UNIVERSITY OF CAPE COAST

EFFECTS OF INSTRUCTIONAL QUALITY ON STUDENTS' LEARNING OUTCOMES IN MATHEMATICS WORD PROBLEMS

ISAAC BENGRE TALEY

2022

UNIVERSITY OF CAPE COAST

THE EFFECTS OF INSTRUCTIONAL QUALITY ON STUDENTS' LEARNING OUTCOMES IN MATHEMATICS WORD PROBLEMS

BY

ISAAC BENGRE TALEY

Thesis submitted to the Department of Mathematics and Information Communication Technology Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast in partial fulfillment of the requirements for the award of Doctor of Philosophy Degree in Mathematics Education

JULY, 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: Isaac Bengre Taley

Supervisors' Declaration

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

Principal Supervisor's Signature ………………………. Date ………………..

Name: Prof. Kofi Ayebi-Arthur

Co-Supervisor's Signature …………………………..… Date ………………..

Name: Prof. Ernest Kofi Davis

ABSTRACT

Word problems are mathematics tasks that are linguistically framed with a context. The context of word problems may involve a story or an application illustration linked to the tasks. The planners of the mathematics curriculum have envisaged the use of word problems to bridge the wedge between mathematics and the real world. Consequently, the Senior High School Core-Mathematics curriculum and the West African Senior Secondary Certificate Examination in core mathematics are inundated with word problem tasks. Nonetheless, researchers and the West African Examination Council have consistently reported weaknesses in high school students' ability to solve word problem tasks. Previous studies and examination reports have sought to question the quality of word problem instruction. Consequently, by using a pragmatist paradigm mainly through questionnaire, interview and test, this study explored how the quality of instruction affected the word problem solving ability of students in six senior high schools in the Ashanti region. The findings showed that students' performance was low and the quality of instruction moderate. Besides, the categorisation of high schools had an effect on students' word problem test scores. Furthermore, the study showed that the quality of instruction as well as students' mathematics language competence directly predicted students' word problem test performance. However, the positive association between instructional quality and performance was dampened by teachers' poor integration of technology in teaching. It is therefore suggested that mathematics teachers should not skip word problems, try to enact quality word problem instruction, endeavour to develop the mathematics vocabulary of students, and devise appropriate strategies to integrate technology tools in teaching word problems.

KEY WORDS

Content-dependent

Content-independent

Instructional quality

Learning outcome

Mathematics language competence

Mathematics word problems

Technology-integrated teaching

ACKNOWLEDGEMENTS

I am most grateful to my supervisors, Prof. Kofi Ayebi-Arthur and Prof. Ernest Kofi Davis for their prompt and inestimable guidance and invaluable advice during the preparation of this thesis. Their suggestions, advice, supervision, and time throughout the study were invaluable contributions to the success of the study. While I acknowledge the immense contribution of my supervisors to the thesis, I take absolute responsibility for any slip and inconsistencies in this project.

I would like to thank the Headmasters, Heads of Department of Mathematics and Mathematics teachers in the six Senior High schools where I conducted this study. My heartfelt gratitude also goes out to all the students who responded to the questionnaire and the achievement test.

I also wish to thank the lecturers of the Department of Mathematics and ICT Education, Faculty of Science and Technology Education, University of Cape Coast for providing me the necessary mentorship. Finally, I am thankful to my family and friends for their support and encouragement, especially my dear wife, Augustina Azumbila, my children Nsuudoon, Negnan, Bengre, Usakpin, and Ilahn, and my father Peter Kofi Taley.

DEDICATION

To my family

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
GES	Ghana Education Service
GSS	Ghana Statistical Service
GWSA	Ghana Water and Sanitation Agency
ICT	Information and Communication Technology
MANOVA	Multivariate Analysis of Variance
MMDED	Metropolitan, Municipal, and District Education Directorate
MoE	Ministry of Education
NCTM	National Council of Teachers of Mathematics
OECD	Organisation for Economic Co-operation and Development
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
RQ	Research Question
SCT	Sociocultural Theory of Cognition and Language Development
SEM	Structural Equation Modelling
SHS	Senior High School
SPIQQ	Students' Perceptions of Instructional Quality Questionnaire
TIMSS	Trends in International Mathematics and Science Study
T-TEL	Transforming Teacher Education and Learning
WAEC	West African Examination Council
WASSCE	West Africa Secondary School Certificate Examination
WPAT	Word Problem Achievement Test

CHAPTER ONE

INTRODUCTION

Background to the Study

Discussions about suitable description of word problems point to the notion that they are mathematics tasks that are framed linguistically (Verschaffel, Greer & De Corte, 2000). Similarly, Fan and Zhu (2000) described word problems as in-text problems which can be routine and closed-ended. Likewise, mathematics word problems have been described as tasks that consist of problem situations imbedded in a linguistic narrative that may contain at least one question whose solution could be obtained by applying some mathematical concept(s) inferred from the information in the problem situation (Verschaffel et al., 2000). It can therefore be said that mathematics word problems are mathematical tasks that are linguistically framed in a convergent form.

The mathematics education research community have identified mathematics word problems as either routine or non-routine word problems. Non-routine mathematics word problems are authentic problems whose solution paths are not obvious. Routine mathematics word problems, on the other hand, are tasks whose solutions are deduced from the application of known mathematical concepts inferred from the problem situation (Fan & Zhu, 2000; Verschaffel, Schukajlow, Star & Van Dooren 2020).

Irrespective of the typology of mathematics word problems, mathematics word problems are different from mathematics tasks which appear bare in written form (for example, $5x - 2 = 13$ or $54 + \frac{3}{4} =$?) and tasks which are presented in oral form (such as, find the product of 30 and two-thirds or find the mean of 7, 10, 11, and 9). Additionally, mathematics word problems may have mathematics structures, semantic structures, context and format (Verschaffel et al., 2000). For example, in a mathematics word problem task, "A man bought some shirts for GH¢720.00. If each shirt was GH¢2.00 cheaper, he would have received 4 more shirts. Calculate the number of shirts bought" (West African Examination Council [WAEC], 2017). The values 'GH¢720.00', 'GH¢2.00' and 'received 4 more' constituted the mathematical structure of the worded problem. The task of calculating the number of shirts bought is the format. The context of the problem is the situation or condition involved in the buying of some shirts. The meaning of the preamble associated with the problem is the sense of purchasing more shirts at a cheaper price.

Mathematics word problems are important tasks in the learning of mathematics (Verschaffel et al., 2020). Through mathematics word problems, students are exposed to mathematics in their everyday life. Invariably, students turn to apply the knowledge gained in the mathematics classroom to solving real-life problems (Bullock, 2015). Verschaffel, Depaepe and Van Dooren (2014) also assert that students gain inner motivation when they experience classroom mathematics in a real-life context and when they can solve problems related to their everyday activities.

Verschaffel et al. (2014) further pointed out that students themselves build their ingenuity and creativity if they have the opportunity to generate word problems. Ronhovde (2009) submitted that mathematics become very significant to the student if the teacher can connect the mathematics word problem to things and activities students apply in their lives. Consequently, word problems have become a wedge for bridging the gap between mathematics and the real world, and also, a means to promote mathematical problem solving in students (Bullock, 2015; Verschaffel et al., 2014; Verschaffel et al., 2020).

Due to the envisaged importance of mathematics word problems, the MoE through the planners of the curriculum has prioritised the teaching and solving of mathematics word problems at the senior high school level (MoE, 2010). For instance, MoE (2010) has as one of its objectives to help students translate word problems into mathematical expressions such as equations and then apply mathematical knowledge in solving the tasks. Additionally, the planners of the mathematics syllabus recommended that mathematics teachers, textbook writers, and curriculum implementers should incorporate mathematics word problems in all topics (MoE, 2010).

Consequently, mathematics word problems have been made to cut across all topics in the core mathematics syllabus (MoE, 2010). It is worth noting that the Ghana Education Service's approved that mathematics textbooks and the West African Secondary School Certificate Examination [WASSCE] incorporate mathematics world problems in their materials. The West African Examination Council [WAEC] has also consistently tested students' ability to both translate mathematics word problems and to solve mathematics word problems using appropriate methods (WAEC, 2016; 2017; 2018; 2019; 2020).

Samples of mathematics word problems culled from these curriculum materials approved for the teaching of core mathematics at the senior high school (SHS) level show that the word problems are routine in form. Word problems are also, either application or non-application. Examples of these mathematics word problems taken from the core mathematics syllabus, core mathematics textbook, and from the West African Secondary School Certificate

Examination (WASSCE) past questions respectively are “Aku has y mangoes more than Baku. If Baku has x mangoes, how many do they have altogether?” (MoE, 2010, p. 15); “one-half of Heather's age two years from now plus one-third of her age three years ago is twenty years. How old is she now?” (Asiedu, 2013, p. 45); and “three times the age of Felicia is four more than the age of Asare. In three years, the sum of their ages will be 30 years. Find their present ages” (WAEC, 2016, p.5).

Despite the potential usefulness of mathematics word problems in the learning of mathematics (Andam, Okpoti, Obeng–Denteh & Atteh, 2015; Verschaffel et al., 2014), students generally find it difficult to solve mathematics word problems. Empirical studies point to this difficulty as manifested in students’ difficulty in comprehending and translating word problem tasks (Adu et al., 2015, Assuah, & Asiedu-Addo, 2015; Andam et al., 2015) and students’ deficiency in applying common sense (Chapman, 2006). Other instances are students’ inadequate mathematical skills and limited ability in selecting appropriate mathematical algorithms in solving given mathematics word problems (Tambychik & Meerah, 2010). Another source of students’ difficulty with word problems is when the tasks are overloaded with text or when the tasks are too lengthy (Latu, 2005; Pearce, Bruun, Skinner & Lopez-Mohler, 2013).

Demonstrating the difficulties of students in solving word problems, a study by Ekwueme and Ali (2012) on errors Nigerian students’ commit in the Senior Secondary Certificate Examination identified four process errors. These are arbitrary, structural, executive and clerical errors. Likewise, Adu et al. (2015) identified comprehension, transformation, computation and encoding errors among a group of first-year SHS students in Ghana. Although, Adu et al.

(2015) observed from the analysis that significant errors were committed at all four levels of the modified Newman Error Hierarchical levels framework, the percentage of errors, however, increased systematically from comprehension to encoding levels.

A review of literature essentially shows that students' difficulty in mathematics word problems is not peculiar to high school students only but it transcends levels and borders. For instance, at the elementary school level, Tong and Loc (2017) understudied the difficulties of Vietnamese's grade three pupils in solving mathematics word problems. It was concluded that the difficulties of the pupils encountered in solving mathematics word problems were due to the misapplication of solution rules (Tong & Loc, 2017).

Davis (2010) also reported that elementary pupils in Ghana had low ability in solving mathematics word problems. Davis' (2010) investigation centred on how elementary class five pupils performed in fraction word problems within the broader study of linguistic influences on children mathematical word problem-solving. It was found that out of the 62 pupils examined in three-word problem tasks in fraction, 24.2%, 67.7% and 14.5% of the pupils had Items 1, 2 and 3 respectively correctly answered. Additionally, Davis (2010) observed that students from relatively well-endowed schools who had better support structures such as access to libraries and trained teachers for their studies outperformed their peers from less endowed schools.

Besides, the low performance of pupils in Davis' (2010) study was attributable to the number of words framing the mathematical task as well as the students' deficiency in cognitive academic language proficiency. Consequently, other researchers (Agbenyega & Davis, 2015; Davis, 2010;

Nortvedt, Gustafsson & Lehre, 2016; Sepeng & Madzorera, 2014) assert that the quality of instruction in mathematics classrooms is facilitated by the language of instruction and students' mathematics language competence. This is because, students who struggle to read and/or struggle to cope with instructional language find it difficult to make meaning of the instruction thereby become challenged in solving mathematics word problems (Agbenyega & Davis, 2015).

Similar to observations with elementary graders, high school students also demonstrate some levels of difficulties in solving mathematics word problems (Adu et al., 2015; Andam et al., 2015; Sepeng & Madzorera, 2014). Adu et al. (2015) conducted a study of Ghanaian first-year SHS students' errors in solving linear equation word problems. The findings show that only two percent of the 60% of students who attempted all the word problem items were able to provide correct solutions. The reason adduced for the students' low performance was students' inability to comprehend and interpret the text framing the tasks (Adu et al., 2015). Andam et al. (2015) also established that students in Mansoman SHS had difficulty making meaning and translating word problems into algebraic equations. By modifying instructional practice to include cooperative learning, group presentation, and emphasising the definitions of terms, Andam et al. (2015) observed that the students' improved on their performance in solving algebraic word problems.

