled by my study.

Zuya (2017) looked at knowledge in algebra concept and procedure of 36 prospective mathematics teachers. The research used only qualitative methods in gathering data. The data was analysed by means and standard deviation, and paired t-est. The result revealed procedural knowledge of the prospective teachers being better than content knowledge. My study considers statistics content knowledge of pre-service teachers, using both quantitative and qualitative data collection approaches.

Aside the above, although research in statistics exist, they either did not much consider basic school pre-service teachers as the population, or were into different aspects of statistics other than statistics content knowledge (Bursal & Paznokas, 2006; Marie & Bryant, 2009; Opolot-Okutut, Opyene-Eluk & Mwanamoiza1, 2008). A mention could be made about Estrella, Olfos, & Mena-Lorca, 2015 who studied primary school teachers knowledge

of pedagogical content in statistics. The work covered how teachers were aware of students' knowledge of statistics, and statistics content. The study used questionnaire which included the understanding a teacher has about graph, cognitive levels and understanding of representational systems. With 85 primary teachers as participants, the study suggested that future teachers should be trained in building the awareness of statistical knowledge of students. The study was on statistics, but not about basic school pre-service teachers. Secondly, the study used only questionnaire. My study employs explanatory sequential method, that is quantitative followed by qualitative methods in considering pre-service teachers' statistics content knowledge.

Schau and Emmioglu (2011) also conducted a study on students' attitude to statistics as introductory statistics course begins, and what changes come about in attitude from the beginning of the course to the end. Teachers taking introductory statistics course at the post-secondary levels formed the participants for the study. Employing Attitude Towards Statistics survey, the study revealed that it will be inadequate to generally, use introductory statistics to determine students' attitude towards statistics. Though the study was on statistics, it was not about pre-service teachers. Moreover, those participating teachers were not for basic schools, but for post-secondary levels of education. The study considered differences in the state of knowledge of contents in statistics of participating teachers according to their sex. My work, therefore, seeks basic school pre-service teachers' statistics content knowledge, as well as whether there is any difference according to sex, regarding pre-service teachers' knowledge in statistics contents.

Through explanatory sequential method, Lovett (2016) researched pre-service secondary school mathematics teachers' preparedness towards teaching statistics. The study used 217 participants. From the results of the study, pre-service teachers neither possessed statistics content knowledge for instructing secondary level statistics, nor confidence for teaching secondary school statistics topics. The study involved secondary, not basic school pre-service teachers. Also the research did not find out anything about participants' preparedness in teaching statistics at the secondary level with respect to their sex. My study seeks to fill the identified gaps.

There was, again, a search into the status of teaching statistics in Uganda (Opolot-Okutut, Opyene-Eklu, & Mwanamoiza, 2008). The study was done to cut across the various levels of education in Uganda: primary, secondary and tertiary institutions. Their study revealed some challenges concerning the teaching of statistics to include rote learning from textbooks, less attention given to the teaching of statistics, and less teaching resources. Similar to Opolot-Okutut, *et al.* (2008) research is that of Garfield and Everson (2009) which came out with online programme of graduate-level course that would demonstrate and build specific knowledge about statistics teaching and learning. Their work was rather on statistics teaching and learning, not about statistics content knowledge of basic school pre-service teachers as my study investigates.

Agyei and Voogt (2012) did a case study (collaborative design) pertaining to secondary school pre-service mathematics teachers' technological pedagogical content knowledge (TPCK). They sampled four pre-service teachers. Experimental teacher interview and teacher evaluation

questionnaire were used for data collection. The study, among other findings, mentioned that an intense effort should be put in for adequate training of pre-service teachers in TPCK development. It was, however, neither on basic school pre-service teachers nor done in statistics content knowledge.

Nsiah-Asante and Mereku (2012) worked on pre-service teachers, the relationship between their content knowledge and mathematics knowledge for teaching (MKT) as regards the teaching of fractions, number operations, and number patterns. Achievement test from MKT was the data collection instrument. With 100 pre-service teachers sampled, the results from their work revealed that pre-service teachers' mathematics knowledge for teaching was low. The study, however, did not consider statistics contents and, also, if there existed any relation in pre-service teachers' contenet knowledge by sex. Again, the study used only quantitative method. That means that some detailed information which could have been revealed, if qualitative method was employed in addtion to the quantitative, perhaps got hidden. My study used both quantitative and qualitative method to investigate statistics content knowledge of pre-service teachers.

Pre-service teachers' Difficulties in Statistics Content

Despite its importance for human life and so its inclusion in the mathematics curriculum to be studied in schools (Groth, 2017), statistics is feared as a course of study at all levels of education (Estrella & Mena, 2014). Students' difficulties in statistics are even reported at the basic school level (Sorto, 2010; WAEC, 2012; 2013; 2019). The phenomena of students showing weak performance in statistics are also found with pre-service teachers (Warren & Cunnington, 2017). According to Warren and Cunnington (2017),

college students see statistics to be interfering with their anticipated degree. Schau and Emmioglu (2011) added that students would not do statistics if they realized it was going to be involving, a statement which portrays that students, in a way, show a kind of disinterest in statistics.

An investigation by (Godino *et al*., 2014) also reports on pedagogical content knowledge model for evaluating and improving pedagogical and statistics content knowledge. Using 55 elementary school prospective teachers, the research recommended that there was a need for better training of pre-service teachers in statistics – a result informing pre-service teachers' difficulties in statistics. Again, Lovett (2016) unearthed that pre-service teachers find difficulties with, among others, reasoning skills, focus on procedures, and then constructing and interpreting graphical representations.

My study seeks to investigate the state of Ghanaian pre-service teachers' knowledge in college statistics content course, and which topic(s) of the college statistics content course pre-service teachers find difficult.

Differences in Pre-service Teachers' Statistics Content Knowledge by Sex

Sex of students has been found to have influence on the learning of the sciences and mathematics (Leder, 2016). Peker, Halat, and Mirasyedioğlu (2010) sought whether there existed any significant difference in teaching anxiety in mathematics regarding the sex of participants. The study used 368 pre-service teachers. Likert-type questionnaire which had 23 items, and independent t-test were employed. The results showed no difference according to sex of pre-service teachers and their teaching anxiety in mathematics. The result from Peker, *et al*. goes contrary to some other researchers who found

sex of participants as playing a role of difference in statistics learning in favour of male students (Ajai & Imoko, 2015; Leder, 2016).

Females, from basic to tertiary levels of education, have been reported in literature to show low performance in mathematics (Bahtiyar, 2017; Leder, 2016). In Mexico, a report on sex of participants and mathematics education buttresses male dominance over females in matters of mathematics education (Ajai & Imoko, 2015; Leder, 2016; Kimani et al., 2013). This result was not different from that obtained in Australia as public opinion that was sought about participants' sex and their achievement in mathematics went in favour of males (Forgasz & Leder, 2017).

In the same fashion, Johnson and Kuennen (2006) in a course in introductory statistics investigated basic skills and performance in relation to students' sex. They found significant difference existing between students' performance and their sex.

Difference according sex and mathematics performance about prospective teachers is also reported in literature. For instance, Naa, Wilmot, and Ashong (2018) investigated if there was any difference regarding mathematics performance and sex of College pre-service teachers. The study used convenience sampling to select 100 participants. The result of the study showed no significant difference in performance in mathematics in relation to participants' sex. Moreover, a research by Chiesi and Primi (2016) showed that there was difference regarding participants' sex and attitude towards statistics, but not in performance in statistics. However, less is known about the sex of college pre-service teachers and their knowledge in statistics contents.

The foregoing discussions provide more than one conclusion to participants' sex and mathematics achievement. Some works advocate there is male dominance over females (Arhin & Hokor, 2021), while some others show no significant difference sex of participants and performance (Peker, *et al.*, 2010). This research investigated if there was any difference in statistics content knowledge considering College pre-service teachers in Ghana and their sex.

Summary

From different explanations of knowledge explored, this chapter considered the concept of knowledge to be in line with Zagzebski (1999) that "knowledge is the individual's cognitive contact with reality." Again, the chapter explained content knowledge and related that to what statistics content knowledge means in this study. Also, contents of basic schools and Colleges of Education statistics in Ghana were mentioned, and Constructivism theory of learning was discussed as the theoretical frame for the study. Furthermore, other studies such as how Shulman (1986) conceptualised Content Knowledge, Groth (2007, 2013) and GAISE (2007) models for statistics formed the conceptual framework for my study. A review of literature pertaining to pre-service teachers' difficulties in knowledge of statistics content, as well as differences in sex of pre-service teachers and their statistics content knowledge was made. Literature showed many works which have been done regarding in-service and pre-service teachers on the topic of content knowledge in diverse areas of mathematics education and statistics. In spite of that, less is known, especially in Ghana, about statistics content knowledge of basic school pre-service teachers, and the difference in pre-service teachers'

sex and thrie statistics content knowledge (Narh-kert & Ampadu, 2014; Asampana, Nantomah, & Tungosiamu, 2017; Asare & Nti, 2014). My study seeks to fill such gaps.

CHAPTER THREE

RESEARCH METHODS

Overview

The work sought to investigate the statistics content knowledge of basic school pre-service teachers in selected Colleges of Education in Ghana. It was intended to investigate the level of pre-service teachers' knowledge level in statistics content. The study also sought which of the college of education statistics contents pre-service teachers find difficult. The study additionally investigated if any difference existed considering pre-service teachers' knowledge in statistics contents with respect to their sex. This chapter provides the methodology for the research to include the research design, population, sampling procedure, and data collection instruments and their reliability, validity, and trustworthiness. The chapter also looks at data collection procedure, data analysis procedure, and ethical considerations.

Research Design

A research design is the procedures on how data is gathered, analysed, interpreted and reported in a research (Creswell & Creswell, 2018). A research design describes the total plan which aids in connecting the theoretical research problems with the relevant, practicable research which is observable. The research design gives the way for obtaining the necessary data, the needed methods for collecting and analysing the data, and how everything of the data will answer the research questions (Grey, 2014).

Different research designs exist for different types of study, one of which is mixed methods (Creswell & Creswell, 2018; Gounder, 2012). Mixed methods are gradually more emerging popular in the research world (Chan &

Wong, 2019). This is because mixed methods support triangulation, where data can be cross-checked or confirmed through more than one method. Mixed methods design "corroborates results from diverse methods of studying a given phenomenon in a more rigorous manner" (Gounder, 2012, p. 16). The researcher is able to find further and better explanations which back and, or shed more light on some issues of interest found in the quantitative analyses. In mixed methods design, quantitative method is used for gathering data which are from predetermined and closed-ended items as in a questionnaire, and qualitative method collects data from open-ended items (Creswell & Creswell, 2018; Gounder, 2012).

Explanatory sequential mixed method design which allows for quantitative, followed by qualitative methods best fits my study. This is because my study investigates Colleges of Education pre-service teachers' content knowledge in statistics. Quantitative data was first collected using questionnaire containing achievement test, while interviews and explanations from participants whose scores depicted certain events of interest to the researcher formed the qualitative data (Creswell & Creswell, 2018).

Population

Final year pre-service teachers at the six colleges of education within the Eastern region, Ghana, formed the population of the research. The final year pre-service teachers would have had tuition in the statistics content courses, and so would be in the position to handle the test items on the data collection instrument. Pre-service teachers of one of the six colleges, however, was used. The selected College was used for the reason that during data collection, the pre-service teachers were having their off-campus teaching

practice programme in various basic schools which were far apart. Thus, the researcher could only concentrate on, and so cover the pre-service teachers in those basic schools in the catchment areas of the selected College. That was also to ensure and enhance an adequate sample size for the study (Taherdoost, 2016). Again, the pre-service teachers in the college selected as well as those in the other colleges elsewhere in the region and the country could be said to be on the same pedestal. For instance, both the pre-service teachers in the selected college and others elsewhere in the country had the same level of education, and read the same statistics content course. They all, also, appear to have issues with statistics contents (Chief Examiners report, IoE, 2021). In all, there were 362 pre-service teachers forming the population from the selected College. Table 3 presents the distribution of population for the study according to sex of participants.

Table 3: Population of pre-service teachers by sex

Sex	Number of Students
Female	142
Male	220
Total	362

Source: Fieldwork, 2021

Sampling Procedure

The study employed Convenience method (a non-probability sampling method), inexpensive and an easy option (Taherdoost, 2016), to choose the region, district and the College selected for the study. The researcher found that it was not only cost effective working within the Eastern region and the selected College, but also to enhance and facilitate the administration and

collection of the research instrument with less cost, but time effective (Taherdoost, 2016). Since pre-service teachers were spread over a large area for their off-campus teaching practice, the researcher selected the College under study conveniently. That assisted the researcher to concentrate on, and so cover as many pre-service teachers as possible in the basic schools within the catchment districts of the selected College. That was also to ensure that the researcher could gather an adequate sample, in terms of size, for the study (Taherdoost, 2016). Purposive sampling technique, based on the researcher's benchmarks or the condition of the elements who are to be included in the study as predefined (Alvi, 2016), was used to obtain the target population. Pre-service teachers in their final year of study from the selected College were used because they fit the criteria of those who have been taught the College statistics content course, and so are comparatively supposed to be capable of responding to the test items on the data collection instruments.

Participants were chosen for the research through multistage probability sampling method (Bukhari, 2021). For the period of data collection, the pre-service teachers forming the population for the study were on their off-campus teaching practice programme in various basic schools within the Kwahu South and Birim North districts, and the Mpraeso Municipality. First, the districts and the basic schools where the pre-service teachers were assigned for their teaching practice were conveniently selected.

Census sampling method which uses all members in a group selected for a study (Daniel, 2012; Lavrakas, 2008) was utilised in selecting pre-service teachers in each basic school the researcher visited. By Krejcie and Morgan (2006) table of sample size determination (in Bukhari, 2021), a minimum of

186 participants should be sampled from the total population of 360. Therefore, the researcher collected and used 191 out of the total population of 362 participants for the study.

Prior to the above, purposive sampling was applied to select 50 final year pre-service teachers for pilot study from OLA College of Education in the Central region of Ghana.

Data Collection Instruments

A questionnaire with teacher-made achievement test and an unstructured interview guide formed the instruments for quantitative and qualitative phases respectively, of the study (Ary *et al*., 2010).

Questionnaire and the Teacher-made Achievement Test

The instrument was organized to have three components, A, B, and C (see Appendix A). The first component A, sought demographic details such as sex and age, from the participants, and part B comprised topics from College of Education statistics content course for the Four-Year Bachelor of Education Programme, and participants were to select which of the topic(s) they found difficult. The topics were put under three Sections. Section one has topics under data collection and representation, section two has topics on measures of central tendency, and section three contains topics under measures of dispersion.

Part C had 63 test items on statistics to be answered by participants from the selected College. The questions were based on the course outline of College of Education statistics content topics (EBS 350). The 63 test items were intended to find out the statistics content knowledge of participating pre-service teachers, and were categorised under Basic Statistics Subject

Matter(BSSM), Statistics Understanding (SU), and Statistics Mastery (SM). BSSM was explained to mean a general, but shallow knowledge of the entire statistics content course, where one could memorise concepts and definitions, but may not necessarily have thorough understanding of such concepts and definitions memorised. SU means pre-service teachers' ability to identify the why behind a statistical activity. SU goes beyond just memorisation of concepts and definitions. SM means one's ability to use achieved statistical ideas to apply, analyse, synthesise, and evaluate and present solutions. SM becomes that comprehensive knowledge which makes the teacher and the student alike have maximum control, a total command over a course or subject, with less difficulty.

The 63 items were further grouped under three Sections. Section I: Collection and presentation of data; Section II: Measures of central tendency; Section III: Measures of dispersion. Each Section contained 21 test items made to measure the three constructs, BSSM, SU, and SM. Each of the constructs, BSSM, SU, and SM was measured by seven test items under each Section.

Table 4 provides summary of the number of test items under each Section, and under each of the three constructs.

Table 4: Number of test items under each section and construct

Construct	Section			Total
	I	II	III	
BSSM	7	7	7	21
SU	7	7	7	21
SM	7	7	7	21
Total	21	21	21	63

Source: Instrument (2022)

Unstructured Interview Guide

This is a common tool employed by researchers to gather qualitative data which are comparatively unbiased, in research (Bihu, 2020). From this assertion then, unstructured interview was used in the study to gather the qualitative data. That was to help give further explanations to the responses of participating pre-service teachers in the quantitative data. Sample of the questions used is found in Appendix B.

Reliability and Validity

For content validity as well as reliability of the instrument, a pre-test was done with final year pre-service teachers from OLA College of Education in Cape Coast, central region of Ghana, after the researcher got the necessary approval from the Principal of the College, with an introductory letter from the Department of Mathematics and ICT Education of Cape Coast University. The pre-service teachers under consideration were also informed and prepared through the help of the head and tutors of the Mathematics Department. Since the participants used for the pre-test had the same level of education as those in the selected College of Education, the result from the pre-test assisted the researcher to reshape the instrument. The reliability coefficient for the teacher-made achievement test through test-retest was 0.702, which Ary *et al*. (2010) see as reliable enough to be used. This formed the instrument for the quantitative data (see Appendix A).

Also, a casual look at the unstructured interview instrument by two PHD students formed the face validity, while a careful look at its construction and re-construction by the researcher and the supervisor ensured its content

and construct validity instrument. That also helped the unstructured interview guide for the qualitative to be fine-tuned.

Trustworthiness

Trustworthiness tells how authentic an interview data is, and so provides the grounds for readers' confidence in a gathered information (Amankwaa, 2016). In establishing the trustworthiness of a qualitative data, at least two of the known approaches could be employed (Ary *et al.*, 2010). Thus, member checking, external audit, and reflexivity which are mostly employed by researchers according to, for instance, Amankwaa (2016) and (Ary *et al.*, 2010) were employed. In member checks, the written interviews were given to interviewees to confirm if what they said was what was written. For external auditing, two Ph.D. students compared and confirmed whether the interview data were supportive of the findings, discussions, interpretations and conclusions. Reflexivity assisted the researcher's self-reflection in coming to recognize self-biases which existed, and duly deleted them.

Data Collection Procedure

The needed permission letters from the appropriate authorities in the Mathematics and ICT Education Department and the Internal Review Board (IRB) of Cape Coast University were received and used to seek permission from appropriate authorities of the College selected for the study (see Appendix C). The researcher made initial visit to the selected College so as to get aquatinted with the environment, the participants, and their tutors. During the visit, the researcher consulted the Principal, Head of Mathematics Department and any other needed administrative staffs, and explained the research objectives to them. Thereafter, the researcher discussed with the

Principal, Departmental head, tutors, and the participants which dates and times the instruments were to be administered and collected.

Data collection procedure for the quantitative data

During the distribution of the instruments the participants were on their off-campus teaching practice, so the researcher went to the participants in the various basic schools where they were assigned. Altogether, the researcher visited thirty basic schools within which the participants were having their off-campus teaching practice. The researcher sought the consent of the heads of the basic schools for the participants to be released for the purpose of the study.

Two schools were visited a day, and so ten schools were visited per week. Thus, the researcher used three weeks to cover all the thirty basic schools. At each visit, all participants in each visited school came together in one classroom in the school to respond to the instruments. Participating pre-service teachers used ninety minutes in responding to the instruments. For the researcher to ensure independency in participants answering the test items, in each school visited, the participants completed and submitted their answers to the researcher. Also, the participating pre-service teachers provided their answers on the test papers for submission, under the supervision of the researcher.

Data collection procedure for the qualitative data

After the quantitative data were collected, the researcher marked and scored the responses. Some of the responses which showed misunderstandings of statistics concepts were selected. The researcher invited and interviewed the respondents of such responses and that formed the qualitative part of the

study. This became possible by the researcher having identified respondents by secret codes given by the researcher to participants, and so known to only the researcher and the individual respondents during the quantitative data collection. The codes were arranged according to participants' basic schools for the off-campus teaching practice. The researcher was thus able contact the needed respondents for the qualitative data for the study without much difficulty. In all, the researcher selected eight participants for the qualitative phase of the study which involved interviewing of the eight selected respondents. The researcher met each of the eight selected respondents individually. They were asked to explain why they responded to some of the questions as identified on their scripts. The answers given by respondents were recorded in writing by the researcher for analysis. Open ended instrument having six questions served as the interview guide used for gathering the qualitative data. The interview questions were based on participants' responses which showed misunderstandings of statistics concepts (see Appendix B).

Data Processing and Analysis

Data collected were first coded under the various constructs, BSSM, SU, and SM, and edited by assigning numerical values where applicable, to the various responses. Then the researcher analysed the coded data using descriptive statistics such as the frequency and percentage distributions as well as mean and standard deviation. Inferential statistics, specifically an independent sample t-test was also employed. The various research questions and hypothesis were analysed as follows:

Research question one

"Which topic(s) in the College of Education statistics content course do pre-service teachers have difficulties in learning?"

Research question one found out the College of Education statistics content topic(s) that participants find difficulties in learning. The list of topics in the College of Education statistics course outline were given in part B of the data collection instrument (see Appendix A). Pre-service teachers selected (by ticking) which topic(s) they find difficult to learn. Responses were coded, and descriptive such as percentages, frequencies and mean were employed for the analysis. This was to aid the researcher easily compare and describe difficult topics by majority or minority responses (Cohen *et al*., 2007).

Research question two

"What is the level of pre-service teachers' statistics content knowledge in the Colleges of Education statistics?"

Research question two pursued the degree of knowledge in statistics content pre-service teachers possess after they have been taught the contents in statistics course at the College of Education. The question sought whether pre-service teachers have very low, low, average, or high knowledge in the contents of statistics. The grading system of University of Cape Coast (UCC) for undergraduate students was adapted for this purpose. Table 5 shows this grading system of UCC.

Table 5: UCC grading scale for undergraduate students

Raw score	Grade	Credit value	Interpretation
80 – 100	A	4.0	Excellent
75 – 79	B+	3.5	Very Good
70 – 74	B	3.0	Good
65 – 69	C+	2.5	Average
60 – 64	C	2.0	Fair
55 – 59	D+	1.5	Barely Satisfactory
50 – 54	D	1.0	Weak Pass
0 – 49	E	0	Fail

Source: UCC, (2022)

In Table 5, the raw score signifies the student's mark in percentage. The grades are letters corresponding to the respective numerical weightings according to the raw scores obtained. From the table for instance, students scoring within 75 and 79 would have grade B+, and students scoring within 50 to 54 would have grade D. The grading system has corresponding interpretation for each grade. For instance, students scoring within 75 to 79 would be seen to be very good in their fields of study. Correspondingly, students scoring within 65 to 69 are seen to be average students in their fields of study.

The researcher adapted UUC's grading system as the yardstick of measurement for two reasons. First, the University's grading system is standard. Second, the level of undergraduate students in UCC matches with that of pre-service teachers in the Colleges of Education as they all for degree programmes. Also, the selected College is under the supervision of UCC. Thus, UCC undergraduate students and teachers in the Colleges of Education

could be graded with same yardstick. The adapted yardstick for measurement from UCC's grading system used to describe pre-service teachers' knowledge level in College of Education statistics content is shown by Table 6.

Table 6: Adapted grading system of the University of Cape Coast

Raw score	UCC's interpretation	Adapted interpretation
80 – 100	Excellent	Very High
75 – 79	Very Good	High
70 – 74	Good	
65 – 69	Average	
60 – 64	Fair	Average
55 – 59	Barely Satisfactory	
50 – 54	Weak Pass	Low
0 – 49	Fail	Very Low

Source: Grading scale, UCC (2022)

The adapted grading scale used is without the grade nor the credit value. From Table 6, if a pre-service teacher scores within, 0 – 49 and 50 to 54, they were described to have very low and low knowledge levels respectively, in College of Education statistics contents. Also, a participant scoring from 55 up to 69 were described to have an average knowledge in College of Education statistics contents. Sores from 70 up to 79 and within 80 – 100 would be described high and very high knowledge levels respectively.

To answer research question two, the researcher analysed participants' scores by descriptive such as percentages, frequencies, mean and standard deviation. The descriptive for the analysis were to aid the researcher easily make comparisons, ranking scores of pre-service teachers into very low, low, average, high and very high statistics knowledge levels as stated in the study.

Research hypothesis

"There is no statistically significant difference between female and male pre-service teachers' statistics content knowledge."

The research hypothesis sought if the scores of respondents showed any difference when male participants were compared to female counterparts. To analyse this research hypothesis, the researcher used independent sample t-test. That was used because two different groups, male and female pre-service teachers were under consideration (Gerald, 2018).

Ethical Considerations

Ethical considerations relating to the study were mentioned in the light of the below subtopics:

Ethical issues relating to the purpose of study

The researcher clearly explained the purpose of the research to the respondents. This ensured that any form of ambiguity was erased. By that, both participants and researcher did not conceive or convey different ideas and purpose, but had the same purpose in mind. Since all participants could read, write and understand basic English, that was the mode of communication.

Issues related to data collection

To protect and value participants, research plans were sent to Institutional Review Board (IRB) of the University of Cape Coast to be reviewed (see Appendix C). The rights and freedom of the respondents during data collection were not trampled upon. So, the participants, for instance, were not forced to partake in the study. The researcher ensured that participants received and responded to items on the instruments under healthy and hygienic conditions in the classrooms used.

Issues relating to data analysis and interpretation

During data collection and analysis, the researcher did not, in any way, reveal the identity of participants or the participants' institution. Thus, participants remained anonymous throughout data collection processes and analysis. Again, the data collected and analysed remained under strict custody of the researcher. In addition, collected data was used for the purpose of the study only.

Issues relating to performance

Participants' performance was not used as sources of competition since that would strongly defeat the purpose of the study.

Issues relating to writing and publishing the research

The researcher reported the results from the study as it was, that is objectively. In that case, in writing and publishing the result from the study, the researcher did not, in any way, add to or subtract from any emerging information from the study.

Summary

The chapter was about the methodology of the study. It looked at the research design, the population, and the sampling method. Also, the chapter explained the instruments the study employed, reliability, validity and trustworthiness of the instruments, the procedure used in collecting data from participants, and ethical issues relating to the study. Finally, the chapter considered how the UCC grading system was adapted to fit the study, and then brought to bear the various tools by which the research questions and hypothesis were analysed.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The study investigated pre-service teachers' statistics content knowledge in a College of Education in the Eastern region of Ghana. The study sought to find out Statistics content topic(s) pre-service teachers have difficulties in learning and the level of pre-service teachers' knowledge in contents of Colleges of Education Statistics. The study also explored if there is any statistically significant difference between female and male pre-service teachers' Statistics content knowledge.

The first phase of the study involved a sample of 191 final year pre-service teachers from the selected College of Education. The second phase involved eight out of the 191 final year pre-service teachers. These eight pre-service teachers were selected for the second phase of the study because their responses exhibited misunderstandings of statistics concepts. Those participants were therefore chosen to give explanations to such responses given in the test, the first phase of the study. Thus, purposive sampling technique was employed to select those pre-service teachers based on their performances in the achievement test used for the study.

This chapter looked at the results of the study in two sections. The first section is about the analysis of results, while the second section is about discussions of results.

Analysis of Results

This section presents the results of the study through the use of tables, figures, frequencies and percentages, snapshots of some pre-service teachers'

results in the achievement test, and then some inferential statistics. Presentation is done in two parts, the quantitative analysis followed by the qualitative analysis.

Quantitative analysis

Table 7 gives a brief demographic details of respondents.

Table 7: Demographic details of respondents

Variable	Subscale	Frequency	Percentage
Age	20-22 years	41	21.5
	23-25 years	109	57.1
	Above 25 years	41	21.5
Sex	Male	101	52.9
	Female	90	47.1

Source: Field survey (2022)

The respondents' age was put into three categories. From Table 7, respondents within the 23-25 years category were the highest, 109 out of 191 which represents 57.1%. Respondents in the 20-22 years and above 25 years categories had the same percentage of 21.5% each, in terms of their numbers. Classification by sex showed that the male respondents outnumbered their female counterparts by 5.8%.