Sepeng and Madzorera (2014) also explored South Africa grade 11 students' sources of difficulty in solving mathematics word problems. They found that mathematics language-impaired both students' comprehension of classroom instruction and their ability to solve word problems correctly. The

Organisation for Economic Co-operation and Development [OECD] (2014) report highlighted grade 12 students' struggle with mathematical tasks which were placed in a real-world context. Deducing from this study, the contextual nature of tasks often posed difficulty for the grade 12 students.

Wilmot, Davis and Ampofo (2015) also shared their observations on difficulties encountered by post-secondary students in solving mathematics word problems. Wilmot et al. (2015) explored Primary and Junior High School teacher trainees low ability in solving mathematics word problems. In their study, Wilmot et al. (2015) observed that teacher-trainees difficulties in solving non-routine word problem tasks were attributable to the student-trainees inability to transform the tasks into appropriate mathematical equations.

A review of selected empirical studies on students' word problem solving difficulties show that although both Adu et al. (2015) and Andam et al. (2015) produced similar results, Adu et al.'s (2015) school of enquiry was unknown, whiles, Andam et al. (2015) study was conducted in a less-endowed category C school. What is unclear is whether students' difficulty in solving word problems transcends the resource index of high schools. Coincidentally, SHSs in Ghana are classified as category A, B, C, D or E according to schools' resource endowment (Ghana Education Service, [GES], 2019).

Interestingly, Olatunde and Otieno (2010) assert that well equipped secondary schools tended to promote better student performance in Mathematics among Kenyans. This assertion by Olatunde and Otieno (2010) was confirmed by the observation among SHS students in Ghana. According to Yusif, Yussof and Noor (2011), students from well-endowed schools are more likely to perform better than those from less-endowed schools. More so, Bernal, Mittag and Qureshi (2016) suggest that school resources and teaching quality are the key determinants of students' achievement.

Amid SHS students' difficulty in solving worded problems accurately, the quality of mathematics instruction particularly in word problems needs to be investigated. This is because empirically, the quality of classroom instruction has proven to affect students learning in mathematics in general (Kunter & Voss, 2013; Kuterbach, 2012; Munasinghe, 2013). Besides, students' competence in solving word problems depends on the quality of instruction (Verschaffel et al., 2020). By examining the quality of classroom instruction in mathematics word problems, at least two intentions will be satisfied.

Firstly, the curiosity about whether empirically tested teaching practices deemed to help students overcome their low ability in solving mathematics word problems are being implemented. This is because, Matsumura, Garnier, Cadman and Boston (2008) hold the view that measuring the quality of instruction directs attention to the quality of learning conditions and practices teachers create for the enhancement of students' learning and achievement. Secondly, by examining the quality of instruction in mathematics word problems, stakeholders in SHS mathematics education would understand how classroom instruction might be affecting the students' performance in mathematics word problems. This will help improve instructional practices and invariably, students' abilities in solving word problems. As posited by Sutton and Title (2002), an improvement in the quality of instructional practices in mathematics can lead to enhanced students' achievement.

Considering elements of instructional quality, re-wording (Chan, 2005; Haghverdi & Wiest, 2016), personalisation (Awofala, 2011; Chapman, 2006;

Walkington & Bernacki, 2015), and incorporation of technology (Clements & Sarama, 2002; Eyyam & Yaratan, 2014; Olsen & Chernobilsky, 2016) are generally deemed to help students overcome their low ability in solving mathematics word problems. Re-wording is seen to be more effective for elementary school students than it is for secondary school and older students (Bernardo, 1999; Haghverdi & Wiest, 2016).

Personalisation works well for secondary school students (Chapman, 2006; Walkington & Bernacki, 2015). In the personalisation of word problems, students' personal information and interest are incorporated into word problem structures to relate to students' context. The contextual nature of the problem makes the problem meaningful, interesting and relevant to students' personal experiences.

The incorporation of technology was also found effective for both elementary and high school levels (Costley, 2014). On the incorporation of technology, researchers admit that the appropriate use of technology improves a deeper understanding of mathematical concepts, enhancing academic performance in mathematics. In addition, it provides immediate feedback to students, promotes collaboration, cooperation and active students' learning (Clements & Sarama, 2002; Eyyam & Yaratan, 2014; Olsen & Chernobilsky, 2016; West & Graham, 2005).

Furthermore, Awofala (2011) suggested that a computerised instructional programme for teaching word problems interwoven with personalisation yields significant results. The observation by Awofala (2011) is on the premise that the 21^{st}-century student is born into a technological world in which he/she spends much of his/her time on technology (Powers &

Blubaugh, 2005). Therefore, decoupling technology from classroom instruction is liken to “separating their classroom experiences from their real-life experiences” (Willingham, 2010, p. 260).

To improve the quality of instruction in mathematics word problems as a second reason for examining instructional quality lies within the ability to measure it. This is because, as often quoted in industrial quality control, “that which cannot be measured, cannot be improved” (Blumenthal & McGinnis, 2015, p. 1901). Likewise, Bell, Dobbelaer, Klette and Visscher (2019) suggest that to gain a better understanding to improve instructional quality, researchers and teachers should be able to measure the quality of instruction.

Consequently, instructional researchers have developed a myriad of models for measuring instructional quality activities in mathematics. For simplicity and better understanding, the instructional activities are classified into dimensions. Prominent dimensions of instructional quality include content-independent instructional activities and content-dependent instructional activities (Praetorius, Pauli, Reusser, Rakoczy & Klieme, 2014). Despite the existence of these models, the description of instruction in mathematics word problems in Ghana remains largely unexplored (Adu et al., 2015).

Specifically, the chief examiner for core mathematics continues to report that mathematics teachers may not be relating mathematics to the real-world context. Additionally, the reports reveal that teachers may not be giving adequate exercises or teachers are skipping some aspects of the mathematics curriculum as some reasons for students’ low ability in solving word problems (WAEC, 2017, 2018, 2019, 2020). These reports are worth considering because according to Junker, Matsumura, and Crosson (2005), students’ low achievement could be attributed to either classroom instruction is not being modified by teachers and/or that students are not responding positively to the changes in instructional provisions.

Therefore, the concern about the feasibility in measuring classroom instructional quality in mathematics word problems, and the uncertainty about how robust instructional quality practices help students to correctly solve word problems are issues worth considering. However, if teachers are providing optimum instructional practices, then it is necessary to understand how students respond to these instructional practices. These and other such concerns warrant investigations. Hence, the need to examine the quality of classroom instruction in relation to mathematics word problems at the SHS level in Ghana.

Statement of the Problem

Empirically, high school students in Ghana (Adu et al., 2015; Andam et al., 2015) and elsewhere (Bullock, 2015; Chapman, 2002; Daroczy, Wolska, Meurers & Nuerk, 2015; Sepeng & Madzorera, 2014) find it difficult to solve mathematics word problems. These difficulties are manifested either in students' low ability to translate mathematics word problems into algebraic expressions or that students are unable to select the appropriate mathematical algorithm to solve mathematics word problem tasks (Ekwueme & Ali, 2012; Mandal & Naskar, 2019; Tong & Loc, 2017).

A study of the chief examiner's reports for core mathematics (WAEC, 2016; 2017; 2018; 2019; 2020) show that students are unable to answer word problem questions correctly. For example, in 2018, WAEC (2018, p. 238), the chief examiner stated that the worded problem in question 9 (b),

> The perimeter of a square and a rectangle is the same. The width of the rectangle is 6cm and its area is 16cm^2 less than the area of the square. Find the area of the square (WAEC, 2018, p. 238).

exposed candidates' inability to translate the given information into mathematical statements, hence, they were not able to find the area of the square.

Similarly, for question 8 (b) of WASSCE (WAEC, 2014, p. 7) "when a fraction is reduced to its lowest term, it is equal to $\frac{3}{4}$. The numerator of the fraction when doubled would be 34 greater than the denominator. Find the fraction.", the chief examiner observed that majority of the students could not form the correct mathematical statements $\frac{x}{y} = \frac{3}{4}$ and $2x = y + 34$. This denied them the ability to solve the problem. Commenting on the performance of students on the word problem "a man bought some shirts for GH¢720.00. If each shirt was GH¢2.00 cheaper, he would have received 4 more shirts. Calculate the number of shirts bought." (WAEC, 2017, p. 212), the chief examiner again indicated that most of the students could not solve it.

Although the chief examiner of core mathematics could not point the exact element(s) of instructional quality that contributed to students' difficulties in correctly solving word problems, the chief examiner concluded generally on a deficiency in classroom instructional quality. This observation about the deficient instructional quality been responsible for students' difficulty in solving word problems is anchored in general education that when students' learning outcomes dip, it could be that quality instruction is not being achieved (Junker et al., 2005). Therefore, there is the need to examine whether students' difficulty in solving mathematics word problems could be attributed to the quality of instruction.

Besides, Verschaffel et al. (2020) have reiterated the dearth of non-interventional research that relates instructional quality in mathematics word problems directly to students' learning outcomes. According to Verschaffel et al. (2020), such studies cited in the past 20 years have been conducted in the Americas (Chapman, 2006; Depaepe, De Corte, & Verschaffel, 2010). Such studies might not reflect the circumstances in Ghana due to instructional context. It is against this background of limited or no study on relationship between instructional quality and students' performance in word problems in Ghana that this study was designed to explore the local situation to inform practice and contribute to literature.

Purpose of the Study

The purpose of this study was to explore how the quality of instruction affect the performance of senior high school students in solving mathematics word problem tasks. The study specifically:

1. Examined instructional activities that define instructional quality in the teaching of mathematics word problems.
2. Explored the correlation between students' performance in word problems and instructional quality.
3. Explained students' rating of instructional quality and performance in mathematics word problems.
4. Explored the association between students' performance in mathematics word problems and instructional quality and its dimensions.

5. Explored the association among technology-integrated teaching, students' mathematics language competence and instructional quality in mathematics word problems.
6. Explained how students' mathematics language competence and teachers use of technology tools in teaching affect students' understanding of word problem lessons.
7. Explored the moderation effect of technology-integrated teaching and students' mathematics language competence on the association between instructional quality students' performance in word problems.
8. Explored how students from the categories of senior high schools differed in their perception of instructional quality, mathematics language competence, and performance in word problem tasks.

Research Questions and Hypothesis

Research questions

The following research questions were answered in this study:

1. What instructional activities define the quality of instruction in the teaching of mathematics word problems?
2. How are students' performance in word problem tasks and their perception about instructional quality corelated?
3. In what ways do students' view about the quality of word problem instruction explain their survey results of the relationship between instructional quality and performance in word problems?
4. To what extent do instructional quality and its content-dependent and content-independent dimensions affect students' learning outcomes in mathematics word problems?

5. How well do technology-integrated teaching, students' mathematics language competence and instructional quality significantly add to predict learning outcomes?
6. How do students' mathematics language competence and use of technology tools in teaching affect students' performance in word problems?
7. How well do technology-integrated teaching and students' mathematics language competence interacting with instructional quality significantly moderate the prediction of students' performance in word problem tests?

Research Hypothesis

The null hypothesis tested in this study was:

H_0: There is no significant difference between the instructional quality of teachers and the performance of students in word problem tests across category of senior high schools.

Significance of the Study

The findings relating to students' perception about the quality of word problem instruction may provide mathematics teachers and researchers with qualitative and quantitative data on how students perceive classroom instruction in relation to word problem. This might further challenge mathematics teachers and researchers to conduct further studies on the quality of word problem instruction using alterative research approaches. Mathematics education researchers interested in classroom instruction may also be challenged to explore the quality of mathematics instruction from the perspectives of content-dependent dimension and content-independent dimensions.

In addition, the findings such as the influence of instructional quality on students' performance in mathematics word problem might inform mathematics educators and researchers about the direct effect teachers' word problem instruction has on students' learning and ability to solve word problem tasks. This may further challenge mathematics teachers to adopt and/or modify their instructional activities in order to enact instruction that may engender positive attitudes of students for word problem tasks.