Analysis of research question one

Research question one states: Which statistics content topic(s) do pre-service teachers have difficulty in learning? Part B of the data collection instrument gave a list of topics in the Colleges of Education statistics content course outline (See Appendix A). Pre-service teachers selected (by ticking) which topic(s) they find difficult from among the listed ones. Responses were

coded "Yes" and "No". "Yes" meant pre-service teachers perceived the topic as difficult, while "No" meant otherwise. The results were analyzed using frequencies and percentages. Table 8 gives the distribution of the responses of pre-service teachers to the College of Education statistics contents topics they perceived as difficult. The topics were grouped under data collection, measures of central tendency, and measures of dispersion.

Table 8: Pre-service teachers' perceived difficult topics in college statistics contents

Variable	Topics under variable	Perceived Difficulty	
		Yes	No
Data Collection	Meaning of data	11(5.8%)	180(94.2%)
	Qualitative data	47(24.6%)	144(75.4%)
	Interviews	21(11.0%)	170(89.0%)
	Questionnaires	21(11.0%)	170(89.0%)
	Survey*	65(34.0%)	126(66%)
	Experiments	51(26.7%)	140(73.3%)
	Line graphs	19(9.9%)	172(90.1%)
	Bar graphs	13(6.8%)	178(93.2%)
	Pie carts	9(4.7%)	182(95.3%)
	Histograms	17(8.9%)	174(91.1%)
	Cumulative curves	44(23.0%)	147(77.0%)
	Stem-and-leaf-plot	59(30.9%)	132(69.1%)
	Interpreting data from graphs	35(18.3%)	156(81.7%)
	Quantitative data	41(21.5%)	150(78.5%)
	Scales of measurement	59(30.9%)	132(69.1%)

*Topic(s) most pre-service teachers found difficult
Source: Field survey 2022

Table 8 (Cont'd.)

Variable	Topics under variable	Perceived Difficulty	
		Yes	No
Measures of Central Tendency	Definition of mean	11(5.8%)	180(94.2%)
	Definition of median	8(4.2%)	183(95.8%)
	Definition of mode	6(3.1%)	185(96.9%)
	Finding mean from ungrouped distribution	18(9.4%)	173(90.6%)
	Finding mean from grouped distribution	19(9.9%)	172(90.1%)
	Finding mean from histograms	40(20.9%)	151(79.1%)
	Finding median from ungrouped distribution	26(13.6%)	165(86.4%)
	Finding median from grouped distribution	19(9.9%)	172(90.1%)
	Finding median from histograms	41(21.5%)	150(78.5%)
	Finding mode from ungrouped distribution	19(9.9%)	172(90.1%)
	Finding mode from grouped distribution	18(9.4%)	173(90.6%)
	Estimating mode from histogram*	56(29.3%)	135(70.7%)
	Interpreting mean, median, mode from a given data	38(19.9%)	153(80.1%)

*Topic(s) most pre-service teachers found difficult

Source: Field survey 2022

Table 8 (Cont'd.)

Variable	Topics under variable	Perceived Difficulty	
		Yes	No
Measures of Dispersion	Range	11(5.8%)	180(94.2%)
	Quartiles*	162(84.8%)	29(15.2%)
	Interquartile range*	157(82.2%)	34(17.8%)
	Semi-interquartile* range	155(81.2%)	36(18.8%)
	Variance*	159(83.2%)	32(16.8%)
	Standard deviation*	153(80.1%)	38(19.9%)

*Topic(s) most pre-service teachers found difficult
Source: Field survey 2022

Table 8 shows that pre-service teachers generally do not have any significant difficulty in College statistics content topics, especially in data collection and in measures of central tendency. For instance, under data collection, most participants, 180(94.2%) do not have difficulties with meaning of data. Also, 182(95.3%) of the 191 pre-service teachers under study do not have difficulties with pie chart. As many as 185(96.9%) of the participants do not have any difficulties with definition of mode, under central tendency.

However, majority of pre-service teachers find all topics under measures of dispersion difficult, except the range. For instance, 162(84.8%), 157(82.2%), and 155(81.2%) of pre-service teachers find difficulties in learning quartiles, interquartile range, and semi-interquartile rage respectively.

Analysis of research question two

Research question two investigated pre-service teachers' knowledge levels of statistics contents in Colleges of Education Statistics. The question states: What is the level of pre-service teachers' statistics content knowledge in the Colleges of Education statistics?

Achievement test on Statistics contents (Part C of the instrument, see Appendix A) was administered to pre-service teachers. Table 9 gives the frequency distribution of the scores of pre-service teachers in the achievement test.

Table 9: Frequency distribution of pre-service teachers' test scores

Score	Frequency	Percentage
20 – 29	4	2.0
30 – 39	3	1.6
40 – 49	25	13.1
50 – 59	50	26.2
60 – 69	58	30.4
70 – 79	48	25.1
80 – 89	3	1.6
Total	191	100

Source: Field survey (2022)

Table 9 reveals that 32 (16.7%) of the pre-service teachers scored below 50%, while 159 (83%) of them scored over 50% on the test. In addition, only 3 (1.6%) of the pre-service teachers had marks within 80-89, but the majority, 156 (82%) of them obtained scores ranging between 50% and 79%. This analysis indicates that pre-service teachers have average knowledge of the college statistics contents course.

The mean score and standard deviation were captured. Table 10 gives the summary performance of pre-service teachers who participated in the study.

Table 10: Descriptive statistics of pre-service teachers' scores in the achievement test

	N	M	SD	Minimum Score	Maximum Score
Score	191	60.71	11.48	22	89

Source: Field survey (2022)

From Table 10, the mean score of the students was 60.71, with a standard deviation of 11.48. This illustrates an average performance in College of Education statistics contents, based on the adapted UCC grading system for undergraduates as defined in the study. The minimum score was 22 and the maximum score was 89. The performance by pre-service teachers was again supported by scores as reported in percentiles in Table 11.

Table 11: Percentiles of pre-service teachers' scores

	5^{th} Percentile	25^{th} Percentile	50^{th} Percentile	75^{th} Percentile	95^{th} Percentile
Score	40.00	54.00	62.00	70.00	78.00

Source: Field survey (2022)

From Table 11, the lowest limit indicated by the 5^{th} percentile denotes that five percent of the final year pre-service teachers obtained scores less than 40 on the test. The 75^{th} percentile illustrates that 75% of pre-service teachers who took the achievement test obtained scores up to 70. The limit indicated as the 95^{th} percentile shows that only five percent of the final year pre-service teachers used for the study achieved scores above 78. The results from the

percentiles therefore indicate good performance by pre-service teachers in College of Education statistics contents.

The results from Tables 9, 10 and 11 indicate that final year pre-service teachers have average knowledge (based on the adapted UCC grading system for undergraduates) of College statistics contents. However, the five percent scoring below 40 marks should be a matter of concern. This has an implication for the ability to handle statistics concepts at the basic school level by pre-service teachers.

In addition, items on the achievement test covered the different knowledge levels described in the study: Basic Statistics Subject Matter (BSSM), Statistics Understanding (SU) and Statistics Mastery (SM). The study grouped pre-service teachers' scores into the three knowledge levels, BSSM, SU, and SM, and then the mean and standard deviation of the test scores for each categorized knowledge level were found. The purpose was to find out pre-service teachers' strengths in Statistics subject matter, Statistics understanding, and Statistics mastery under data collection, measures of central tendency, and measures of dispersion.

Table 12 gives summary information about final year pre-service teachers' performance in the specified statistics areas and knowledge levels under the three College statistics content topics considered.

Table 12: Pre-service teachers' performance in the categorised levels of statistics content knowledge

Statistics topic	Knowledge levels	M	SD
Data Collection	BSSM	0.80	.353
	SU	0.55	.430
	SM	0.59	.462
Measures of Central Tendency	BSSM	0.82	.341
	SU	0.56	.430
	SM	0.62	.434

Source: Field survey (2022) N = 191

Data organized in Table 12 revealed that participating final year pre-service teachers have very high Basic Statistics Subject Matter (BSSM) knowledge (M = 0.8, SD = .353) in data collection. This indicates that pre-service teachers have high general knowledge regarding basic concepts, computational skills, procedures, methods and generalisations, and the inter-relatedness of all such knowledge regarding data collection. In other words, participants have general knowledge in the basics of data collection, though not with an in-depth understanding. Thus, pre-service teachers could identify topics, sub-topics, formulas in data collection. The table further shows that under data collection, pre-service teachers have average knowledge in both Statistics Understanding (SU) (M = 0.55, SD = .43) and Statistics Mastery (SM) (M = 0.59, SD = .462). Generally, the final year pre-service teachers demonstrate an appreciable knowledge in data collection as a subtopic of the College statistics content course. They, for instance, could state and

manipulate the variables in a formula under data collection with some in-depth understanding and less difficulty.

Similarly, from Table 12, final year pre-service teachers show good performance in measures of central tendency. They have very high Basic Statistics Subject Matter (BSSM) knowledge (M = 0.82, SD = .34), average knowledge in Statistics Understanding (SU) (M = 0.56, SD = .43) and in Statistics Mastery (SM) (M = 0.62, SD = .43). Consequently, by the results, pre-service teachers possess basic knowledge about measures of central tendency with some in-depth understanding and mastery.

Under measures of dispersion, though participating pre-service teachers had high performance in BSSM (M = 0.79, SD = .375), they had very low performance in SU (M = 0.43, SD = .404) and in SM (M = 0.23, SD = .351). This means that generally, participating pre-service teachers, on average, have very low knowledge in measures of dispersion as a subtopic of College statistics contents. In that sense, pre-service teachers can identify basic ideas but do not possess much understanding nor mastery in measures of dispersion.

Although final year pre-service teachers have average knowledge in College statistics contents, according to Table 10 and Table 11, they showed weak performance in answering some specific questions. Their performances on those questions were then given attention and analysed under the three sub-content areas of College statistics content course: Data collection, measures of central tendency, and measures of dispersion.

Data Collection

Table 13 gives the distribution of pre-service teachers' wrong and correct responses to items on the achievement test under data collection.

Table 13: Pre-service teachers' wrong and correct responses to items under data collection

Question	Wrong	Correct
1	56(29.3%)	135(70.7%)
2	6(3.1%)	185(96.9%)
3	6(3.1%)	185(96.9%)
4	85(44.5%)	106(55.5%)
5	45(23.6%)	146(76.4%)
6*	112(58.6%)	79(41.4%)
7	81(42.4%)	110(57.6%)
8	19(9.9%)	172(90.1%)
9*	138(72.3%)	53(27.7%)
10	36(18.8%)	155(81.2%)
11	93(48.7%)	98(51.3%)
12*	129(67.5%)	62(32.5%)
13	40(20.9%)	151(79.1%)
14	17(8.9%)	174(91.1%)
15	25(13.1%)	166(86.9%)
16	57(29.8%)	134(70.2%)
17*	144(75.4%)	47(24.6%)
18	88(46.1%)	103(53.9%)
19*	106(55.5%)	85(44.5%)
20	83(43.5%)	108(56.5%)
21	61(31.9%)	130(68.1%)

*Items not answered successfully
Source: Field survey (2022)

Table 13 shows that as many as 185, representing 97% of participating pre-service teachers, had the correct response to item 2 and item 3 on the test instrument. Item 2 sought participants' knowledge of the definition of a

sample, while item 3 demanded identification of the types of data. In addition, over 70% of the pre-service teachers responded correctly to eight more items. These are item one (70.7%), item five (76.4%), item eight (90.1%), item 10 (81.2&), item 13 (79,1%), item 14 (91.1%), item 15 (81.2%), and item 16 (70.2%). However, Table 13 further reveals that pre-service teachers had weak performance in answering some specific items, which call for attention. These included items 6, 9, 12, 17 and 19.

Figure 2 reveals the diagrammatic representation of the number of pre-service teachers who responded to items 6, 9, 12, 17 and 19 correctly or wrongly.

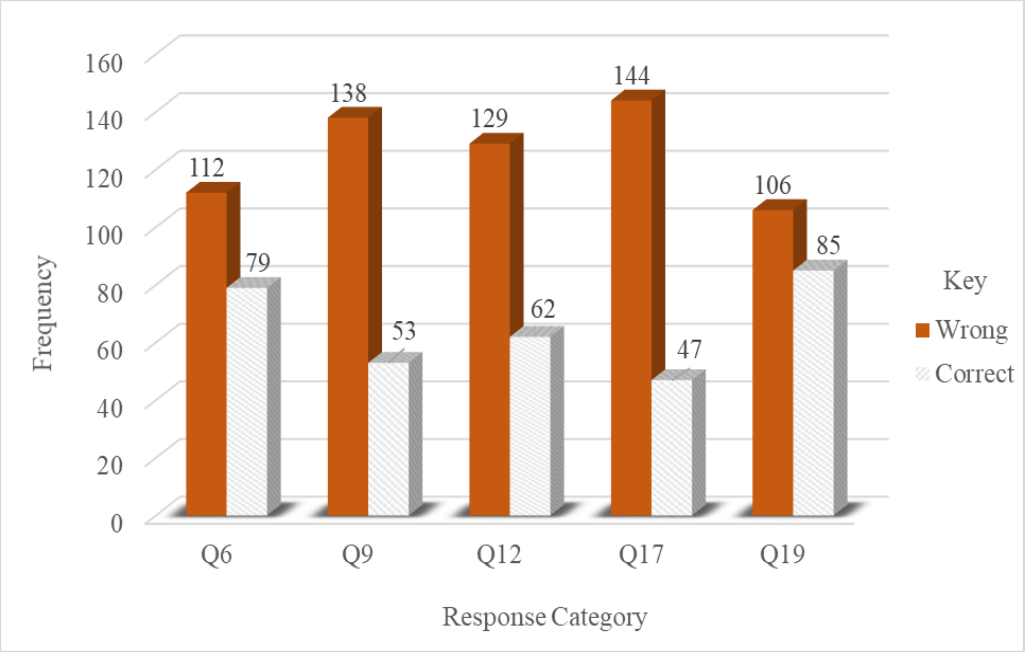


Figure 2: Pre-service teachers' responses to questions 6, 9, 12,17 and 19

Question 6: The following can be used to represent qualitative data except……

A. Frequency polygon

B. Multiple bar chat

C. Pictogram

D. Simple bar chat

This question sought pre-service teachers' knowledge in graphical representation under data collection. This needed further attention because pre-service teachers had low performance in it. Figure 2 shows that 112 (58.6%) of pre-service teachers had the wrong answer to this item. More than half of the participating pre-service teachers could not identify the correct option. That means that not many of the pre-service teachers used in the study have adequate knowledge in graphical representation.

Question 9: Which of the following graphs is the most appropriate for representing the information given in the table?

Vehicle	Busses	Cars	Pick-ups
Frequency	12	16	8

A. Frequency polygon

B. Histogram

C. Line graph

D. Pie chart

From Figure 2, 138, representing 72.3% of the pre-service teachers could not identify the right option while 53, representing 27.7% got it right. This also points out that most pre-service teachers have weak knowledge

regarding which graph to be used for representing information in statistics. These results are disturbing because basic school students learn about the graphical presentation in statistics (Handling data), and are tested on the Basic Education Certificate Examination (BECE) mathematics. If pre-service teachers have difficulties with this area, it implies they may transfer such weak knowledge to basic school students in their teaching.

Question 12: One distinction between a population parameter and a sample statistic is ……

A. a population parameter changes each time you try to measure it, but a sample statistic remains fixed across samples.
B. a population parameter is only based on conceptual measurements, but a sample statistic is based on a combination of real and conceptual measurements.
C. a sample statistic changes each time you try to measure it, but a population parameter remains fixed.
D. the true value of a sample statistic can never be known but the true value of a population parameter can be known.

Out of the 191 pre-service teachers, only 62 (32.5%) of them responded to the question correctly (see Figure 2), while as high as 129(67.5%) pre-service teachers chose the wrong answer. Most pre-service teachers could, thus, be said to have a challenge in distinguishing between population and sample statistic. They are therefore likely to encounter problems in further studies in research and statistics.

Question 17 too, was not well answered by pre-service teachers and so calls for consideration.

Question 17: Frequency polygon is drawn from relative frequencies of a given data set.

A. True

B. False.

Only 47 pre-service teachers were able to answer the question correctly. As many as 144(75%) of participating pre-service teachers got the answer wrong. The result backs the claim obtained from the results of questions 6 and 9 that majority of pre-service teachers have weak knowledge on graphical representation in statistics (see Figure 2).

In addition, participants could not tackle question 19 quite well. The question tasked participants to identify which scale of measurement – nominal, ratio, ordinal, and interval – fall under either qualitative or quantitative.

Question 19: Match the items under A to the items under B using arrows.

A	B
Qualitative	Nominal
Quantitative	Ratio
	Ordinal
	Interval

According to Figure 2, most participants, 106 (which represents 55.5%) gave incorrect response while 85 (44.5%) of participating pre-service teachers could not identify which of the given scales of measurement was either qualitative or quantitative. This gives the presumption that pre-service

teachers do not have adequate knowledge as far as scales of measurement are concerned.

Measures of Central Tendency

Items 22 to 42 of the achievement test were on measures of central tendency. Table 14 is a distribution of proportion of pre-service teachers who gave wrong and correct responses to these items.

Table 14: Distribution of pre-service teachers' responses to items under measures of central tendency

Question numbers	Wrong	Correct
22	11(5.8%)	180(94.2%)
23	7(3.7%)	184(96.3%)
24	10(5.2%)	181(94.8%)
25	29(15.2%)	162(84.8%)
26	47(24.6%)	144(75.4%)
27	91(47.6%)	100(52.4%)
28*	127(66.5%)	64(33.5%)
29	76(39.8%)	115(60.2%)
30*	104(54.5%)	87(45.5%)
31	21(11.0%)	170(89.0%)
32	59(30.9%)	132(69.1%)
33	29(15.2%)	162(84.8%)
34	26(13.6%)	165(86.4%)
35	54(28.3%)	137(71.7%)
36	68(35.6%)	123(64.4%)
37	52(27.2%)	139(72.8%)
38*	161(84.3%)	30(15.7%)
39	39(20.4%)	152(79.6%)
40	60(31.4%)	131(68.6%)
41	51(26.7%)	140(73.3%)
42	82(42.9%)	109(57.1%)

*Items not answered successfully
Source: Field survey (2022)

Table 14 shows that a good number of pre-service teachers performed well with respect to items under measures of central tendency. For instance, over 70% of the pre-service teachers chose the correct option for 12 of the items on measures of central tendency. That shows pre-service teachers have good knowledge in measures of central tendency. This is an encouraging result and an indication of pre-service teachers' competency in this aspect of statistics.

However, pre-service teachers' responses to questions 28, 30 and 38 were very discouraging and so call for attention.

Figure 3 shows graphical presentation of the proportion of pre-service teachers responding correctly or wrongly to questions 28, 30 and 38.

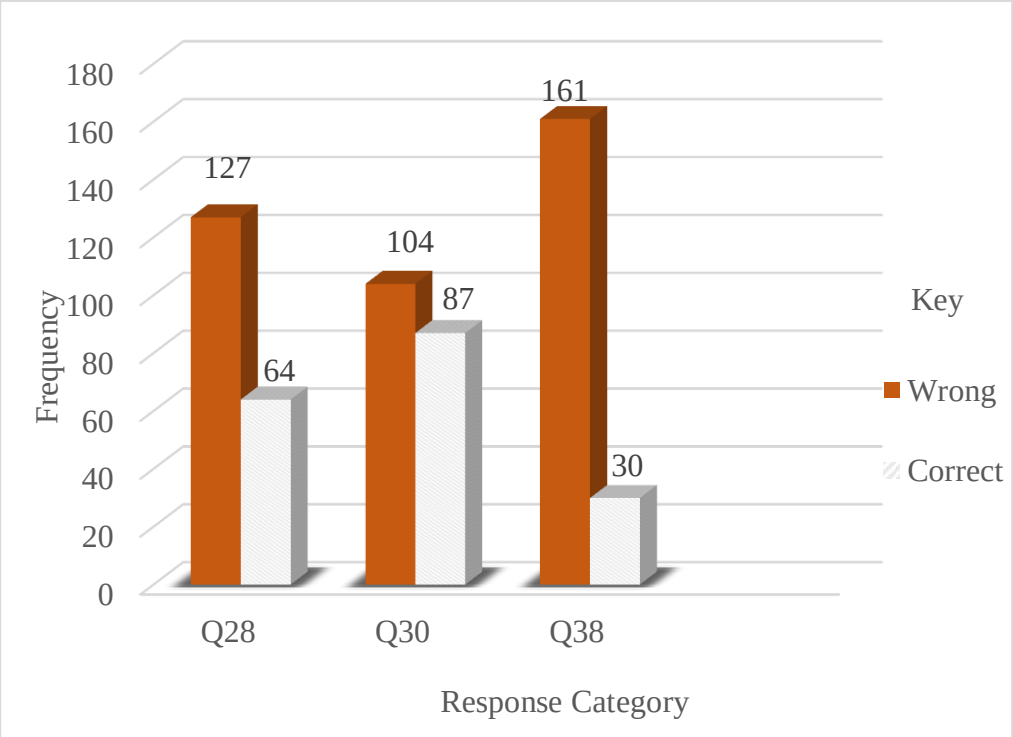


Figure 3: Pre-service teachers' responses to questions 28, 30 and 38

Question 28: The word average in statistics implies……..

A. mean and mode only

B. mean only

C. mean, mode and median

D. median only

The result as shown in the figure indicates that pre-service teachers have weak statistics content knowledge as far as the definition of the term average is concerned. As many as 127 (65%) of the participants, had the answer to question 28 wrong. Pre-service teachers are likely to transfer such weak statistics knowledge to basic school students they would teach in the future.

In a similar way, pre-service teachers demonstrated weakness in answering question 30 sought some facts about the mode. Question 30 was framed thus:

Which of the following is true about the mode? The mode…….

A. Always exceeds the mean.

B. Can exceed the median.

C. Is always bigger than the median.

D. Never exceeds the mean.

Per the report, most pre-service teachers, 104 out of 191 could not respond correctly to item 30 (see Figure 3). Though 87(45.5%) of the pre-service teachers had correct answer to question 30, that number was not encouraging since it represented less than of the participants.

Question 38: The median is always the middle observation in a sample.

A. False

B. True.

According to Figure 3, only 30(15.7%) of the pre-service teachers were able to identify that the median is not always the middle observation. This means that 84% of final year pre-service teachers who took part of the research did not consider that median is not always the middle observation in a sample. This is a signal of weak understanding final year pre-service teachers may possess in clearly defining the median of a sample. It is evident that the concept of median is not clearly grasped by the pre-service teachers.

Measures of Dispersion

Items 43 to 63 of the achievement test were on measures of dispersion. Almost half of the questions under measures of dispersion were wrongly answered by most of the participating final year pre-service teachers. Table 15 shows the distribution of the pre-service teachers who responded to items under measures of dispersion wrongly or correctly.

Table 15: Distribution of pre-service teachers' responses to items under measures of dispersion

Question	Wrong	Correct
43	29(15.2%)	162(84.8%)
44	22(11.5%)	169(88.5%)
45	17(8.9%)	174(91.1%)
46	56(29.3%)	135(70.7%)
47	95(49.7%)	96(50.3%)
48	37(19.4%)	154(80.6%)
49	20(10.5%)	171(89.5%)
50	23(12.0%)	168(88.0%)
51*	146(76.4%)	45(23.6%)
52*	140(73.3%)	51(26.7%)
53*	151(79.1%)	40(20.9%)
54	23(12.0%)	168(88.0%)
55*	163(85.3%)	28(14.7%)
56*	187(97.9%)	4(2.1%)
57*	190(99.5%)	1(0.5%)
58*	138(72.3%)	53(27.7%)
59*	137(71.7%)	54(28.3%)
60	95(49.7%)	96(50.3%)
61*	127(66.5%)	64(33.5%)
62*	140(73.3%)	51(26.7%)
63*	128(67.0%)	63(33.0%)

* Items not answered successfully
Source: Field survey (2022)

As specified in Table 15, over 70% of pre-service teachers had correct responses to eight out of 21 items under measures of dispersion. Further information from Table 15 shows that participants of the study were not successful in answering as many as 11 out of the 21 items under measures of dispersion. Consequently, such items were given further consideration. These items included questions 51, 52, 53, 55, 56, 57, 58, 59, 61, 62, and 63.

Figure 4 depicts a diagrammatic representation of pre-service teachers' responses to questions 51, 52, 53 and 55.

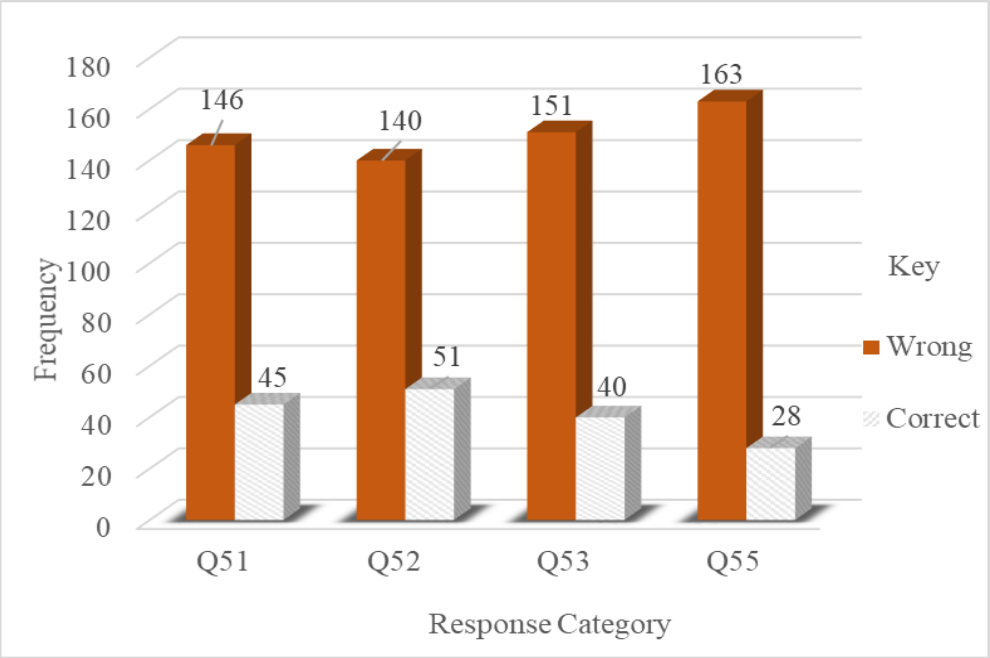


Figure 4: Pre-service teachers' responses to questions 51, 52, 53 and 55

Question 51 was to assess pre-service teachers' knowledge on the range of values variance may take.

Question 51: The variance can **never** be……

A. greater than the standard deviation.

B. less than the standard deviation

C. negative

D. zero

As shown in Figure 4, 146, which is far more than half of the participating final year pre-service teachers, faced a challenge in answering item 51. They could not determine the range of values for variance. Thus, pre-service teachers could be said to possess weak knowledge as regards the range of values the variance may take.

Question 52: Which of the following measures of dispersion is affected by extreme values?

A. Interquartile range.

B. Range.

C. Standard deviation

D. Variance.

One hundred and forty of the pre-service teachers had the wrong answer to item 52. This seems to portray that final year pre-service teachers have difficulty with determining which measures of dispersion is affected by extreme values.

Question 53 sought pre-service teachers' knowledge on when to use some measures of dispersion.

Question 53: In case of open-ended classes, the appropriate measure of dispersion to be used is……...