Furthermore, the findings relating to the influence of instructional quality and students' mathematics language competence on students' performance in mathematics word problem may inform mathematics educators and researchers about how students' mastery of mathematics language augments the teacher's instruction in helping SHS students improve their performance in solving word problem tasks. This may challenge mathematics teachers to deliberately develop students' mathematics language. Hence, it may help improve students' ability to mathematics word problems in WASSCE.

More so, the findings relating to the interaction effect of technology-integrated teaching on the relationship between instructional quality and word problem performance may inform mathematics teachers to appropriately use suitable technology tools in word problem instruction. This is because, if suitable technology tools are used in word problem instruction, the positive relationship between instructional quality and performance may not be dampened.

Besides, students' performance in the word problem test in relation to the category of schools may help mathematics teachers and researchers appreciate how the resource index of schools contributes to differentiating students' performance. This may challenge mathematics teachers and school management in least-endowed schools provided mathematically designed instructional resources to aid students' learning and ability to solve word problem tasks.

Delimitations

Mathematics word problems run through all branches of the SHS core mathematics syllabus (MoE, 2010). Nonetheless, this study was restricted to the branch of algebra because most of the mathematics word problems at the WASSCE are algebra inclined. Besides, a fundamental procedure in solving word problems involves translating the worded phrases into equations and/or inequalities using variables. Since algebra is the generalisation of arithmetic in which variables are mostly used (Croteau, Heffernan, & Koedinger, 2004), the scope of this study was limited to algebraic word problems.

In adapting Praetorius et al. (2014) instructional quality framework, this study explored the quality of classroom instruction using the cognitive activation (content-dependent) and individual student support (content-independent) dimensions excluding the classroom management dimension. The dimension of classroom management was excluded because unlike cognitive activation and individual support, classroom management is more generic in focus. Besides, the mere maintenance of discipline in the classroom, which is the main focus of classroom management does not necessary foster learning (Decristan et al., 2016).

Furthermore, this study was confined to second-year students in six senior high schools in the Ashanti region. The selection of the six schools was based on the GES categorisation because it provided a fair criterion for a representation of all school category in the study. Granted that word problems cut across the three levels of senior high school core mathematics curriculum (MoE, 2010), the algebraic topic of equations and inequalities is taught in the second-year.

Limitations of the Study

The limitations of this study were related to the data collection and data analysis.

Regarding the data collected for this study, classroom observation of instruction was not applied in this study. Although observation is an important instrument for assessing instructional quality, classroom observation was not applied in this study because of Covid-19 restrictions. Consequently, the findings as reported in this study are students' views validated which were validated using teacher interviews.

With regard to the data analysis, the data on students' word problem test scores and students' ratings of teachers' integration of technology in teaching word problems were transformed. This is because, these data sets violated normality tests. It is possible that the actual data could have produced different statistical results. Therefore, inferences into the findings reached in this study should be discussed with caution.

Definition of Terms

Dimension: The underlying instruction trait in mathematics lessons.

Grade: The class/stage in an educational level

Instruction: A description of the interactions between what teachers and students say and do during the mathematics lessons.

Learning outcome: Students' performance score in word problem test

Instructional quality: The overall distinctive features of classroom instruction in the mathematics word problem.

Scale: The tools for measuring the instructional dimensions or constructs.

Student: A learner in high school or higher level of education

Organisation of the Study

This study was structured into five interconnected chapters. Chapter one highlights the need to examine the quality of classroom instruction in mathematics word problems at the senior high school level. Research questions and hypothesis to be tested empirically as well as the purpose of the study are captured in this chapter. Additionally, the extent to which findings of this study could be applied was delineated in this chapter.

The conceptual framework that describes the relations among the instructional quality, students' mathematics language competence, technology-integrated teaching, and students' word problem performance are presented in Chapter two. Theories supporting the conceptual map together with related literature about instructional quality vis-à-vis students' mathematics language competence and students' learning outcomes in word problems are elaborated further. The third chapter describes how data was collected and presented within an ethically approved research climate. The appropriateness of the research design adopted with respect to the research questions and hypothesis, and data analysis are discussed in chapter three.

In Chapter four, the analysis of the data collected from the research schools is presented. In addition, a discussion of research findings which was presented according to the research questions and hypothesis are made available. Finally, Chapter five contains the summary of the findings in the study. Implications for classroom instruction and recommendations for further research form part of chapter five.

CHAPTER TWO

LITERATURE REVIEW

The purpose of this research was to explore how the quality of instruction affect the performance of senior high school students in solving mathematics word problems. This chapter presents concepts related to instructional quality and learning outcomes, the theoretical foundations underpinning this study and the conceptual framework for this study as well as the review of related empirical literature. Also presented in the chapter is the summary of the literature reviewed.

Conceptual Review

This section of the study presents the review of related concepts as explained in other studies. The conceptual review entails the categorisation and description of mathematics word problems, learning outcomes, instructional quality in mathematics, and teaching context in instructional quality.

Mathematics word problems

Mathematics word problems are sometimes referred to as application problems or story problems (MoE, 2010). Fan and Zhu (2000) generally categorised mathematics tasks as either an exercise or text/word problems. However, Leacock explained mathematics word problems as “short stories of adventure and industry with the end omitted” (as cited in Chapman, 2003, p. 197). In addition, Verschaffel et al. (2000) saw mathematics word problems as problem situations that are embedded in a linguistic narrative and may contain at least one question whose solution could be obtained based on an application of some mathematical concept inferred from the information in the problem situation.

Ordinarily, students need to read the text, adequately understand the text framing the problem, figure out the question, create algebraic/numeric equation(s)/inequality(ies) and solve. This systematic process makes solving a mathematical word problem task a form of text comprehension (Fuchs, Fuchs, Compton, Hamlett & Wang, 2015). More so, word problems are seen as mathematical tasks that are linguistically framed with a context. The context that describes the problem as well as the problem itself, are both stated in word text. The context of the word problem task is the stories or the application illustration that colligate the task. In mathematics word problem tasks, the mathematical concept explored is readily known and the solution path may involve an application of routine strategy learned within the concept. Mathematics word problem tasks come with known and unknown quantities that can be deduced from the tasks.

Mathematics word problems have structures that make them slightly different from other mathematics tasks. These structures of mathematics word problem according to Verschaffel et al. (2020) distinguishes them from mathematics tasks that appear bare in written form (for example, $5x - 2 = 13$ or $54 + \frac{3}{4} =?$), and mathematical tasks which are presented in oral form (such as find the product of 30 and two-thirds, or find the mean of 7, 10, 11, and 9).

Verschaffel et al. (2000) divided mathematics word problems into four principal constituent structures. These are the mathematical structure, semantic structure, context, and format. The mathematical structure depicts the mathematical operations involved and the nature of known and expected quantities. The semantic structure refers to the text and its relation to the mathematical concepts. The context explains the situation of the problem, whiles the format describes the problem formulation and presentation. Besides this classification, mathematics word problems may also be presented in a straightforward application form, which may contain one or two mathematical operations to the data embedded in the problem statement.

In addition, mathematics word problems can be categorised into two categories - routine and non-routine problems (Fan & Zhu, 2000; Verschaffel et al., 2020). Non-routine mathematics word problems or authentic life problems may have the mathematical structure, semantic structure, context, and format and thus could be solved mathematically. These types of problems may lack clarity with regards to the nature of questions they present, and the solution paths (Kaiser, 2017; Verschaffel et al., 2020).

More so, non-routine tasks could be created from everyday life scenarios or abstract unrealistic situations for which at least one solution method may exist (Sheffield & Cruikshank, 2000). These non-routine tasks usually do not have an immediate method of solution, as well as the exactness of the answers. Examples of non-routine mathematics word problems from literature are:

1. Separate 15 into two parts such that twice the smaller is 3 more than the larger (Ebner, 2002).
2. Find the two-digit number which has the sum of the cubes of its digits equal to three times itself (Fan & Zhu, 2000).

These two examples will appear to have ambiguous conditions aside from the lack of a straightforward application of known mathematical operations to the data embedded in the problem statement. Example 1 for instance has two answers 6 and 9.

Fan and Zhu (2000) further described routine word problems as tasks whose solution paths are readily known to the solver. The mathematics word problems require administering standard algorithms, procedures, and formulas to solve them. They are usually framed to tease out the application of a mathematical concept to a real-life situation. For example, a boy went into a bookshop and bought 3 notebooks and 2 ballpoint pens. These cost him GH₵1.55. His sister bought 1 notebook and 2 ballpoint pens; she paid GH₵ 0.65. What is the cost of a notebook and the cost of a ballpoint pen? (Macrae, 2008). From this task, a notebook and a ballpoint pen cost GH₵ 0.45 and GH₵ 0.10 respectively.

Routine mathematics word problems can be categorised into other classes such as closed and open-ended or application and non-application word problems. Where a task requires just a single answer or solution, such tasks are closed. For example, "When a fraction is reduced to its lowest term, it is equal to $\frac{3}{4}$. The numerator of the fraction when doubled would be 34 greater than the denominator. Find the fraction" (WAEC, 2014). This question produces a single answer (numerator is 51 and denominator is 68). For open-ended word problem tasks, more than one solution is expected. For example, "A triangle has sides of $x\ cm$, $(x+4)cm$ and $11cm$, where x is a whole number of cm. If the perimeter of the triangle is less than $32cm$, find the possible values of x" (Macrae, 2008). This task has a solution $\{1,2,3,4,5,6,7,8\}$. An example of an application word problem is "Three bells toll at intervals of $8\,min$, $15\,min$ and $24\,min$ respectively. If they toll together at $3\ p.m.$, what time will it be when they toll together again?" (Fan & Zhu, 2000). The possible solution is at $5p.m, 7\ p.m,$ etc (that is after every $120\ mins$).

Learning Outcomes in Mathematics

Every educational learning event strives to produce a desirable learning outcome in learners. Learning outcomes can be described as expectations of what a person knows, understands, and/or can demonstrate as a result of a learning or instructional activity (Adam, 2004; Donnelly & Fitzmaurice, 2005; Moon, 2002). From this description, learning outcomes can be also be explained as a tool for measuring the effectiveness and accountability of instructional practice (Proitz, 2010). Defining the type and level of learning outcome in an instructional context is important. According to Huitt (2003), the significance of instructional factors contributing to the realisation of the learning outcomes is defined by the level of the attained learning outcome. Different learning outcomes other than those relating to the cognitive domain are important for students' development and future career selection (Blömeke, Olsen, & Suhl, 2016). Nonetheless, Praetorius, Klieme, Herbert, and Pinger (2018) and Huitt (2003) maintain that students' learning outcomes can be assessed using the measure of students' achievement.

The most learning outcome assessed in mathematics education relates to students' achievement (Al-Agili, Mamat, Abdullah & Maad, 2013). Therefore, students' achievement in mathematics word problem tasks may be used to estimate their learning outcome. This is because an understanding of students' achievement gauges the significance of the other constructs in the teaching and learning chain. These constructs include the teaching and learning resources, the quality of teaching, teacher quality, and student make-up (Huitt, 2003; Yusif et al., 2011).

Among the constructs identified by Yusif et al. (2011), instructional quality is an important determinant of students' achievement (Bellens, Van Damme, Van Den Noortgate, Wendt & Nilsen, 2019b; Bloom, 1956; Verschaffel et al., 2020). Notably, the National Council of Teachers of Mathematics [NCTM] (2015) indicates that gaps in students' achievement in mathematics can be attributed to differential instructional opportunities. For this reason, McIlrath and Huitt's (1995, p. 2) asserted that "almost all students can earn A's if … students are provided quality instruction".

Instructional Quality in Mathematics

Holzberger, Philipp, and Kunter (2013) used the term instructional quality to represent how well a teacher engages students. Similarly, Nilsen and Gustafsson (2016) described instructional quality as a "construct that reflects those features of teachers' instructional practices well known to be positively related to student outcomes, both cognitive and affective ones" (p. 5). These instructional practices connote all appropriate psychological and curricular experiences within an instructional event (Kuterbach, 2012). By extension, instructional quality may be seen as the suitability in the teacher's organisation of instructional resources and the presentation of instructional tasks to students. These instructional practices, that is both verbal and nonverbal instructional practices of the teacher should aim at supporting the cognitive development of learners (Winne, 1987). Admittedly, the quality of instruction is high if instructional activities provide opportunities for students to learn quickly and proficiently within the shortest period (Baier et al., 2019; Kuterbach, 2012).