A. quartile deviation

B. range

C. standard deviation

D. variance

In responding to question 53, majority of the respondents, 151 (79%) could not choose the correct option. That could mean that final year pre-service teachers show weak knowledge in measures of dispersion as a sub-content area of College statistics content course.

Question 55: The ages of six girls are 14, 12, 11, 17, 19, and 16. The semi-interquartile range of their ages is……. years.

A. 1

B. 2.5

C. 5

D. 8

Question 55 demanded pre-service teachers to calculate semi-interquartile range from a given data. As shown in Figure 4, pre-service teachers showed low knowledge in such area of measures of dispersion. Only 28 participants were able to correctly calculate the semi-interquartile range. This is worrying because if pre-service teachers have weak knowledge in quartile, interquartile and semi-interquartile ranges, then they are likely to find difficulty in applying them to life situations.

Figure 5 presents how pre-service teachers responded to items 56 and 57 on the teacher made achievement test.

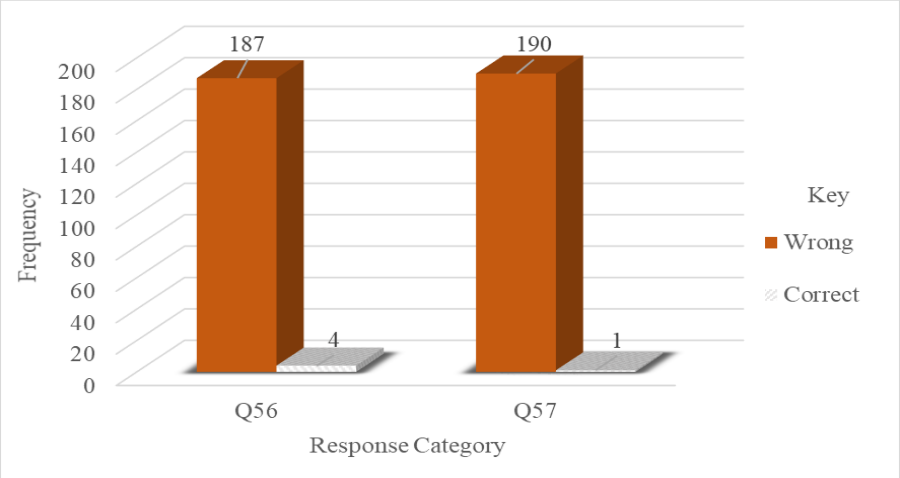


Figure 5: Pre-service teachers' responses to questions 56 and 57

Question 56 was to make respondents identify the meaning of the various values for quartile deviation (semi-interquartile range).

Question 56: When the value of the quartile deviation (semi-interquartile range) is small, it implies……

A. higher dispersion.

B. higher mean.

C. lower dispersion

D. lower mean.

Figure 5 shows that pre-service teachers have very low knowledge on the interpretation of the values for semi-interquartile range. Only 4 (2%) pre-service teachers could rightly interpret what a small value of the semi-interquartile range implies. As many as 187 (97.9%) failed to obtain the right answer to question 56.

Question 57: The sum of squares is 20. If the sample variance of the data is 5, what is the number of observations?

A. 4

B. 5

C. 15

D. 25

Nearly all participants, 99.5%, were not successful in getting the answer to question 57. This item is an application of variance of data. The outcome, as presented in Figure 5, shows that a significant number of final year pre-service teachers have deficient knowledge of the application of the sum of squares in measures of dispersion. It is quite clear that respondents did not know the process involved in calculating the number of observations,

given the variance and the sum of squares, and are likely to encounter difficulties in applying the concept of sum of squares and variance to real life situations.

Pre-service teachers' performance on questions 58 and 59 were also discouraging.

Use the information in the table to answer questions 58 and 59.

Marks (%)	10-19	20-29	30-39	40-49	50-59
	2	5	7	6	20

Question 58: In which class lies the 25th percentile? ……

Question 59: In which class lies the median mark? ……

The diagrammatic representation of pre-service teachers' responses to these questions is shown in Figure 6.

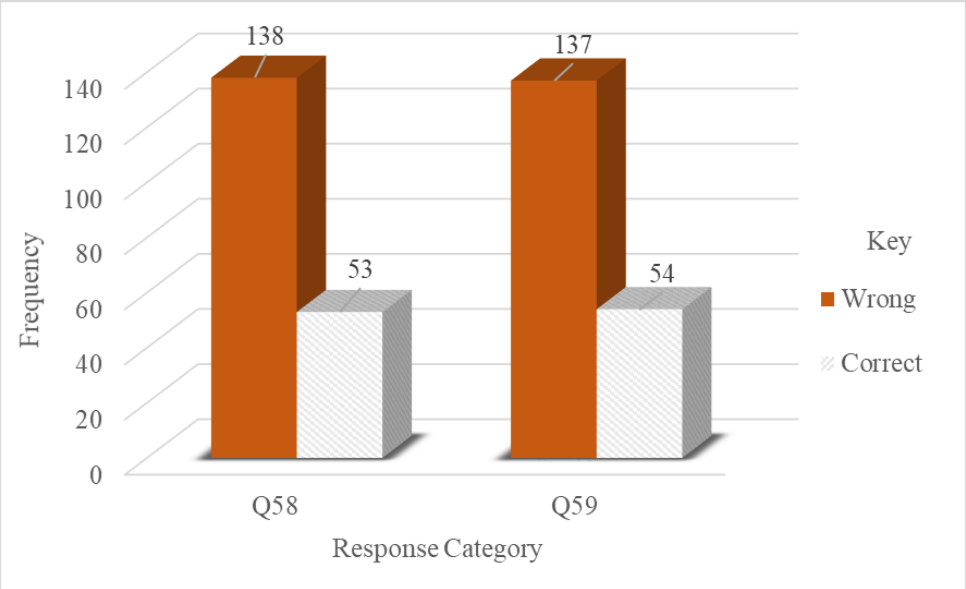


Figure 6: Pre-service teachers' responses to questions 58 and 59

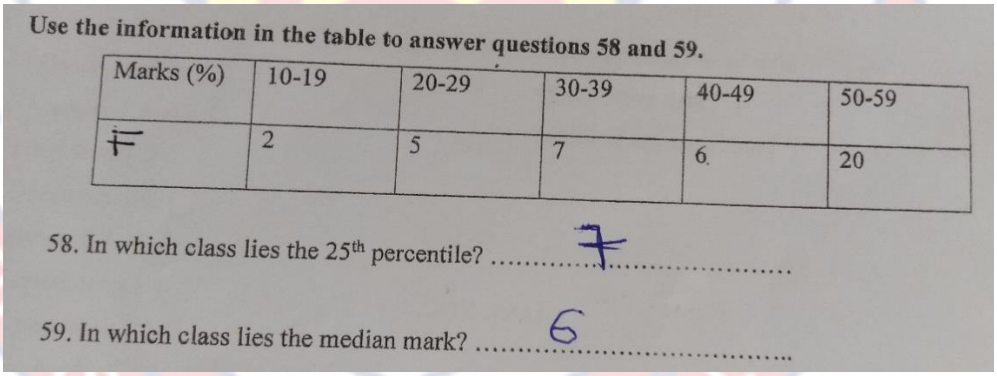
Regarding items 58 and 59, it was discouraging to see that a good number of the respondents, 138 (72.3%) and 137 (71.7%) were unable to tell

the 25th percentile and the median mark respectively, from a grouped frequency table. Only a few respondents, 53 (27.7%//) and 54 (28.3%) made the correct choices for questions 58 and 59 respectively.

The results shown by Figure 6 implies that pre-service teachers do not have adequate knowledge on finding percentiles and median mark from a given grouped frequency distribution table. This is supported by how some of the participants presented solutions to questions 58 and 59. They showed errors and wrong conceptions in answering these questions.

For question 58, some pre-service teachers selected the frequency of the class in which lies the 25th percentile as the answer. That is, they wrote 7 which is the frequency of the class having the 25th percentile instead of the class 30-39. Similarly, for question 59, some pre-service teachers wrote the frequency, instead of the class in which lies the median.

Figure 7a shows a snapshot of a sample response to questions 58 and 59.



Use the information in the table to answer questions 58 and 59.

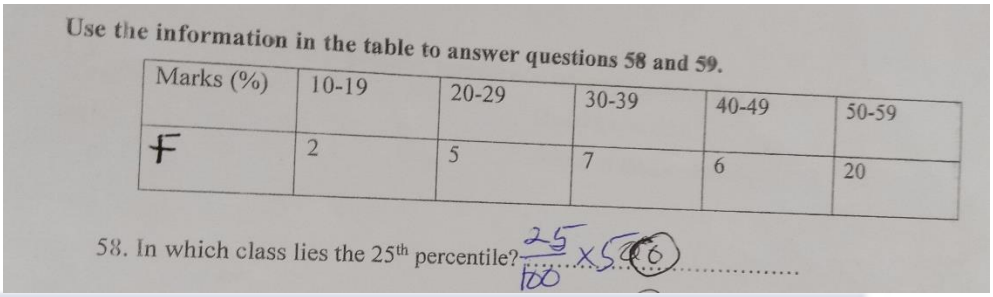
Marks (%)	10-19	20-29	30-39	40-49	50-59
f	2	5	7	6	20

58. In which class lies the 25th percentile? ..... 7 .....

59. In which class lies the median mark? ..... 6 .....

Figure 7a: A pre-service teacher's response to Questions 58 and 59

Moreover, finding the 25th percentile, some pre-service teachers multiplied $\frac{25}{100}$ by some individual frequencies instead of the total frequency, 40 and even ended at that. Figure 7b provides a snapshot of such a response.



Use the information in the table to answer questions 58 and 59.

Marks (%)	10-19	20-29	30-39	40-49	50-59
F	2	5	7	6	20

58. In which class lies the 25th percentile? $\frac{25}{100} \times 50$ (6)

Figure 7b: A pre-service teacher's response to Question 58

The issue of these misconceptions and erroneous thinking by pre-service teachers is worrying. This is because pre-service teachers can highly influence their basic school students with such errors and wrong concepts in statistics in their future classroom teaching and learning. Again, pre-service teachers may not be able to apply these concepts in their further research.

Pre-service teachers' responses to questions 61, 62, and 63 are also worrying as shown by Figure 8. For questions 61 and 62, pre-service teachers were to calculate the upper quartile and the semi-interquartile range respectively, from the data set 10, 12, 7, 5, 19, 7, 21, 9, 10, and 7. Question 63, on the other hand, asked pre-service teachers to calculate the standard deviation from the data 2, 3, 8, 8, and 9.

Participants' responses to questions 61, 62, and 63 are portrayed in Figure 8.

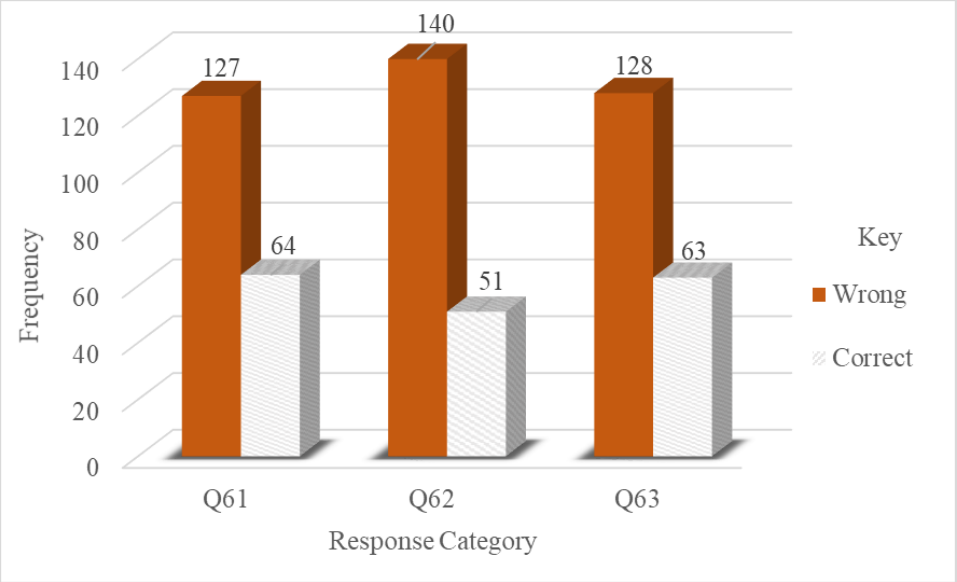


Figure 8: Pre-service teachers' responses to questions 61, 62 and 63

In responding to question 61, only 64(33.5%) got the correct calculations. Thus, 127(66.4%) of the participants showed less adequate knowledge in the calculation of upper quartile. In the same vein, only 51 (26.7%) of participating final year pre-service teachers demonstrated adequate control over question 62, whiles 140 (that is 73%) of them chose the wrong option to the question. Furthermore, pre-service teachers' difficulties with College statistics content showed up in question 63. Most of the final year pre-service teachers, 128 (67%), could not calculate standard deviation correctly.

One source of such weak performance could be due to certain misunderstandings and erroneous thinking in statistics concepts pre-service teachers exhibited. For instance, regarding question 61, some pre-service teachers used the calculation of the position for the upper quartile as the actual upper quartile. Figure 9 gives the snapshot of a sample of such calculations.

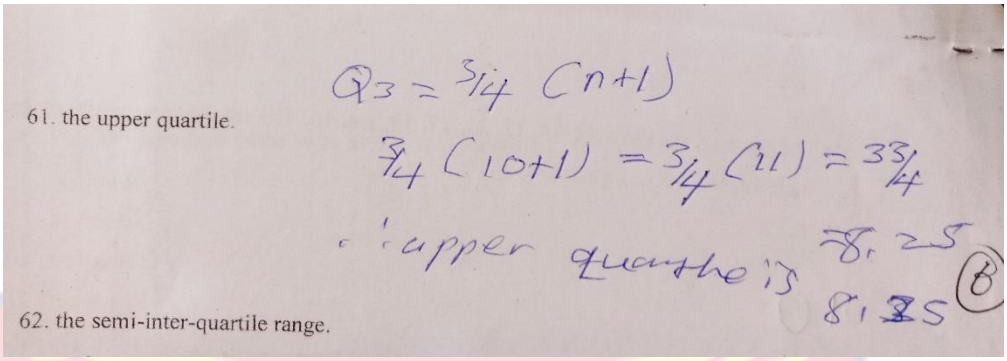


Figure 9: A pre-service teacher's error and misunderstanding in calculating the upper quartile

Also, some of the errors and misunderstandings in statistics concepts pre-service teachers exhibited in answering question 62, the calculation of semi-interquartile range, include writing and simplifying $\frac{Q_3 + Q_1}{2}$ instead of $\frac{Q_3 - Q_1}{2}$. Some others misrepresented semi-interquartile range as $\frac{1}{2}f$.

Pre-service teachers' misunderstandings and erroneous thinking with respect to question 63 stems from some pre-service teachers using the mean as variance. Others did not square the mean deviation before using it in the calculation of standard deviation.

Analysis of Research Hypothesis

The research hypothesis sought if there was any difference in the scores of male and female pre-service teachers. The null hypothesis was given as:

H_0: "There is no statistically significant difference between female and male pre-service mathematics teachers' statistics content knowledge."

To analyse the research hypothesis, the researcher looked first at the distribution of the test scores of male and female pre-service teachers. This is shown in Table 16.

Table 16: Distribution of pre-service teachers' test scores by sex

	Gender of Respondents			
	Male		Female	
Score	F	%	F	%
20 – 29	1	1.0	3	3.3
30 – 39	1	1.0	2	2.2
40 – 49	9	8.9	16	17.8
50 – 59	27	26.7	23	25.6
60 – 69	29	28.7	29	32.2
70 – 79	34	33.7	14	15.6
80 – 89	0	0.0	3	3.3
Total	101	100	90	100

Source: Field survey (2022)

As depicted in Table 16, 34 males as against 14 females had scores ranging between 70-79. Also, more males, 90 (89.1%) had scores above 50% than their female counterparts, 69 (76.7%). However, three females had scores in the range of 80-89, no male counterpart got a score greater than 79. These test scores seem to suggest some differences in performance between male and female participants.

To find out whether the observed difference between the scores of male and female participants is significant, an independent sample t-test was used at 5% significant level. Table 17 shows the independent t-test summary statistics of the scores of pre-service teachers in the achievement test by sex.

Table 17: Independent sample t-test to compare performance of male and female participants

Sex	*M*	*SD*	*Md.*	*Std. Error Diff*	*t*	*Df*	*P*
Male	62.56	10.333					
			3.931	1.643	2.392	189	.018
Female	58.63	12.365					

Source: Field survey (2022)

The results in Table 17 point out that the males had mean = 62.25 and standard deviation = 10.333 of their test scores, while the female counterpart had mean = 58.63 and standard deviation = 12.365. The t-test results show that t(189) = 2.392, p = .018. Since the obtained p-value, $.018$, is less than α = 0.05, it implies that there is statistically significant difference between female and male pre-service teachers' statistics content knowledge. The males had a mean score of 62.25 which is higher than that of the female, 58.63. These results suggest that the males have comparatively higher statistics content knowledge than the female pre-service teachers.

Qualitative Analysis

The second phase of the study is the qualitative aspect, which took place after test items were scored. This involved the interview results of purposively selected pre-service teachers. Under this phase, the researcher considered snapshots of the selected pre-service teachers' responses and the corresponding explanations they gave during the interview sessions.

Snapshots of selected pre-service teachers' responses and corresponding explanations

Figure 10 gives the snapshot of selected pre-service teacher's response to finding the mean from a frequency distribution table.

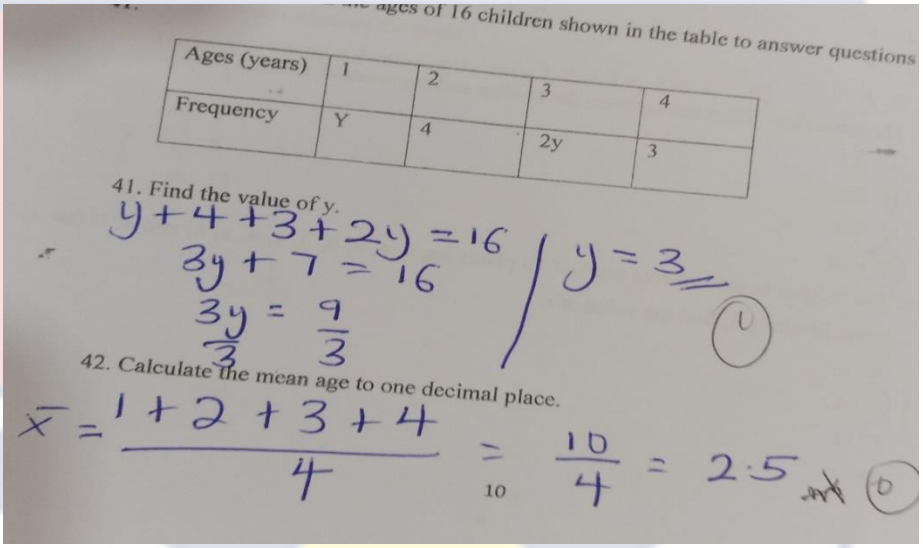
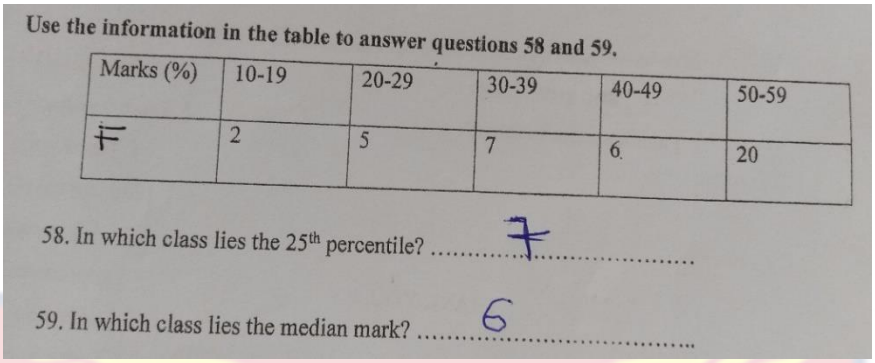


Figure 10: Snapshot of a selected pre-service teacher's response to finding the mean

Figure 10 shows a pre-service teacher's response to question 42 which demanded the calculation of the mean from the given distribution. This pre-service teacher rather added the individual ages and divided the total by the number of items as arranged in the table (that is, 4 items). When the researcher made a follow up to find out why such a response, the respondent mentioned, "*I have always understood mean as sum of numbers in a set divided by total frequency. That is why I did it like that.*" This is a clear erroneous thinking and misunderstanding of the concept of the mean in identifying the variables and the number of times they appear in a distribution.

Figure 11 is the snapshot of a selected pre-service teacher's response to finding the class for the 25th percentile and the median from a frequency distribution table.


Use the information in the table to answer questions 58 and 59.

Marks (%)	10-19	20-29	30-39	40-49	50-59
F	2	5	7	6	20

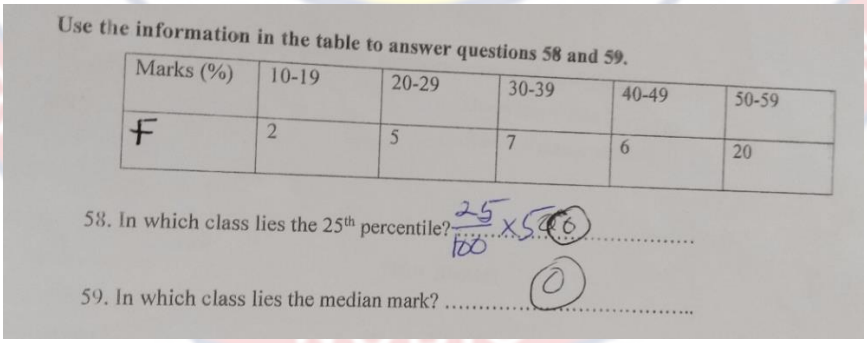
58. In which class lies the 25th percentile? ..... 7 .....

59. In which class lies the median mark? ..... 6 .....

Figure 11: A pre-service teacher's response to finding the 25th percentile and the median classes

Instead of writing the classes 30-39 and 40-49, which contained the 25th percentile and median mark respectively, this pre-service teacher rather wrote the respective frequencies of the classes 7 and 6. When the researcher probed further why such a response, through the interview, the respondent said, "*7 and 6 are the next frequencies that must be added to obtain the 25th percentile and the median marks. So I thought the 7 and 6 are what I must record*." This pre-service teacher then has erroneous thinking, which can be transferred to basic school students.

A different response by another pre-service teacher to item 58 in finding the 25th percentile class is depicted in Figure 12.


Use the information in the table to answer questions 58 and 59.

Marks (%)	10-19	20-29	30-39	40-49	50-59
F	2	5	7	6	20

58. In which class lies the 25th percentile? ..... 25/100 x 5 = 0 .....

59. In which class lies the median mark? ..... 0 .....

Figure 12: A different pre-service teacher's response to finding the 25th percentile class

According to Figure 12, this participant wrote 25 on 100 and multiplied by five as the 25th percentile class. When interviewed, the pre-

service teacher said, "*The number 25 is within the class 20-29. Also, the frequency for the class 20-29 is 5. That is how I obtained my answer*." This is also a misunderstanding the pre-service teacher has about finding the class of a given percentile from a grouped frequency table.

Figure 13 displays a snapshot of a pre-service teacher's response to calculating the lower quartile from a data set.

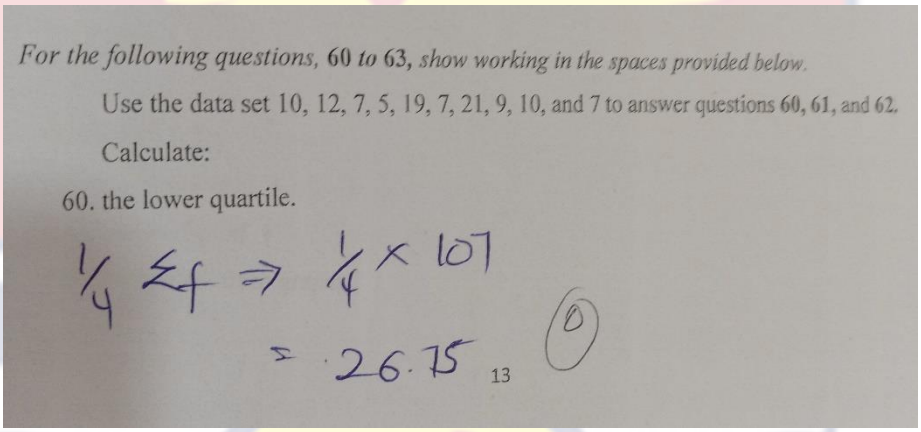


Figure 13: A pre-service teacher's response to calculating lower quartile from a data set

Here, instead of a quarter of the number of scores arranged in order, the pre-service teacher wrote a quarter of the sum of the individual scores. In an interview with this respondent, the pre-service teacher mentioned that "*What I know is that those numbers represent the frequency and must be added to obtain* $\sum f$." This pre-service teacher has a misunderstanding regarding the calculation of the lower quartile from a data set.

Moreover, a pre-service teacher calculated the semi-interquartile range as shown in Figure 15.

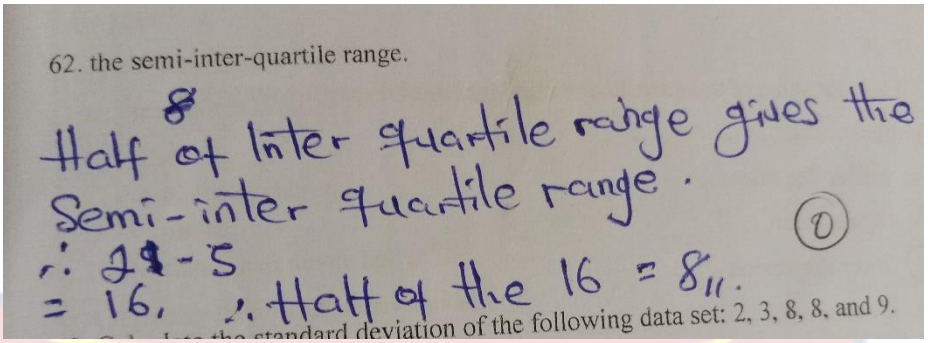


Figure14: A pre-service teacher's calculation of semi-interquartile range

The semi-interquartile range is one-half the difference between the first and the third quartiles. However, the respondent in question rather calculated the semi-interquartile range as one-half of the difference between the highest observation (25) and the least observation (5). In an interview, the pre-service teacher explained the response that, "*I know the range is the highest minus the least value, and 'semi' means half. That is why I wrote that answer."* This is also an indication of a misconception the pre-service teacher has about finding the semi-interquartile range.

Figure 15 is a selected pre-service teacher's response to finding the third quartile.

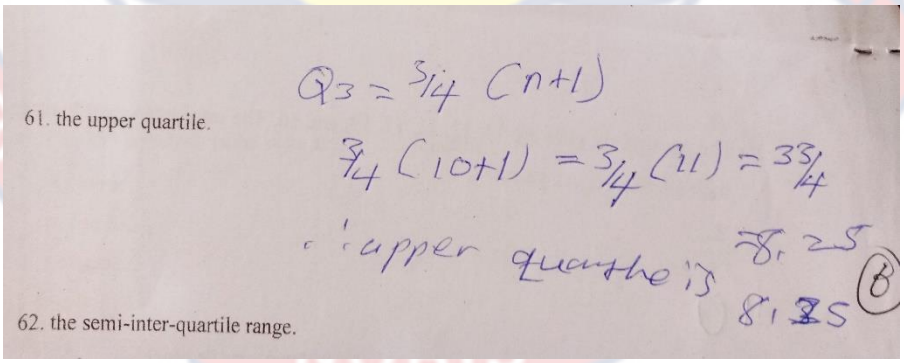


Figure 15: A pre-service teacher's response to finding the third quartile

The respondent mistook the quartile position for the actual quartile. That also explains the pre-service teacher's misconceptions about quartile position and the actual quartile.