Previous instruction researchers have sought to identify a myriad of activities that constitute instructional quality. For example, Ottmar, Decker, Cameron, Curby, and Rimm-Kaufman (2014) summarised the features of instructional quality to include; teachers' feedback to students, teachers' use of language to facilitate students' learning, the opportunities provided for higher-order thinking, and understanding of concepts. Bloom (1956) also identified cues, reinforcement, participation, and feedback/correctives as four constituents of instructional quality.

Given the complexity in the description of instructional quality constituents (Charalambous & Praetorius, 2018; Dunkin & Biddle, 1974), different frameworks for the study of classroom instructional quality have emerged. For example, the Elementary Mathematics Classroom Observation Form (Thompson & Davis, 2014), the Instructional Quality Assessment [IQA] (Matsumura et al., 2008), the Mathematical Quality of Instruction [MQI] (Loewenberg-Ball, Hyman & Hill, 2011), and the Mathematics-Scan [M-Scan] (Walkowiak, Berry, Meyer, Rimm-Kaufman & Ottmar, 2014). Other approaches include the TEDS-Instruct framework (Schlesinger, Jentsch, Kaiser, König & Blömeke, 2018), the Three Basic Dimension framework [TBD] (Klieme, Pauli & Reusser, 2009), the Teaching for Robust Understanding [TRU] (Schoenfeld, 2013).

Charalambous and Praetorius (2018) categorised the frameworks for studying instructional quality into three models: generic, hybrid, and content-specific frameworks. Some generic frameworks include the Classroom Assessment Scoring System [CLASS], Framework for Teaching [FfT], and the Three Basic Dimensions framework [TBD]. These generic frameworks are inclined toward instructional aspects that are general and do not focus on subjects and the teaching demands of any specific discipline. Hence, such general frameworks do not sufficiently assess the quality of mathematics instruction (Charalambous & Praetorius, 2018; Loewenberg-Ball et al., 2011). In contrast, Jentsch and Schlesinger (2017) argued that the TBD which was originally developed to assess instructional quality in mathematics (Lipowsky, Rakoczy & Pauli, 2009) could be operationalised to cater for the so-called mathematical dimensions that are not adequately handled within the TBD.

On content-specific frameworks, Charalambous and Praetorius (2018) described these as frameworks developed to address instructional concerns in specific subject matter such as mathematics. The content-specific frameworks include the Elementary Mathematics Classroom Observation Form, the Mathematical Quality of Instruction [MQI], and the Mathematics-Scan [M-Scan] that examine precision and accuracy in task execution, the appropriateness of mathematical language, notations, and communication that are enveloped in teacher-student and student-student interactions. The Teacher Education and Development Study [TEDS-Instruct] framework that incorporates aspects of TBD with MQI and IQA, the UTeach Observation Protocol [UTOP] and the Teaching for Robust Understanding [TRU] were classified as hybrid frameworks.

Investigations into the quality of instructions in mathematics education have either focused on the content-specific and pedagogic perspectives or surface and deep structures of the instruction (Kunter & Voss, 2013; Schlesinger & Jentsch, 2016). These categorisations of instructional quality birthed psychometric structures described as dimensions of instructional quality. These dimensions of instructional quality include:

1. Pianta, Paro and Hamre's (2008) emotional support, classroom organisation, and instructional support;
2. Danielson's (2013) planning and preparation, classroom environment, instruction, and professional responsibilities;
3. van de Grift's (2007) safe learning climate, classroom management, clear instruction, activating teaching methods, learning strategies, and differentiation;
4. Lipowsky et al's. (2009) classroom management, student support, and cognitive activation;
5. Loewenberg-Ball et al's. (2011) mode of instruction, the richness of the mathematics, working with students and mathematics, errors and imprecision, student participation in meaning-making and reasoning;
6. Jentsch and Schlesinger (2017) classroom management, personal learning support, cognitive activation, mathematics educational characteristics.

Despite the quantum of extant research into the measurement of instructional quality in mathematics, Charalambous and Praetorius (2018) caution that no single framework is robust enough to capture all facets of instructional quality equally. However, from the psychometric point of view, Praetorius et al. (2014) observed that classroom management, individual learning support, and cognitive activation have become the most commonly studied dimensions since the pioneering work of Kounin (1970).

Praetorius et al. (2014) further classified the dimensions of instructional quality into content-dependent and content-independent. Specifically, classroom management and individual learning support are content-independent whereas cognitive activation is a content-dependent dimension (Praetorius et al., 2014). Since mathematics word problem is a content-specific area in the senior high mathematics curriculum, it is convincing to approach the study of instructional quality in word problems from content-related perspectives.

Content-dependent dimension of instructional quality

The content-dependent dimension of instructional quality relates but is not limited to opportunities made available for students to activate previously learned content, provisions that challenge students to be creative, and empowering students' independence and diversity in thinking (Lipowsky et al., 2009; Praetorius et al., 2014). To meet these instructional demands, the following four instructional practices proposed by Bruner (1966) should be adhered to. First, mathematics classroom instructions may be structured such that the instruction is inclined toward students' active learning and participation in the learning process. Secondly, the instruction may be structured to provide for the organisation of knowledge for students' understanding. Thirdly, there is the need for the sequential and logical presentation of the content material to students during instruction. Lastly, a system of rewards and punishments may be created to associate with the learning process.

Fulfilling the content-dependent instructional activities go beyond the provision of manipulatives, learning guides, or other forms of behavioural actions however necessary. It also involves the provision of opportunities that act directly on the cognitive structures of students (Kunter & Voss, 2013). Other activities may include interspersing routine word problem tasks with non-routine tasks, pose tasks with multiple solution paths, demand for students' explanations to their solutions, and encourage students to formulate their word problems. Where there is a deficiency in the content-dependent dimension, students become defunct to adequately activate their cognition leading to gaps and potential failure to make meaning and transfer knowledge to application tasks.

Content-independent dimension of instructional quality

Research (Kim, 2016; Wijaya, den Heuvel-Panhuizen, Doorman & Veldhuis, 2018) shows that students do not react to instruction the same way. The setting within which the instruction is enacted also determines students' learning outcomes. The setting of the instruction defines the content-independent structures of instructional quality. These content-independent activities hinge on the quality of scaffolding and the quality of the teacher-student relationship.

Vygotsky (1978) holds the view that when students are supported and scaffolded in the teaching and learning process, they are catapulted and motivated to engage and excel in challenging tasks. It is the challenging tasks that activate the cognitive demands of learners. Challenging tasks alone cannot in themselves motivate students to obtain the desired quality of instruction but with the support provided by the teachers as well (Pitkäniemi & Häkkinen, 2018; Stefanou, Perencevich, Dicintio & Turner, 2010).

In line with previous research (Atlay, Tieben, Hillmert & Fauth, 2019; Fauth, Decristan, Rieser, Klieme, & Büttner, 2014; Krauss, Jü, Ae & Blum, 2008), content-independent structures of instruction are also the socio-emotional aspects of instruction that are also cognitively directed. These are summarised in three levels – the level of support rendered to the students, the feedback students receive, and how well a teacher relates to the students in the academic space (Baumert et al., 2010; Jentsch & Schlesinger, 2017; Praetorius et al., 2018).

The level of instructional activities reflecting in the teacher's feedback to students may connote the teacher's reaction to students' errors, misconceptions, and strengths. In addition, the level of teacher-student relationship which is a measure of how well a teacher relates to students reflects the appropriateness of motivational support rendered by the mathematics teacher to students during word problem instruction and discourse.

The level of support may take the form involving the teacher's explanations of word problems to students knowing that the language and context of the problems may pose a relative challenge to students. Since the medium of instruction at the high school level is restrictively English, teachers need to be patient in enacting quality instruction to students whose primary language is not English whiles recognising also that the use of English in instruction puts some students at a disadvantage (Agbenyega & Davis, 2015). Even more importantly, Davis (2003) singled out the patience of the teacher during instruction. This is because teachers are mandated to complete a projected scheme of work within a specified period of instruction. It takes a teacher with patience to enact instruction at a pace appropriate to learners (Kunter & Voss, 2013).

Following its dimensionality, the quality of mathematics instruction has been explored primarily using observational approaches (Bell et al., 2019; Pianta & Hamre, 2009). According to Pianta and Hamre (2009), observation is a valid tool for exploring instructional quality. Aside from observations, correlational studies in which students and teachers rate instructional quality abound in the literature. Whereas, Greenwald (as cited in Decristan et al., 2016, p. 72) questions the validity of students' rating of instructional quality, Wisniewski, Zierer, Dresel and Daumiller (2020), Bellens et al. (2019b), Decristan et al. (2016) and Fauth et al. (2014) observed that students' rating is a source of understanding the quality of instruction. This is because students are the direct beneficiaries of instruction conducted by the teacher. More so, Kunter and Baumert (2006) argue that students have experienced varied teaching from different teachers which make them masters in rating the quality of teaching. Nonetheless, Kunter and Baumert (2006) further suggest that students' rating of instructional quality should be augmented with teachers' appraisal of their teaching. This is because, students' ratings could be contaminated by teacher popularity (Fauth et al., 2014).

Teaching Context in Instructional Quality

The concept of teaching context from extant literature is varied. Morettini (2012) identified anything within the school environment (classroom environment, student behaviour, school district policy, and school demographics) that can influence participants' engagement for teaching. Deng, Benckendorff and Gannaway (2020) also described teaching context as comprised of any background factors (such as the role of the teacher) that can influence the learning processes and outcomes. Thus, teaching contexts are can be considered classroom conditions and student formative experiences that either affects classroom instructional processes or learning outcomes or both for which the mathematics teacher must adjust to.

Teaching context is included in instructional quality and student achievement studies because every teaching context is different (Richards & Farrell, 2011). Besides, teaching context can influence major aspects of instruction (Phelps & Howell, 2016). Arguably, book authors in instructional quality (Dunkin & Biddle, 1974; Weinert, Schrader, & Helmke, 1989) contend that teaching context has in many studies confounded the true effect of instructional quality on students' achievement. As explained in previous studies (Asiamah, Mends-Brew & Boison, 2019; Dettmers, Trautwein, Lüdtke, Kunter & Baumert, 2010), confounding factors have the potential of orchestrating fictitious results in research. It is therefore imperative that confounding (such as teaching context) factors are adequately controlled to assure a measure of valid effects of some variable(s) on another/others within a research study (Vander Weele & Shpitser, 2013).

Teaching context has a broad scope and has an endless list of contextual factors (Huitt, 2003; Richards & Farrell, 2011). An attempt to summarise these context factors has not been uniform. Dunkin and Biddle (1974) used teacher presage and student context as a classification tool. Lee, Linn, Varma and Liu (2010) summarised teaching context factors into three groups – student experience, teacher experience, and school characteristics. Nonetheless, Richards and Farrell (2011) opted for structural and personal influencers. For brevity, student experience (instructional language) and teacher experience (technology support in instruction) of Lee et al. (2010) categorisation of teaching context are included in this study.

One important teaching context factor relating to students in the instructional quality and student achievement discourse is students' mathematics language ability. Morgan (2014) explained mathematics language to mean a system of formal notations including its vocabulary of symbols as well as grammatical rules governing mathematical statements used for instruction, communication, and expression of mathematical information.

Literature is replete with evidence that suggests the central position of mathematics language in the instructional quality and student achievement discourse. For instance, Seethaler, Fuchs, Star and Bryant (2011) contend that a central component for students' success in mathematics is mathematics language. Similarly, van der Walt (2009) is of the view that students' mathematics performance is a function of their general knowledge of mathematical vocabulary. Earlier researchers have also sought to establish that variations in students' mathematics language ability have been a source of disparities in students' achievement in mathematics (Nortvedt et al., 2016; Sepeng & Madzorera, 2014) and mathematics word problem tasks (Agbenyega & Davis, 2015; Davis, 2010).

Given the importance of mathematics language in mathematics instruction, Moschkovich (2012) admonishes that mathematics language should not be viewed as the ability to memorise mathematical vocabulary. Although necessary to memorise the mathematics lexicon, it is not sufficient to engender achievement. But most importantly, mathematics language should be seen as a communicative tool. While agreeing with Riccomini, Smith, Hughes and Fries (2008) that mathematics language aid in effective mathematics instruction and proficiency, Riccomini et al. (2015) contend that the ability to use mathematics vocabulary improves communication.

Teacher's technology support is yet another teaching context factor (Lee et al., 2010). Technology support provided by teachers in mathematics instruction might take the form of teaching with technology or teaching through technology (Fox, 2007; McIntyre, 2011). Technology support in instruction is typified by the integration of digital technologies by teachers into classroom instruction. Irrespective of the form, the use of digital technologies should enhance task construction and solution (Bennett, 2015), enhance teaching and concept formation (Riccomini et al., 2015; West & Graham, 2005). Better still, Svinivki & McKeahie (2014) hold the view that technology should help students develop communication and interaction among themselves or with the instructor, organise and display information in a text or graphic format, and also, aid teachers to distribute course materials such as syllabus, assignments and feedback among students.

Technology has been integrated into mathematics instruction because the syllabus (MoE, 2010), professional bodies (NCTM, 2000), and the job market (Fede, 2010) require the use of digital technologies in the teaching, learning, and assessment of senior high school core mathematics in general and word problems in particular. Interestingly, Powers and Blubaugh (2005) claim that students in the 2000s are born into a technological world that is natural to their culture. They spend much of their time on technology, to the extent that decoupling technology from classroom instruction is liking to "separating their classroom experiences from their real-life experiences" (Willingham, 2010, p. 260).

Empirical evidence from the literature suggests that technology tools make mathematics and mathematical assessment real (Bennett, 2015; Jantjies, Moodley, & Maart, 2018; Riccomini et al., 2015). Moreover, technology improves a deeper understanding of mathematical concepts, provides immediate feedback to students, and encourages collaboration. Similarly, technology promotes cooperative learning, active students' learning, enhances problem writing and solving abilities, and thus improves academic performance in mathematics (Clements & Sarama, 2002; Eyyam & Yaratan, 2014; Fede, 2010; Harskamp & Suhre, 2007; Olsen & Chernobilsky, 2016). Furthermore, technology support serves as an instructional aid, a tool for the development of students' cognition and individual student support (Baek, Jung & Kim, 2008; Berry & Ritz, 2004; Bijlsma et al., 2019). Moreover, improvement in instructional quality (Bijlsma et al, 2019) and the development of mathematics language (Jantjies, Moodley & Maart, 2018; Riccomini et al., 2015) can be attributed to the level of technology support in mathematics instruction.

Deducing from this review of literature, the confounding effect of teaching context on the effect of instructional quality on students' learning outcomes may differ among schools. As shown in earlier studies (Good, 1991; Kelcey, Hill & Chin, 2019; Ko, Sammons & Bakkum, 2013), the differing effect is traceable to the differing levels of teaching context.

Theoretical Framework

Three theories underpin this study. These are the gestalt theory of learning (GTL), the process-product theory (PPT), and the sociocultural theory of cognition and language development (SCT).

The gestalt theory of learning

The Gestalt Theory of Learning (GTL) was spearheaded by Max Wertheimer, Kurt Koffka, and Wolfgang Kohler (Seel, 2012). These psychologists (Gestaltists) held on to the view that experiences are meaningful and well perceived if they are presented in intact form, whole, or configuration known as gestalts rather than in isolated pieces (Schunk, 2012; Seel, 2012). The German word gestalt means the “shape of an entity’s complete form”. A holistic view of a phenomenon requires that not only the whole but also the constituent parts of that whole. Nonetheless, the whole of the phenomenon is emphasised the more (Paisal, 2019). This illustrates why the study of instructional quality should go beyond the quantum of instructional tasks.

Among others, GTL advances that educational instruction should be based upon the laws of organization: similarity, proximity, closure, and simplicity. In explaining these principles of the law of organisation respectively, Seel (2012), Moore and Fitz (1993), and Wagemans (2018) have all suggested that perceptual elements similar in some form tend to be grouped. Also, perceptual elements that are close to each other are grouped as perceptual units based on their immediacy. Additionally, elements are meaningfully perceived if they are organised into simplistic figures, based on their symmetry, smoothness, and regularity. Finally, the law of organisation suggests that within a phenomenon, elements are bound together because they form part of an entity.

Inferring from Schunk's (2012) submission, instructional quality is more meaningful when perceived as a whole construct and this meaningfulness is lost when it is reduced into the study of either content-dependent or content-independent dimensions alone. This supports the adoption of an instructional framework that assesses classroom instruction from both content-dependent and content-independent perspectives. By so doing, a holistic view of instruction may adequately be studied rather than selecting aspects of instruction that tend to narrow the perception of instructional quality.

Furthermore, the law of organisation provides for an in-depth understanding of the dimensions of instructional quality based on the components of similarity, proximity, simplicity, and closure of indicators defining the various dimensions of instructional quality. Besides the theoretical ability of GTL to lay the foundation for a study of instructional quality from a holistic perceptual perspective coupled with the need for grouping instructional dimensions.

The presage-process-product theory

According to Tran (2015), theoretical models for studying teaching and student learning, such as the presage process produce model originally developed by Dunkin and Biddle (1974) and further developed by Biggs (1993), can be used to examine teaching in any teaching evaluation instruments. Dunkin and Biddle (1974) contended that presage and context factors together fed into the process factors, and which in turn produced the product in a unidirectional model. Besides, the Presage Process Produce theory provides a structure for studying the interaction between instructors and students (Parrish, 2009).

To describe a cycle of events in which student characteristics (student presage – student formative experiences, and student properties), teaching context (teaching presage – formative experiences, teacher training experience, and teacher properties), and student learning processes (process – observable behavioural interactions between the teacher and students) were continuously interacting to produce learning outcomes (product), Biggs (1993) developed a systems model of teaching and learning (Figure 1).

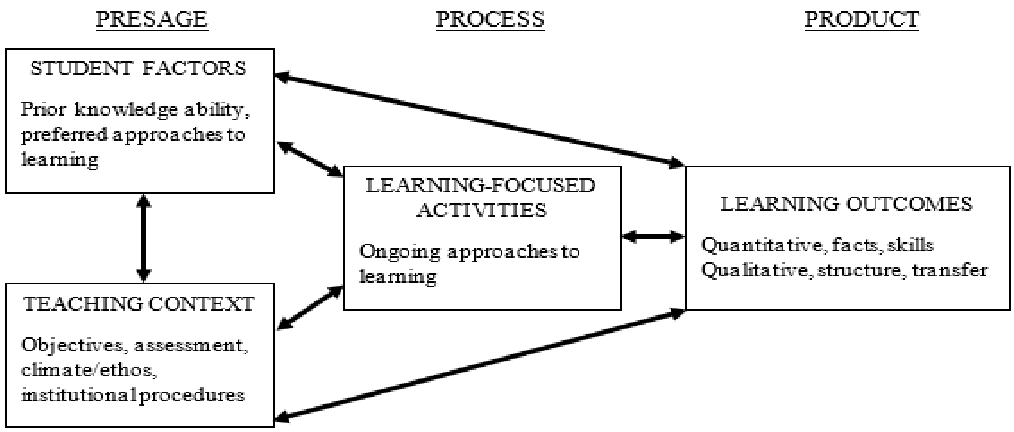


Figure 1: Biggs's presage process product model of teaching and student learning (Biggs, 1993)

The presage process product model has guided associative and causative studies relating to relationships and the interaction between students, instructional process, and students' achievements. Good and Grouws (1977) used the process-product phase of the model to guide a study of teacher effectiveness and students' performance within. Whereas Good and Grouws (1977) collapsed the presage and context variables into a single context factor, Biggs (1993) adapted the model to describe student learning, teaching and classroom interaction and learning outcome.

Recent studies conducted within the presage process product architecture, researchers (Jentsch & Schlesinger, 2017; Praetorius, Lenske & Helmke, 2012) have sought to illuminate the association between instructional practices (process) and students' learning outcomes (product). Research in the process-product paradigm also deploys the overt and observational classroom instructional behaviours and actions of teachers (teaching strategies, orientations, and performance dimensions) to predict the cognitive mechanism of students' learning (achievement) (Parrish, 2009; Weinert et al., 1989; Winne, 1987).

The sociocultural theory of cognition and language development

Lantolf, Thorne and Poehner's (2015) sociocultural theory of cognition and language development [SCT] is an extension of Vygotsky's (1978) sociocultural theory. The sociocultural theory of cognition and language development extends the belief that learning is a social process and is mediated by sociocultural tools. Significant among these tools according to Lantolf et al. (2015) is language. SCT assumes that language plays a central role in children's mental development and ability to construct knowledge.

Mathematics as described by Halliday is a textual discipline guided by the mathematics register (Lantolf et al., 2015). The mathematics register defines the mathematical language which is constituted by the mathematical vocabulary and symbols, and their appropriate functions and usage. Commonly described as the technical language (Davis, 2010), mathematics language may differ from everyday language usage semantically and/or syntactically. Language is seen as a powerful artefact that influences the relationship between individuals and their social world, among individuals and within the self. It is believed to function as a unit of social interaction where communication of thought among individuals is completed, and also as a unit of thinking that regulates cognition and mental activities (Lantolf, 2006; Lantolf et al., 2015; Mahn & Fazalehaq, 2012).

An extension of the SCT is that language is not the only social tool or artefact but technology as well (Chinnappan, 2006; Geiger, 2006). Both language and technology mediate the transformation of human learning and thinking for the creation of new forms of understanding. More importantly, Geiger (2006) argues that technology, on one hand, functions as a cultural tool that amplifies and reorganises cognitive processes when it is integrated into the community of mathematics learning.

Mathematics instruction as a process of learning deploys language and technologies to organise cognitive activities in solving mathematical problems. The learner's engagement within the community of learners such as the classroom is fundamentally important for the development and use of new artefacts necessary for cognition and higher mental process. Therefore, Bao (2017) envisaged that regular engagement in socio-cultural activities provides opportunities for assimilation and accommodation of the language for social and cognitive use.

Additionally, Geiger (2006) suggests that the learning engagements that challenge learners to move beyond their competencies are augmented by the technology available. Furthermore, Geiger (2006) believes that the amount of guidance and facilitation mathematics teachers provide to students reduces as students are given more independence in a technological learning environment. Accordingly, Chinnappan (2006) concludes that when instructional engagement is mediated by the use of technologies, it helps students to build a stronger representation of real-life applications of mathematical concepts.

Conceptual Framework

The main purpose of instructional quality is to create the needed learning experiences that promote conceptual understanding in the student and also provide the support needed to sustain the student's learning (Dorfner, Förtsch & Neuhaus, 2018; Kunter & Voss, 2013). The GLT provides that the overt characteristics of instructional quality could be understudied holistically by grouping indicators of instructional quality according to the laws of organisation: similarity, proximity, simplicity, and closure. Hence, instructional quality construct could be perceived from the perspectives of whether or not certain instructional indicators may be content dependent or independent. By exploring the perception of students, it is likely to categorise perceived instructional activities as content-dependent or content-independent dimensions of instructional quality.

Subsequently, the PPT makes room for associating these dimensions of instructional quality to students' achievement in a mathematics word problem. It is expected that students with high achievement levels will have benefited from high quality of instruction. Since the PPT has provided grounds for correlational studies between instructional quality and achievement, the SCT contests that this relationship can be confounded by context factors that may influence the level of association (Dunkin & Biddle, 1974; Weinert et al., 1989)

Deducing from the reviewed literature, the conceptual model depicting the association between instructional quality and students' learning outcomes in mathematics word problems is presented in Figure 2.

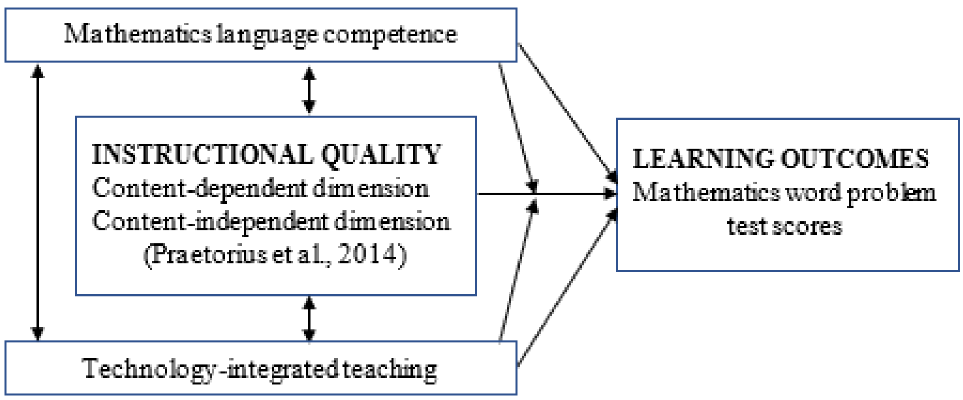


Figure 2: Conceptual model of the effect of instructional quality on learning outcomes

Source: The researcher's construct

From Figure 2, the process and product factors are defined by the quality of the teacher's classroom instruction and learning outcome respectively. Also included in the framework is the context which is defined by technology-integrated teaching and mathematics language competence. The contextual factors confound the hypothesised relationships.

The product construct is the learning outcome which is proxied by mathematics word problem test scores. The process construct represents classroom instruction. It depicts the instructional activities of the teacher and students during classroom mathematics instruction. The process (instructional quality) construct is made up of content-dependent and content-independent dimensions of instructional quality. These classroom activities justify the enactment of quality instruction during mathematics word problem lessons.

The horizontal arrow is indicative of a presumed direct effect of instructional quality on learning outcomes (Baumert et al., 2010; Kunter & Voss, 2013). Thus, it can be inferred from Figure 2 that both content-dependent and content-independent dimensions of instructional quality can affect students' performance directly.

It is expected that within the teaching context, the appropriate integration of technology in mathematics instruction might affect the relationship between instructional quality and word problem test scores (Berry & Ritz, 2004; Eyyam & Yaratan, 2014; Fede, 2010; Olsen & Chernobilsky, 2016). Similarly, since mathematics word problems are linguistically and contextually framed tasks (Verschaffel et al., 2000), it is assumed in this study that students' mathematics language competence can affect the relationship between instructional quality and word problem test scores (Ocak, 2006).

Furthermore, it is expected that technology support in instruction and students' mathematics language competence will correlate to unleash a confounding effect on the relationship between instructional quality and word problem test scores (Chinnappan, 2006; Geiger, 2006).

Mathematics language in this study defines students' understanding of instructional terms as well as their ability to decode algebraic terms. The educational policy is that mathematics instruction in Ghanaian high schools is delivered in English. Therefore, students articulate their views, misconceptions, and challenges using English as a medium of instruction (Agbenyega & Davis, 2015). This educational policy puts pressure on students who are naturally not proficient in the English language and/or are not comfortable with the use of mathematical terms (Latu, 2005). In this conceptual framework, mathematics language competence was expected to correlate with technology-integrated teaching.

A summary description of the components based on the conceptual framework of this study is presented in Table 1.

Table 1: Tabular Representation of Components of the Conceptual Framework

Components	Constructs	Operationalised
Instructional quality	1. Content-dependent dimension	a) Challenging levels of tasks and questions during instruction; b) Relevance of word problem tasks; c) Potential of instruction to draw on and activate students' prior knowledge; d) Opportunities created for eliciting students' thinking through explanation
	2. Content-independent dimension	a) Teachers' feedback to students b) Adaptive support
Teaching context	1. Technology-integrated teaching	Technology-enhanced teaching
	2. Mathematics language competency	Students' competency of algebraic instructional language, and ability to appropriately decode algebraic terms
Learning outcomes	1. Mathematics word problem test scores	Students' performance on routine algebraic word problem tasks

From Table 1, five scales in three components of the conceptual framework are studied in this research. Table 1 provides information on the description of the scales and how they are operationalised. For instance, the content-dependent dimension construct of instructional quality is defined in terms of learning opportunities that activate students' cognition such as the challenging levels of tasks posed to students; activation of students' prior knowledge; and the propensity of the instruction to elicit students' thinking through explanations and relevant task.

Empirical Reviews

The literature reviewed in this section related to instructional quality dimensions, students' mathematics language competency, and students' learning outcomes in word problems. The section was presented under the following headings:

1. High school students' difficulties in solving mathematics word problems
2. Relating instructional quality and performance in mathematics word problems to instructional resources
3. Relationship between instructional quality and performance in mathematics
4. The relationship between instructional quality and mathematics language
5. Interrelationship among instructional quality, mathematics language and technology-integrated teaching in teaching mathematics.

High school students' difficulties in solving mathematics word problems

Empirically-based studies (Adu et al., 2015; Chapman, 2002; Sepeng & Madzorera, 2014), book authors (Bullock, 2015) as well as reports from the West African Examination Council (WAEC, 2012; 2013; 2014; 2016; 2017; 2018) show that students have difficulty in solving mathematics word problem tasks. These difficulties are epitomised in erroneous solutions students provide for word problem tasks. The difficulties are manifested in students' inability to appropriately translate the preambles in the mathematics word problems into mathematical expressions (equations).

Adu et al. (2015) used the modified Newman Error Hierarchical levels at reading, comprehension, transformation, process skills, and encoding errors to examine errors senior high school students in Ghana commit in solving word problems in linear equations. With 10-word problem tasks, Adu et al. (2015) concluded that students had difficulty solving mathematics word problems. The difficulty of the students was attributed to their inability to comprehend mathematics vocabulary. As a result, the students were unable to interpret the tasks. According to Adu et al. (2015), about 75% and 84% of the students committed comprehension and transformation errors respectively.

Similarly, WAEC chief examiner's reports on core mathematics suggest that students are unable to answer word problem questions correctly (WAEC, 2012; 2013; 2014; 2016; 2017; 2018). The chief examiner has consistently pointed out students' difficulties in deducing correct equations and/or formulating appropriate mathematical expressions from problem tasks. For instance, in 2012, candidates were given a routine algebraic word problem question " If $\frac{3}{4}$ of a number added to $\frac{5}{6}$ gives the same results as subtracting $\frac{7}{8}$ of the number from $20\frac{1}{3}$, find the number" (WAEC, 2012, p. 4) to solve. Although the mathematical quantities were explicitly numeric, it seems that students could not correctly interpret the mathematical phrases 'of a number' and 'same results as' 'added to' and 'subtracting'. This is because the chief examiner remarked that "the part (b) was poorly done since most of the candidates were unable to write down the relevant equation from the word problem" (WAEC, 2012, p. 4).

The chief examiner again indicated that "most candidates found it difficult to formulate the required equation to the task "A man drives from Ibadan to Oyo, a distance of 48 km, in 45 minutes. If he drives at 72 km/h where the surface is good and 48 km/h where it is bad, find the number of kilometres of good surface" (WAEC, 2014, p. 4). In this problem, students were expected to find expressions for the time the man spent on both the good surface $T = \frac{x}{72}\ hrs$ and bad surface $T = \frac{48-x}{48}\ hrs$, add the expressions and then equate the sum to the total journey time to obtain the number of kilometres on the good surface. As indicated by the chief examiner, students did not understand the question hence their inability to write appropriate equations.

Similarly, the chief examiner identified that students could not translate a worded problem into mathematical expressions and because of that, they were unable to find the area of the square in the task “The perimeter of a square and a rectangle is the same. The width of the rectangle is 6cm and its area is 16cm^2 less than the area of the square. Find the area of the Square” (WAEC, 2018, p. 238). Perhaps, in this question, the students might have had the difficulty in decoding the terms ‘same’, and ‘less than’ hence the students’ inability to write the expected equations.

The inability of students to solve mathematics word problems could be traced to student-related factors and instructional-related factors (Pearce et al., 2013). On student-related factors, Pearce et al. (2013) identified that vocabulary and interest militate against students’ ability to provide correct answers in solving mathematics word problems. Since mathematics word problems are linguistically framed tasks, it is envisaged that students read to access and make meaning of mathematics tasks (Nortvedt et al., 2016).

Conversely, language (that is, the comprehension of text and mathematical vocabulary) has become a barrier that has limited students’ ability to gainfully benefit from word problem instructions (Adu et al., 2015; Agbenyega & Davis, 2015; Davis, 2010; Sepeng & Sigola, 2013). Due to students’ deficiency in understanding the algebraic terms, they find it difficult to write the appropriate symbolic expressions corresponding to the word problem tasks. When students wrongly interpret ‘at least’ to mean ‘$\leq$’, (because of the lateral meaning of 'least' that is 'small') the structural error committed at this initial stage will produce an erroneous solution.

Latu (2005) admits that the complex wording of mathematical sentences challenge students' learning and solving mathematical tasks. Corroborating, Adelson, Dickinson and Cunningham (2015) further reiterated the stance that students' comprehension of word problems and their ability to solve these word problems was affected by the wording and structure of the worded problems. The incidence of these structural errors is also traceable to students' inadequate mathematical skills in real numbers, visual and spatial information skills (Tambychik & Meerah, 2010). Aside from the structural errors, students sometimes commit arbitrary errors where students ignore part of instructions contained in a question while acting on some part or misapplication of solution rules (Ekwueme & Ali, 2012; Tong & Loc, 2017).

On instructional-related factors, Sepeng and Madzorera (2014) attributed deficiencies in 11th graders mathematical language which affected their success in solving word problem tasks to the manner teachers presented mathematical vocabulary. According to Sepeng and Madzorera (2014), teachers' presentation of mathematics language got students stuck to the contextual meaning ascribed to the terms during instruction. As a result, Agbenyega and Davis (2015) claim that few students benefit from classroom instruction implying that the majority of students are left to struggle to overcome their difficulties in understanding and proffering appropriate solutions to worded problems.

To minimise students' difficulties in solving mathematics word problems, literature proposes that, if the barrier imposed by language during instruction is addressed, it might help students maximise learning opportunities (Davis, 2010). In agreeing with Davis (2010), Pearce et al. (2013) admonish teachers to help students overcome the difficulty in comprehending the text in worded problems rather than focusing on the amount of text framing a problem. This is because, the development of mathematics language is vital for the comprehension, study, and advancements in mathematics (Riccomini et al., 2008).

Furthermore, Latu (2005) challenges teachers to seek to develop the mathematical concepts of students rather than the language of instruction. The basis for Latu's (2005) conclusion emanates from an exploration of language factors that affected mathematics teaching and learning among Pasifika high school students. In the study, Latu (2005) found that students performed well on instructional language tests but abysmally on word problem tasks.

In addition, Munasinghe (2013) proposes that problems encountered by students in learning word problems could be eliminated through appropriately designing teaching instruction procedures. These instructional procedures include providing individual student attention, sufficient representation of mathematical concepts, the caring ethos for students, and the development of basic mathematical language skills. Munasinghe (2013) further encouraged mathematics teachers to exhaustively equip students with learning content prescribed for the students at their respective grade levels.

Moreso, teachers should endeavour to correct errors committed by students. This is because, students may commit errors (Ekwueme & Ali, 2012) and when students' errors are not identified early and appropriate instructional measures are taken, students' learning challenge compounds leading to undesirable learning outcomes.

Relating instructional quality and performance in mathematics word problems to instructional resources

Mathematics instruction researchers have and continue to measure the quality of mathematics instruction. The quality of instruction is measured to improve teaching (Bell et al., 2019; Waxman et al., 2004). Invariably, the level of the quality of mathematics instruction is mixed. On a scale of 0 (Never) to 3 (every or almost every lesson), the parcel of mean rating of the quality of mathematics instruction by teachers in England and Sweden in the TIMSS 2011 data were 2.89 and 2.02 respectively (Blömeke et al., 2016). Besides, a survey conducted by Ren and Yang (2017) on the level of satisfaction of 752 students showed that students' satisfaction with the quality of instruction was low. Nonetheless, Bellens et al. (2019b) suggest that a high rating of instructional quality is indictive of better teaching that leads to enhanced students' learning.

A review of instructional literature in mathematics word problems shows the occurrences of some deficiencies in instructional structures. These deficiencies could explain why students gave low ratings of the quality of teaching they received (Ren & Yang, 2017). In their study of how instructional language intersected inclusive pedagogy, Agbenyega and Davis (2015) observed two mathematics lessons and interviewed some learners. The findings of Agbenyega and Davis (2015) was not different from the conclusion of Ren and Yang (2017) in that the former also cast misgiving about the quality of instruction. Consequently, Agbenyega and Davis (2015) concluded that the deficiencies in the instruction excluded some learners from fully benefitting from the teaching, thus, hampered the abilities of learners in developing conceptual understanding in mathematics.

Additionally, Depaepe, Corte and Verschaffel (2007) explored mathematics lessons and observed that although teachers connected word problem tasks to students' experiential world, basic instructional practices such as praising students, exploring, modelling, and scaffolding in the mathematics lessons were lacking. Depaepe et al. (2007) added that teachers did not solve cognitively challenging problem tasks with the students. Munasinghe (2013) has also raised concern about the provision of individual student support teachers provide during instruction. It is believed that errors made by students are committed on the blind side of teachers during instructional delivery (Munasinghe, 2013).

Another source of deficiency is the skewness of teachers' instructional actional activities. A review of the three lessons presented in the study of Charalambous and Praetorius (2018) showed that mathematics teachers turn to emphasise content-dependent structures with little or no regard for content-independent structures in their lessons. In as much as content-dependent structures promote conceptual understanding and meaningful learning of word problems (Dixon et al., 2014; Lipowsky et al., 2009), Stefanou et al. (2010) admonish teachers not to relegate content-independent structures in teaching. This is because content-independent structures are needed to foster the interest of students in studying mathematics word problems as the teacher is responsible for creating a learning opportunity for students' cognitive engagement and learning (Kunter & Voss, 2013).

One key condition that may determine the quality of instruction is the availability of instructional resources. For instance, Grossman, Cohen and Brown (2015) investigated potential factors that may affect the quality of instruction received by middle school students. It was observed that given the steady downward trend in instructional quality, educational districts should target the improvement of instructional resources. By deduction, the resource index of a school could impact the quality of instruction provided by teachers.

Similarly, Mutai (2000) asserted that adequate resources such as textbooks, exercise books, teaching aids, and classrooms, can improve instruction and learning. This finding implies that the provision of conducive classrooms, laboratories, and other teaching/learning resources can positively change teachers' attitudes toward mathematics teaching, thus, make the subject very interesting, meaningful, and exciting to students. Consequently, Olatunde and Otieno (2010) were convinced that this positive change can encourage mathematical exploration and manipulation in students thereby, keeping students alive and thinking mathematically. Bettini, Park, Benedict, Kimerling and Leite (2016) also cited other sources to support the claim that instructional resources could influence the quality of instruction.

Not only does the resource index affects instructional quality, but it also affects the level of students' mathematics performance. Whereas Blömeke et al. (2016) intimated a positive causal effect of resources on students' mathematics achievement, other correlational studies (Bernal et al., 2016; Davis, 2010; Du & Hu, 2008; Jenkins & Love, 2021; Konte, 2021; Olatunde & Otieno, 2010; Yusif et al., 2011) have concluded that learning outcomes are a function of the resources available for the enactment of instructional quality.

For example, Yusif et al. (2011) investigated factors that might influence the performance of SHS students in Ghana. 1,129 students from ten SHSs in Ashanti and Brong Ahafo regions participated in the study. Using logistic regression, the study showed that students who attended well-resourced schools (that is, with better infrastructure) are 66.5% more likely to excel academically whiles students who attended less-endowed schools were 17.9% less likely to excel academically. Similarly, Davis (2010) also noticed that learners in urban schools outperformed their peers in rural schools in word problem tests because the urban schools were better resourced with learning opportunities and support.

The empirical review on high school students' difficulties in solving mathematics word problems, as well as the examination of instructional quality and performance, underscores the multifaceted challenges faced in this domain. The deficiencies identified in instructional structures, as highlighted by Agbenyega and Davis (2015), Ren and Yang (2017), and others, contribute to students' dissatisfaction and hinder their conceptual understanding. Notably, the study by Charalambous and Praetorius (2018) emphasizes the imbalance between content-dependent and content-independent structures in mathematics lessons. The role of instructional resources emerges as pivotal, with Grossman, Cohen, and Brown (2015) suggesting that improved resources positively impact instructional quality.

Relationship between instructional quality and performance in mathematics

Literature is replete with empirical evidence that supports the finding that instructional quality relates positively to students' performance in solving mathematics word problems. In a review of 116 documents published between

1983 and 2020, Verschaffel et al. (2020) observed that the quality of instruction received by students influences their learning outcomes in solving mathematics word problems. This observation provides credence to the conclusion that instructional quality is a key determinant of students' learning outcomes in mathematics (Baumert et al., 2010; Bellens et al., 2019b; Davis, 2007; Kunter & Voss, 2013; Neubrand, Jordan, Krauss, Blum, & Löwen, 2013).

Empirically, Lipowsky et al. (2009) have established a positive association between students' achievement gains and instructional quality dimensions of classroom management and cognitive activation activities involving 39 mathematics classrooms. Arguably, cognitive activation has proven to potentially predict students' learning gains in mathematics (Baumert et al., 2010; Kunter & Baumert, 2006; Lipowsky et al., 2009).

Therefore, Kunter and Voss (2013) stress the need for mathematics teachers to create instructional activities that act directly on the cognitive structures of students through the use of the cognitive-rich instructional practice. This is practically important because where students are deficient in the quality of instruction, they get constraint to adequately activate their cognition. The inadequacy in activating the cognition of students lead to the creation of gaps and potential failure in making meaning and transfer knowledge (Pearce et al., 2013).

Despite, the myriad of evidence in support of the positive relationship, Blömeke et al. (2016) found that except for three countries (Oman, Hong Kong and the USA), instructional quality was not a predictor of students' mathematics achievement. Furthermore, the association between instructional quality and mathematics achievement was negative for the USA but positive for Oman and

Hong Kong. This observation by Blömeke et al. (2016) was based on TIMSS 2011 data. Nonetheless, learning activities aimed at ensuring appropriate achievement in mathematics word problem lessons should holistically embrace instructional quality and advance students' mathematics language competence.

The relationship between instructional quality and mathematics language

Nortvedt et al. (2016) studied how instructional quality moderated the effect of reading on grade four students' mathematics achievement. The data set of TIMSS 2011 and PIRLS 2011 from 37 countries were studied. It was concluded that there was a strong correlation between reading comprehension and mathematics achievement in all the countries included in the study. However, a positive correlation between instructional quality and reading, and mathematics achievement was only established in some countries (Nortvedt et al., 2016).

Further analysis by Nortvedt et al. (2016) on the same data indicated an inconclusive relation on how instructional quality moderated between mathematics and reading. This was because the effect of reading comprehension on mathematics achievement was significantly moderated by instructional quality in only six of the 37 countries. Despite these contradictory findings, Nortvedt et al. (2016) were however convinced that reading comprehension and instructional quality could influence mathematics achievement. Drawing from Nortvedt et al. (2016), teaching intended to develop mathematical competence in students should help students use their mathematical competence to solve problems, reason, and communicate mathematically. Hence, the place of reading and mathematical language in accessing, comprehending, and adopting an algorithm to mathematical problems is important.

Agbenyega and Davis (2015) also explored how instructional language and inclusive pedagogy affected pupils learning of mathematics in Ghanaian basic schools. It was concluded that the combined effect of instructional language and pedagogy influenced pupils' learning and solving mathematical problems. Consequently, an instructional language that was not familiar to learners inhibited learners' understanding which led to a situation where mathematics instruction became a preserve for a few privileged pupils (Agbenyega & Davis, 2015).

Grammer et al. (2016) also examined the development of mathematical skills such as calculations of grade two pupils concerning teachers' use of cognitive-processing language during instruction. Grammer et al. (2016) observed a positive correlation between teachers' use of cognitive-processing language during instruction and pupils' mathematics fluency and calculation achievement. Grammer, Coffman, Sidney and Ornstein's (2016) study focused on the teachers' use of cognitive-processing language during instruction but did not necessarily examine the cognitive-processing language competency of the pupils nor sought to find out how this competency affected the pupils' growth of mathematics skills.

From extant literature, it has been observed that instructional quality and mathematical language interactively correlate with students' learning growth and achievement (Agbenyega & Davis, 2015; Grammer et al., 2016; Nortvedt et al., 2016). Whereas Nortvedt et al. (2016) saw instructional quality as a tool for enhancing the students' language competency for improvement in their mathematics achievement, Grammer et al. (2016) and Agbenyega and Davis (2015) discovered that appropriate mathematical language was a vehicle through which instructional quality would yield desired mathematical learning results. Consequently, Edwards, Esmonde, Wagner and Beattie (2011) believe that mathematics learning and language are intertwined and inseparable to the point that assessing students' mathematical learning requires examining the role of language in mathematical activity.

Interrelationship among instructional quality, mathematics language and technology-integrated teaching in mathematics

Empirical studies in mathematics education show that mathematics teachers have advanced multiple efforts in a quest to improve students ability to solve mathematics word problems. One such effort has been the increase in the integration of technologies in the teaching of mathematics word problems. This is because, technology has been heralded as a way to improve the teaching and learning of mathematics (MoE, 2010; NCTM, 2000, 2012, 2014). In addition, it is projected that technologies will become the fulcrum around which the teaching and learning of mathematics will revolve in the future (Burton, Falk & Jarner, 2004). This projection has started manifesting with widening access and availability to technologies both at home and in schools (Lavicza, 2008).

Nevertheless, research since 2010 in countries where the technologies are widely integrated into the teaching and learning of mathematics indicate that the association between technology-integrated teaching and mathematics achievement is ambivalent (Eickelmann, Gerick & Koop, 2016). These seemingly contradictory results suggest that the association between students' mathematics performance and teachers' integration of technologies in the teaching of mathematics is not always positive for all mathematics learning competencies. For instance, in Australia, Norway and Singapore, Eickelmann et al. (2016) did not find any statistically significant effects of the use of technologies for mathematics teaching on students' mathematics achievement.

Besides, research also indicates that when mathematics-specific technologies are integrated with instructional activities, there are gains in students' mathematics learning (Lee & Chen, 2015; Meggiolaro, 2017). For example, Meggiolaro (2017) identified Italy as one of the countries in Europe with a relatively high percentage of ICT access. Italy purports to prioritises investigations into how ICT usage in Italian schools relates to the performance of students in mathematics. A study of the importance of ICT usage in the mathematics performance of secondary schools students in Italy was conducted by Meggiolaro (2017). The study generally revealed a positive association between mathematics performance and ICT use. In particular, Meggiolaro (2017) observed a positive influence of ICT use in the creation of mathematics content and knowledge and problem-solving activities.

Similarly, Bulut and Cutumisu (2018) also understudied the Programme for International Student Assessment [PISA] 2012 data of 8,829 Finnish and 4,848 Turkish students to explore how the use and availability of ICTs impacted mathematics achievement. In both countries, the study revealed that the use of ICTs at school for mathematics lessons was negatively associated with mathematics achievement. Interestingly, ICTs availability at schools in Finland exceeded the availability of ICTs at schools in Turkey. However, the use of ICTs in mathematics lessons in Finland was lower than the use of ICTs in mathematics lessons in Turkey.

In addition, Zhang and Liu (2016) investigated the influence of ICT use on the mathematics performance of students. The data used by Zhang and Liu

(2016) was the PISA data from 2000 to 2012. The results of this study showed that by controlling for students' context (background) information, school-level ICT-related variables were negatively related to students' learning outcomes in mathematics in the long term. Other studies with secondary school students (Ayieko, Gokbel & Nelson, 2017; Kadijevich, 2015; Skryabin, Zhang, Liu & Zhang, 2015) further show that ICT integration had a negative association with students' academic performance.

The negative relationship between technology-integrated teaching and mathematics achievement is indicative that a more frequent ICT use at school correlates with lower achievement. More so, the explanation could also mean that the more frequent students use technology tools do not necessarily reflect higher scores in mathematics (Zhang & Liu, 2016). Despite the observed negative relationship, teachers should aspire to create appropriate learning context through the proper integration of technology in the teaching of mathematics word problems. This is because, although students' learning outcomes are not produced by teachers, the teacher is expected to create a learning opportunity for students' cognitive engagement (Kunter & Voss, 2013).

With the increasing use of technology in the teaching of mathematics (Zhang & Liu, 2016) coupled with the mixed relationship between technology-integrated teaching and students' mathematics performance (Eickelmann et al., 2016), it seems appropriate to discuss possible factors affecting technology-integrated teaching. Besides, the possibility of integrating technologies in teaching could be explained as a function of several factors rather than a single factor (Afshari, Bakar, Fooi, Samah & Say, 2009). For example, Hartsell, Herron, Fang and Rathod (2010) identified three factors that might influence the use of technologies in instruction. These are the availability of the needed technological devices, the technical support needed for using the technologies, and the comfort level of teachers.

Besides, Afshari et al. (2009) categorised the factors that might influence the use of technologies in instruction as either manipulative or non-manipulative school and teacher factors. The non-manipulative were described as factors which the school cannot influence. Such non-manipulative factors are the teacher's age, teaching experience, teacher's technological experience, governmental policy. and the availability of external support for schools. Teachers' attitudes towards technology-integrated teaching, technology knowledge of teachers, and the availability of the technologies were categorised as manipulative factors.

Arguably, the intersection of technology integration and instructional quality in mathematics education is a multifaceted terrain that demands a nuanced understanding. While existing literature extensively delves into the relationship between technology use and instructional quality, a critical aspect that deserves more attention is the role of mathematics language in shaping instructional effectiveness. Mathematics language serves as the conduit through which complex mathematical concepts are conveyed, making it a pivotal element in instructional quality. The precise articulation of mathematical ideas, clarity in conveying problem-solving strategies, and fostering a shared mathematical vocabulary between teachers and students are integral components of effective instruction. Therefore, an examination of technology integration should not only scrutinize its impact on instructional strategies but also assess how it influences the development and utilization of mathematics language in the classroom. This nuanced perspective acknowledges that the effectiveness of technology in enhancing instructional quality is intricately linked to its ability to facilitate meaningful mathematical discourse and communication. Integrating mathematics language into the discourse surrounding technology in education will undoubtedly contribute to a more comprehensive understanding of its implications for instructional quality.

Chapter Summary

Based on extant review of literature, there is an overwhelming consensus among researchers that students have difficulty solving mathematics word problems (Adu et al., 2015; Bullock, 2015; Chapman, 2002; Sepeng & Madzorera, 2014; Verschaffel et al., 2020). Students' difficulty in solving mathematics word problems is also prominently documented in the chief examiner's report on senior high school core mathematics (WAEC, 2016; 2017; 2018; 2019; 2020). What is obvious in research is the conclusion that students learning outcomes are influenced by the quality of instruction (Groth, 2013; Huitt, 2003; Junker et al., 2005), and by implication, instructional quality relates positively to learning outcomes (Baumert et al., 2010; Kunter & Voss, 2013).

Arguably, the review further shows that the rate of relationship between instructional quality and learning outcomes differs because of differences in the teaching context. Notably, students' competence in mathematics language (that is, the mathematics vocabulary and symbols embedded in the medium of instruction and tasks) and technology affordances employed by mathematics teachers can confound this relationship (Agbenyega & Davis, 2015; Ayieko et al., 2017; Bulut & Cutumisu, 2018; Eickelmann et al., 2016; Meggiolaro, 2017; Nortvedt et al., 2016).

Nevertheless, empirical literature on surveys relating the quality of instruction to learning outcomes in word problems among high school students is scarce (Verschaffel et al., 2020). Besides, although the instruction in mathematics word problems is a social process, which is affected by sociocultural tools such as language and technology (Chinnappan, 2006; Lantolf, 2006; Lantolf et al., 2015; Mahn & Fazalehaq, 2012), not much empirical literature is known about how these sociocultural tools confound the relationship between instructional quality and learning outcomes.

This conceptual review has delineated the appropriateness of conceptualising instructional quality based on content-relatedness (Praetorius et al., 2014) rather than generic frameworks. Also, learning outcomes in mathematics word problem instruction has been conceptualised in line with current literature (Praetorius et al., 2018). In addition, the relationship between instructional quality and learning outcomes, and the its confounders has been situated in theory (Dunkin & Biddle, 1974; Lantolf et al., 2015; Seel, 2012).

CHAPTER THREE

RESEARCH METHODS

This study was undertaken to explore how the quality of instruction affect the performance of senior high school students in solving mathematics word problem tasks. Sections discussed in this chapter are; the research paradigm, the research design, the population, the sample and sampling procedure. The instruments for data collection, the method of data collection and analysis are also presented in this chapter.

Research Design

The study of quality classroom instruction is a complex phenomenon because instructional activities are context-based and temporal (Baumert et al., 2013; Dunkin & Biddle, 1974). According to Salkind (2010), exploring such a complex phenomenon in multiple settings require not a single best research approach but that which permits opposing assessments to be validated and paired against each other. Besides, Morgan (2007) has also suggested that the incorporation of research approaches mostly happens with the sequential combinations of qualitative and quantitative methods. Consequently, the sequential explanatory mixed methods design (Creswell & Plano Clark, 2018; Nieswandt & McEneaney, 2009) was adopted for this study. The sequential explanatory mixed methods design involved three chronological phases of quantitative, follow-up qualitative and interpretive phases (Bowen, Rose & Pilkinton, 2017).

In this design, the quantitative, numerical data is gathered and analysed first, and the qualitative, textual data is gathered and analysed second in sequence. The third phase involves interpreting and explaining the quantitative and qualitative findings to draw sound conclusions and research implications. Eventually, the qualitative data assists in explaining or elaborating on the quantitative results gained in the first phase. The justification for combining the two forms of data is that neither quantitative nor qualitative approaches are sufficient on their own to investigate the complex situations (Creswell & Plano Clark, 2018) of instructional quality and its consequences on high school students' word problem learning. Besides, the design's sequential structure ensures that the qualitative phase will offset the limitations in the quantitative phase (Caruth, 2013). According to Johnson and Turner (2003), quantitative and qualitative approaches work best when combined because they give a more complete overview of the research problem.

The three chronological phases (that is, quantitative, qualitative and interpretive) phases helped me to understand the effect of teachers' instructional quality on students' performance in mathematics word problems at the senior high school level. Precisely, this design was appropriate for the meeting the research objective of explaining the relationship between students' rating of instructional quality and their performance in mathematics word problems. At the quantitative phase of this study, a survey (Fowler, 2014) was used to verify how students' perception about the quality of mathematics word problem instruction related to their ability to solve word problem tasks. In addition, an examination of how students' mathematics language competence and technology-integrated teaching in teaching word problems added to predict students' ability to solve word problem tasks. Therefore, four kinds of quantitative data were collected from a cross-section of SHS students in Ashanti.

The data collected were students' perception of the quality of instruction in mathematics word problems and their perception of teachers' level of integrating technology in teaching word problems. Also, data on students' mathematics language competence and their performance in word problems test were gathered. The data collected were then examined to determine whether instructional quality predicted learning outcomes in mathematics word problems.

At the qualitative phase of this study, a follow-up in-depth semi-structured interviews (Creswell, 2012) with students and teachers from selected SHSs in Ashanti region was conducted. The interview responses were used to explain how the quality of instruction affected students' ability to solve word problem tasks. More so, the interview responses were used to explain the combined effect of students' mathematics language competence and technology-integrated teaching in teaching word problems on the quality of instruction and students' ability to solve word problems.

The third stage of this study was the interpretive phase. In this phase of the design, joint displays (Creswell & Plano Clark, 2018; Finley et al., 2013; Guetterman et al., 2015; Igo, Riccomini, Bruning & Pope, 2006) were used to summarise and interpret students' perception of the quality of word problem instruction and their word problem test scores. Consequently, it became possible to discuss the extent to which instructional quality affected students' learning outcomes in mathematics word problems. The sequential explanatory mixed methods design as applied in this study is presented in Figure 3.

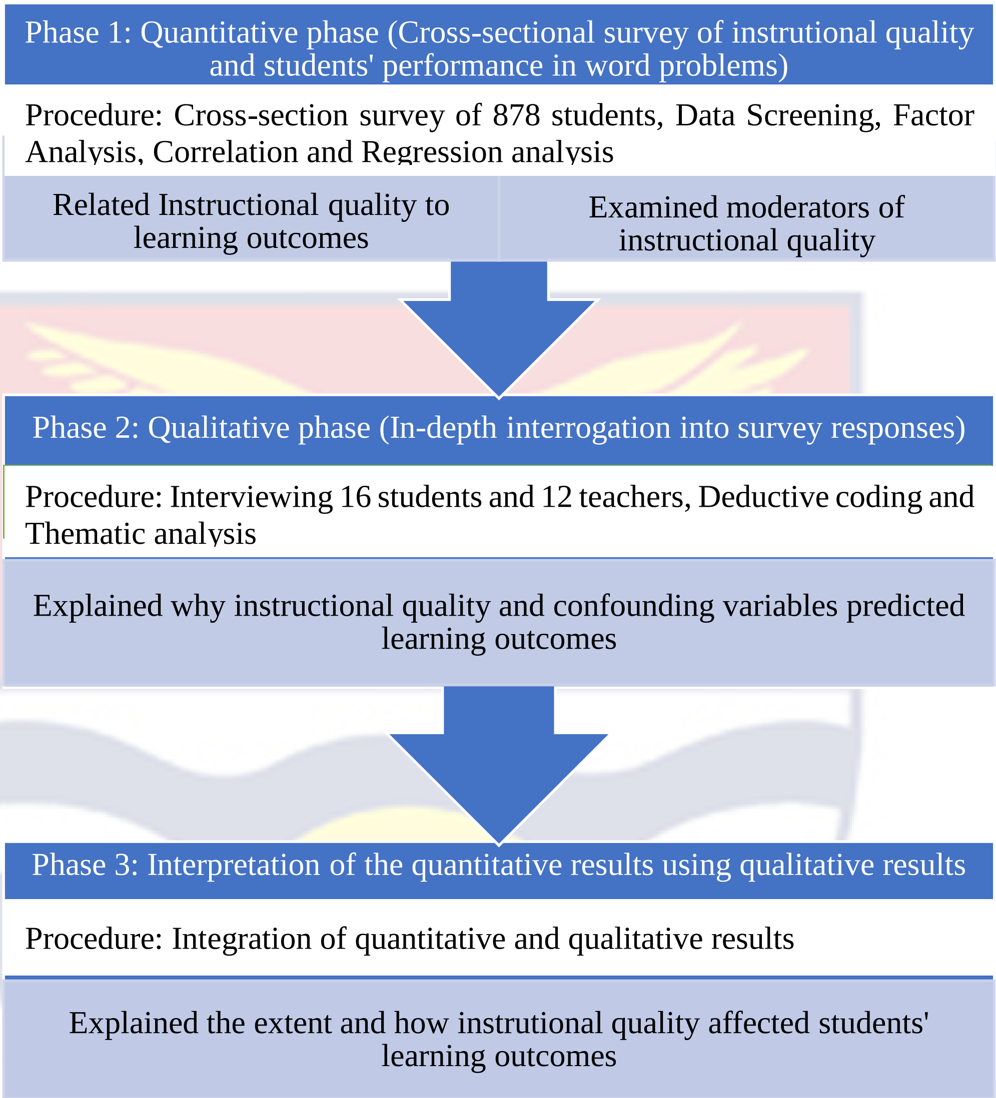


Figure 3: Adapted phases of the sequential explanatory mixed methods (Creswell & Plano Clark, 2018)

Study Area

This study was undertaken in the Ashanti region of Ghana. In terms of land size, Ashanti Region is the third largest of the 16 regions in Ghana (Ghana Statistical Service [GSS], 2020). The region occupies a surface land area of approximately 24,389 square kilometres representing about 10.2 per cent of the total land area of Ghana. Ashanti region is located between the longitudes 0.15^0W and 2.25^0W, and latitudes 5.50^0N and 7.46^0N (Figure 4). It has its administrative capital in Kumasi. Ashanti region shares boundaries with the Western, Central, Eastern, Bono, Bono East, and Ahafo regions.

It is also the most populated region in Ghana with about 5,924,298 inhabitants representing 19.4 per cent of the total population of Ghana (GSS, 2020). The region has 24 districts, 18 municipals and one metropolitan assembly (Ghana Water and Sanitation Agency, 2019). The central position of Ashanti region relative to the map of Ghana makes it not only an attractive destination for economic activities but also for education.