Furthermore, Figure 16a displays the response of a pre-service teacher's to finding the standard deviation from a set of data.

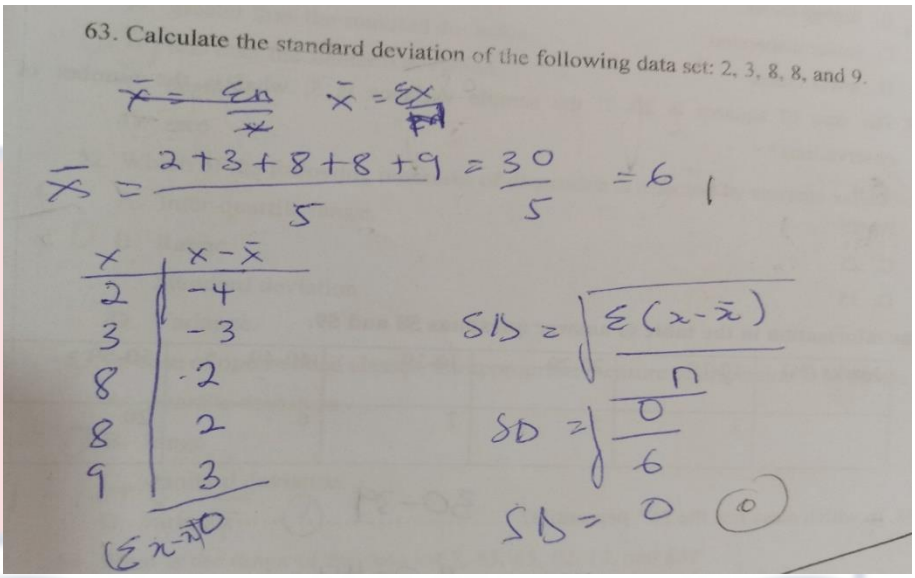


Figure 16a: A pre-service teacher's response to finding the standard deviation

From the figure, the pre-service teacher has wrong conceptions about calculating the standard deviation. The pre-service teacher was able to find the mean and has an idea about the mean difference, but appears not to have the concept of squaring the mean difference to obtain the variance. In an interview on why that answer, the respondent said, "*That is all I could remember*." This respondent possibly forgot the variables in the standard deviation formula.

Figure 16b presents the response of another pre-service teacher on calculating the standard deviation.

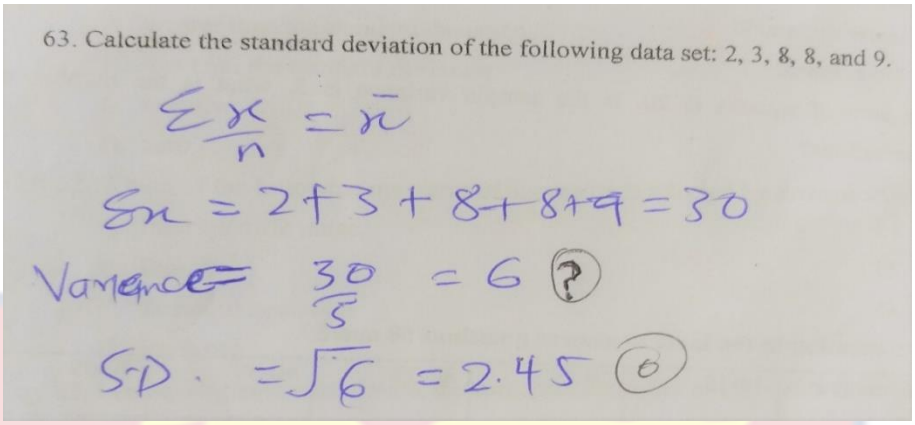


Figure16b: A response of a pre-service teacher to finding the standard deviation

The participant used the square root of the mean as the standard deviation. When asked why that answer, the pre-service teacher explained, "*I have not mastered the standard deviation formula*."

Figures 16a and 16b show that those pre-service teachers have not grasped the concept of standard deviation, though they had learned that in the College of Education statistics content course.

Following the qualitative part of the study, pre-service teachers' weakness in statistics contents can be said to have resulted mainly from misunderstanding, wrong conceptions and erroneous thinking in statistics concepts.

Discussion of Results

This section discusses the results of the study, according to the research questions and hypothesis.

Research question one

"Which Statistics content topic(s) do pre-service teachers have difficulty in learning?"

Findings from the analysis of research question one showed that pre-service teachers generally do not have any significant difficulty in college statistics content topics, especially in data collection and in measures of

central tendency. Over 66% of pre-service teachers do not have difficulties with most topics under data collection and measures of central tendency. This therefore, is in contrast with the findings of Gal and Gingsburg (1994) and Warren and Cunnington (2017) that seem to paint the picture that college students see most aspects of statistics as difficult. The result could be that these aspects of statistics are easy to comprehend. Also, it could mean that college mathematics tutors possibly applied teaching methods that made topics in data collection and measures of central tendency interesting to be learned. The findings contradicts the Chief Examiner's report which mentioned low pre-service teachers' performance in statistics contents (Institute of Education, 2021).

Majority of pre-service teachers find as many as 11 out of 25 items on topics under measures of dispersion difficult to learn. From the analysis, most of the pre-service teachers say they find difficulties in learning quartiles (84.8%), interquartile range (82.2%), semi-interquartile range (81.2%), variance (83.2%) and standard deviation (80.1%). These results agree with the findings of Lovett (2016) which assert that students find difficulties with some topics in statistics. The finding implies that generally, this aspect of statistics is quite challenging to be learned.

Research question two

"What is the level of pre-service teachers' statistics content knowledge in the Colleges of Education statistics?"

The finding from the analysis of research question two on knowledge levels of pre-service teachers was that, final year pre-service teachers generally have average knowledge in College of Education statistics contents,

(M = 60.71, SD = 11.457). The participating final year pre-service teachers exhibited comparatively, adequate knowledge of statistics contents. The percentile reportage supports that 75% of the final year pre-service teachers in the study obtained scores up to 70. This result does not support the findings of Sorto (2010) which speculated that generally, college students have weak statistics knowledge.

However, pre-service teachers showed weak performance and limited knowledge in some specific aspects of College of Education statistics contents, especially in the area of Statistics Understanding (M = 0.43, SD = .404) and in Statistics Mastery (M = 0.23, SD =.351) under measures of dispersion. The finding is consistent with Estrella and Mena (2014) and Sorto (2010) who concluded from their findings that college students show weak statistics knowledge. In this case, pre-service teachers need to be trained in some identified aspects of statistics, as asserted by Godino, Batanero, Roa, and Wilhemi (2014).

The situation of pre-service teachers having difficulties in specific areas of College of Education statistics is worrying. This is because first, final re-service teachers have gone through various stages of education, and have supposedly gained high maturity which can match that of any tertiary level students, and are going to teach basic school students. They are, therefore, expected to handle any aspects of College of Education statistics content course with competence which builds good statistics foundation for basic school students.

Research hypothesis

The research hypothesis that guided the study was "There is no statistically significant difference between female and male pre-service teachers' statistics content knowledge."

An independent sample t-test conducted revealed a statistically significant difference $(t = 2.392, p = .018)$ between the scores of males (M = 62.25, SD = 10.333) and females (M = 58.63, SD = 12.365). According to the results, the male pre-service teachers have higher statistics content knowledge than their female counterparts. The finding corresponds with some early results in the literature that there is a gender difference between the performance of males and females in mathematics and statistics (Ajai & Imoko, 2015; Bahtiyar, 2017; Forgasz & Leder, 2017; Leder, 2016), and that males have higher mathematics knowledge than their female colleagues. However, the finding does not go in line with Peker, Halat, and Mirasyedioğlu (2010), and Naa, Wilmot, and Ashong (2018) whose findings showed no statistically significant difference between male and female pre-service teachers' mathematics knowledge. That means that regarding gender difference of pre-service teachers in statistics, one may not be conclusive.

Summary

The chapter looked at the analysis and discussion of results that emerged from the responses of participants to the research instrument for the study. Two research questions and one hypothesis were analysed and discussed. It came out that although pre-service teachers have an average knowledge of statistics contents, they show weak knowledge in some specific areas of statistics. Those areas were given attention for further analysis and

discussion in the qualitative aspect of the study. Also, although the highest performance in the test score was found among the female pre-service teachers, the male pre-service teachers on the average, showed higher performance than their female colleagues. Out of the three college statistics content course areas, participants seemed to have less difficulty with items on data collection and measures of central tendency than on measures of dispersion.

However, there were certain misunderstandings, wrong concepts and errors that respondents exhibited in all three subtopics of the college statistics content course. For instance, participating pre-service teachers were seen to have a challenge in the calculation of the mean from the frequency table. Again, instead of the 25^{th} percentile and the median classes, some pre-service teachers reported on the respective frequencies. Others, still, interpreted the semi-inter quartile range as half of the range of the data set.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter presents the summary, conclusions and recommendations derived from the study which investigated the statistics content knowledge of pre-service teachers of a selected College of Education. It also includes suggestions for further research.

Summary

The purpose of the study was to investigate the statistics content knowledge of pre-service teachers in a college of education in the Eastern region of Ghana. The study adapted and used the UCC grading system for undergraduate students as a yardstick for measuring the level of pre-service teachers' statistics content knowledge. This is because first, the University's system is of standard; second, the level of undergraduate students in UCC matches with that of pre-service teachers in the colleges of education. The following research questions and hypotheses guided this study:

Which Statistics content topic(s) do pre-service teachers have difficulties in learning?

What is the level of pre-service teachers' statistics content knowledge in the colleges of education statistics?

H_0: There is no statistically significant difference between female and male pre-service teachers' statistics content knowledge.

The study employed explanatory sequential mixed method design which allows for quantitative, followed by qualitative method. The study purposively sampled 191 final year pre-service teachers from a college of

education conveniently selected in the Eastern region of Ghana. An instrument that combined questionnaire and achievement test was used for data collection. The researcher analysed research questions one and two using percentages and frequencies, mean and standard deviation, and used independent sample t-test to analyse the research hypothesis.

The findings from the analysis showed that pre-service teachers from the selected college generally do not have any significant difficulties in college statistics content topics, especially in data collection and in measures of central tendency. However, participating pre-service teachers admit they find some topics under measures of dispersion difficult.

Also, final year pre-service teachers used for the study generally have average knowledge in college of education statistics contents, with mean score of (M = 60.71, SD = 11.457). However, other indications pointed out that those final pre-service teachers possess weak knowledge in some specific aspects of college of education statistics contents. For instance, participating pre-service teachers showed difficulties in finding mean, median, and percentiles from a frequency distribution table. They also had challenges in finding the semi-inter quartile range and standard deviation. In general, topics under measures of dispersion were found to be more challenging to pre-service teachers.

Furthermore, participating pre-service teachers showed misunderstandings, erroneous thinking and misconceptions in certain areas of college statistics contents course. For example, in calculating semi-interquartile range, $\frac{Q_3 + Q_1}{2}$ was used by a number of them instead of $\frac{Q_3 - Q_1}{2}$.

Some pre-service teachers too, misinterpreted the semi-interquartile range as one-half of the total frequency (that is $\frac{1}{2}f$).

Explanations to why pre-service teachers exhibited weak knowledge in some statistics content areas suggested that pre-service teachers used in the study perhaps, did not learn some statistics concepts so well. As a result, they forget statistical formulas or facts, and principles easily. That made pre-service teachers used for the study to possess erroneous thinking and misconceptions in statistics contents. There also seemed to be a kind of pre-service teachers' disinterest in statistics contents.

The findings indicated a significant mean gender difference in the statistics test scores of participating males (M = 62.25, SD = 10.333) and females (M = 58.63, SD = 12.365; t (189) = 2.392, p = .018, two tailed). In other words, the study showed that there was statistically significant difference between participating female and male pre-service teachers' statistics content knowledge. The male pre-service teachers obtained higher mean scores in the statistics content test than their female colleagues used for the study.

Conclusions

From the findings of the study, the following conclusions are drawn: Pre-service teachers used for the study generally have average knowledge in college of education statistics contents. Thus, participating pre-service teachers in general, can identify what they have treated in statistics contents, and can give basic definitions regarding statistics concepts. They have at least basic ideas about the statistics content course. However, they possess certain erroneous thinking and misunderstandings regarding some of the topics in the college statistics content course.

Pre-service teachers from the selected college do rather have particular or specificity of weakness in statistics contents, but not a general weakness in statistics. Specifically, topics in measures of dispersion largely emerged the sub-content area of college statistics content course that the participating pre-service teachers exhibited difficulty in learning.

Moreover, participating pre-service teachers do not have deeper understanding of some statistics concepts. They do not show mastery over some statistics content topics; this suggests a weak statistics foundation for basic school statistics items that are covered in the mathematics paper in the Basic Education Certificate Examination (BECE).

This point to a link between final pre-service teachers' weak knowledge in some areas of college statistics contents and basic school students' weak performance in some areas of statistics items in the BECE mathematics paper. For, teachers' knowledge influence students' performance. On the whole, significant difference in male and female pre-service teachers' statistics content knowledge was established, in favour of the male pre-service teachers used for the study.

Recommendations

Based on the findings, the following recommendations were made: The aspects of finding mean, median, and percentiles from a frequency distribution tables, and the calculation of standard deviation and some topics under measures of dispersion should be relooked at by both college of education mathematics tutors and pre-service teachers. Since the selected pre-service teachers showed profound weakness in such areas, college of education tutors are encouraged to employ teaching strategies such as problem-based learning

(Boye & Agyei, 2023) which will actively involve pre-service teachers in the learning of these topics contextually.

Also, since pre-service teachers from the selected college portrayed certain erroneous thinking and misunderstandings in college statistics content course, college of education tutors are encouraged to assist and guide pre-service teachers to unlearn erroneous concepts and principles in statistics. Pre-service teachers used for the study should strive to unlearn their misconceptions and errors in statistics as they are coming out to teach. If not, they could influence basic school students with their misconceptions and the cycle of weak statistics foundation at the basic school level would not be broken.

Teacher Education and all stakeholders of female education are encouraged to use teaching learning strategies such as Problem-based learning (Boye & Agyei, 2023) and inquiry-based instructional strategies (Althauser, 2017) to assist the selected female pre-service teachers' mathematics and statistics learning, since there was a difference, according to sex, in selected pre-service teachers' statistics content knowledge to the advantage of the male counterparts. In other words, college tutors need to make frantic effort by putting practical activities that will ensure that no gender gaps exist in the performance of pre-service teachers' statistics in particular, and mathematics in general.

Suggestions for Further Research

Further studies could be conducted to explore pre-service teachers' misunderstanding and misconceptions in statistics.

Also, further studies could be carried out to investigate why pre-service teachers find most topics under measures of dispersion difficult.

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APPENDICES

APPENDIX A: QUANTITATIVE DATA COLLECTION INSTRUMENTS

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION

FACULTY OF ICT AND TECHNOLOGY EDUCATION

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

Dear students,

This questionnaire and achievement test are meant to explore your knowledge in College of Education Statistics Content course. Please, provide your genuine responses to each of the items that follow. Be assured that the information you provide will be treated strictly confidential and will be used only for this research.

PART A: BACKGROUND INFORMATION

1. Age. …….. years
2. Gender: Male [ ] Female [ ]
3. Level of Studies: leve1 100 [ ] Level 200 [ ] Level 300 [ ] Level 400 [ ]
4. Name of College:……

PART B: STATISTICS CONTENT TOPIC(S) FOUND DIFFICULT

Select by ticking (√) from among the following Statistics Content topics, those you find difficult to understand.

Section I: Collection, representation and analysis of data

Meaning of data [ ] Quantitative data [ ]

Qualitative data [ ] Scales of measurement [ ]

Interviews [ ] Questionnaires [ ]

Survey [ ]

Experiments [ ]

Line graphs [ ]

Bar graphs [ ]

Pie carts [ ]

Histograms [ ]

Cumulative curves [ ]

Stem-and-leaf-plot [ ]

Interpreting data from graphs [ ]

Section II: Measures of central tendency

Definition of mean [ ]

Definition of median [ ]

Definition of mode [ ]

Finding mean from ungrouped distribution [ ]

Finding mean from grouped distribution [ ]

Finding mean from histograms [ ]

Finding median from ungrouped distribution [ ]

Finding median from grouped distribution [ ]

Finding median from histograms [ ]

Finding mode from ungrouped distribution [ ]

Finding mode from grouped distribution [ ]

Estimating mode from histograms [ ]

Interpreting mean, median, mode from a given data [ ]

Section III: Measures of dispersion

Range [ ]

Quartiles [ ]

Interquartile range [ ]

Semi-interquartile range [ ]

Variance [ ]

Standard deviation [ ]

Interpreting measures of dispersion [ ]

PART C: TEST ITEMS

Circle the option that best answers the test items below

Section I: Collection, representation and analysis of data

1. A collection of measurement or attributes on individuals is known in Statistics as……...
   A. data
   B. population
   C. sample
   D. variable
2. A portion of the population of interest is……
   A. data
   B. inference
   C. sample
   D. statistics
3. The two types of data are……
   A. Qualitative and Descriptive
   B. Qualitative and Inferential
   C. Qualitative and Quantitative
   D. Quantitative and Inferential
4. Which one of the following takes clearly defined values such as 0, 1, 2, 3,….?
   A. Continuous
   B. Discrete
   C. Nominal
   D. Ordinal

5. Gender and marital status fall into……. scale.

   A. interval

   B. nominal

   C. ordinal

   D. ratio

6. The following can be used to represent qualitative data **except** ……

   A. Frequency polygon

   B. Multiple bar chat

   C. Pictogram

   D. Simple bar chat

7. Which of the following is a pair of continuous data?

   A. Age and six pens

   B. Height and age

   C. Outcome of tossed coin and length of a log.

   D. Weight and number of blocks

8. Which of the following **is not** a continuous variable?

   A. Colour of a dress

   B. Height of a student

   C. Temperature of a patient

   D. Weight of a machine

9. Which of the following graphs is the most appropriate for representing the information given in the table?

Vehicle	Busses	Cars	Pick-ups
Frequency	12	16	8

A. Frequency polygon

B. Histogram

C. Line graph

D. Pie chart

10. Three classes in a grouped frequency table are 20-29, 30-59, and 60-79. The class boundary of the second class is……..

A. 19.5-59.5

B. 29.5-59.5

C. 30-59.5

D. 30.5-59.5

11. Which one of the following statements **is** true?

A. In a survey, respondents form the information the researcher needs.

B. Sample survey is the term for a survey conducted on the entire population.

C. Surveys form part of primary sources of data.

D. Surveys form part of secondary sources of data.

12. One distinction between a population parameter and a sample statistic is ……

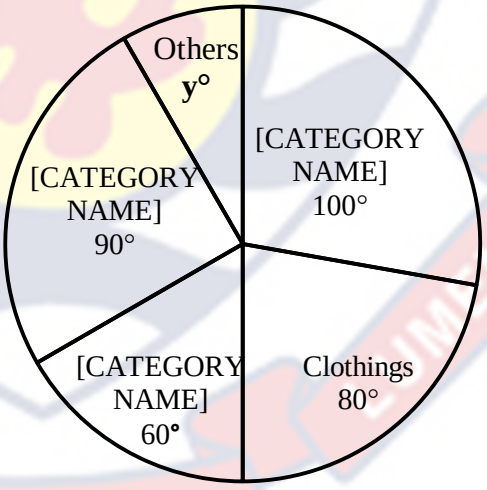
A. a population parameter changes each time you try to measure it, but a sample statistic remains fixed across samples.

B. a population parameter is only based on conceptual measurements, but a sample statistic is based on a combination of real and conceptual measurements.

C. a sample statistic changes each time you try to measure it, but a population parameter remains fixed.

D. the true value of a sample statistic can never be known but the true value of a population parameter can be known.

13. The pie chart shows the expenditure made by Mr. Ofori on selected items in a month.



If he spent GH₵ 600.00 on water bills, how much was spent on "others"?

A. GH₵ 100.00

B. GH₵ 300.00

C. GH₵ 200.00

D. GH₵ 400.00

14. Pick the odd one out from the following alternatives.

A. Experiment

B. Internet

C. Observation

D. Survey

15. Choose the odd one.

A. Experiment

B. Frequency

C. Observation

D. Survey

Indicate by circling, whether the following is **true** *or* **false** *for questions* **16** and **17.**

16. Histograms consist of rectangular bars with equal widths and separated by gaps.

A. True

B. False

17. Frequency polygon is drawn from relative frequencies of a given data set.

    C. True

    D. False.

18. A researcher needs information on which teaching style is preferred. The appropriate instrument that could be used to gather such information is ……

19. Match the items under A to the items under B using arrows.

A	B
Qualitative	Nominal
Quantitative	Ratio
	Ordinal
	Interval

Use the information in the table to answer questions 20 and 21. Show working in the given space.

Marks	Frequency
20 – 25	5
30 – 35	3

20. Determine the class boundaries for each class.

21. Write down the class midpoints for each class.

Section II: Measures of central tendency

22. The middle observation in an ordered sample is the……..

    A. average

    B. mean

    C. median

    D. mode

23. The most frequently occurring number in a data set is called the…….

    A. mean

    B. median

    C. mode

    D. range

24. Summing all values in a data set and dividing by the number of items in the data set gives the ..……

    A. mean

    B. median

    C. mode

    D. range

25. Which one of the following **is** affected by extreme values?

    A. Mean

    B. Median

    C. Mode

26. There can be more than one mean in a data set.

    A. False

    B. True

27. Which of the following is useful for identifying products in greatest demand?

    A. Mean

    B. Median

    C. Mode

    D. Range

28. The word average in Statistics implies……..

    E. mean and mode only.

    F. mean only.

    G. mean, mode and median

    H. median only.

29. The mean is applicable to quantitative data. The statement is……

    A. Always false

    B. Always true

    C. Sometimes true

30. Which of the following is true about the mode? The mode…….

    A. Always exceeds the mean

    B. Can exceed the median

    C. Is always bigger than the median.

    D. Never exceeds the mean.

31. What is the modal value of the data: 2, 7, 9, 8, 6, 2, 9, 8, 7, 8?

A. 3

B. 7

C. 8

D. 29

Use the distribution in the table to answer questions**32** and **33**.

Observation	12	1 5	5	20
Frequency	3	2	4	1

32. What is the mean from the distribution?

A. 9.6

B. 10.6

C. 11.6

D. 12.6

33. The mode from the distribution is ……...

A. 3

B. 4

C. 5

D. 20

Consider the data set 3, 4, 2, 4 and 5. Use the information to answer questions **34** and **35**.

34. What is the median of the distribution?

A. 2
B. 3
C. 4
D. 5

35. The numerical difference between the median and the mean of the data is……

A. 0.1
B. 0.2
C. 0.3
D. 0.4

36. The heights in centimetres (cm) of 10 plants are 9, 4, x, 4, 3, x, 4, x, 6, and 8. If the mean height is **5**, find the value of x.

A. 3
B. 4
C. 5
D. 6

For questions **37** *and* **38,** *indicate by circling, whether the given statement is* **true** *or* **false.**

37. The median **is not** affected by extreme values.

A. False
B. True

38. The median is always the middle observation in a sample.

    A. False

    B. True

For the following questions, **39** ***to*** **42,** *show working in the spaces provided below.*

The rainfall recorded in millimetres (mm) over one-month period for **ten** communities are 12, 17, 11, 20, 12, 21, 6, 19, 7, and 10. Use the information to answer questions **39** and **40.**

39. Determine the median rainfall.

40. Calculate the mean rainfall for the ten communities over the one-month period.

Use the information on the ages of 16 children shown in the table to answer questions **41** and **42**.

Ages (years)	1	2	3	4
Frequency	Y	4	2y	3

41. Find the value of y.

42. Calculate the mean age to one decimal place.

Section III: Measures of dispersion

43. The difference between the largest and the smallest numbers of a data set is the……...

    A. average

    B. interquartile range

    C. quartile range

    D. range

44. Lower quartile is equivalent to…… percentile.

    A. 10^{th}

    B. 25^{th}

    C. 50^{th}

    D. 75^{th}

45. Which one of the following describes a data set divided into four parts?

    A. Mean deviation

    B. Quadruple

    C. Quartile

    D. Range

46. The 50^{th} percentile is the same as……..

    A. semi-interquartile range.

    B. second quartile

    C. mean

    D. mean deviation

47. Measures of dispersion is also called measures of ……..

    A. central tendency

    B. range

    C. spread

    D. standard deviation

48. The positive square root of the variance is the ……

    A. interquartile range

    B. mean deviation

    C. spread

    D. standard deviation

49. The 75th percentile is the same as…… quartile.

    A. lower

    B. second

    C. semi-

    D. third

50. Circle the odd one out.

    A. Interquartile range.

    B. Mode.

    C. Standard deviation.

    D. Variance.

51. The variance can **never** be……

    A. greater than the standard deviation.

    B. less than the standard deviation

    C. negative

    D. zero

52. Which of the following measures of dispersion is affected by extreme values?

    A. Interquartile range.

    B. Range.

    C. Standard deviation

    D. Variance.

53. In case of open-ended classes, the appropriate measure of dispersion to be used is……...

    A. quartile deviation

    B. range

    C. standard deviation

    D. variance

54. What is the range of the data set 7, 85, 85, 62, 12, and 85?

    A. 7

    B. 78

    C. 85

    D. 92

55. The ages of six girls are 14, 12, 11, 17, 19, and 16. The semi-interquartile range of their ages is……. years.

    A. 1

    B. 5

    C. 2.5

    D. 8

56. When the value of the quartile deviation (semi-interquartile range) is small, it implies…….

    A. higher dispersion.

    B. higher mean.

    C. lower dispersion

    D. lower mean.

57. The sum of squares is 20. If the sample variance of the data is 5, what is the number of observations?

A. 4

B. 5

C. 15

D. 25

Use the information in the table to answer questions **58** and **59**.

Marks (%)	10-19	20-29	30-39	40-49	50-59
Frequency	2	5	7	6	20

58. In which class lies the 25th percentile? ……

59. In which class lies the median mark? ……..

For the following questions, **60** ***to*** **63,** *show working in the spaces provided below.*

Use the data set 10, 12, 7, 5, 19, 7, 21, 9, 10, and 7 to answer questions **60, 61,** and **62.**

Calculate:

60. the lower quartile.

61. the upper quartile.

62. the semi-interquartile range.

63. Calculate the standard deviation of the following data set: 2, 3, 8, 8, and 9.

THANK YOU.

APPENDIX B: INTERVIEW GUIDE

The following formed the interview guide for the qualitative aspect of the study:

1. Why did you calculate the mean from the given frequency table the way you did?
2. Why did you rather report on 7 and 6 as the percentile class and median class respectively?
3. How did you obtain your answer to finding the class in which lie the 25^{th} percentile?
4. Why did you calculate the lower quartile the way you did?
5. What do you know about the semi-interquartile range and its calculation?
6. Why your answer to calculating the standard deviation?

APPENDIX C: ETHICAL CLEARANCE LETTER

UNIVERSITY OF CAPE COAST
INSTITUTIONAL REVIEW BOARD SECRETARIAT
TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/1354
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

10TH MAY, 2022

Mr. Stephen Appiah
Department of Mathematics and ICT Education
University of Cape Coast

Dear Mr. Appiah,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2022/02)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Statistics Content Knowledge of Pre-Service Teachers in the Colleges of Education in Ghana.** This approval is valid from 10th May, 2022 to 9th May, 2023. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST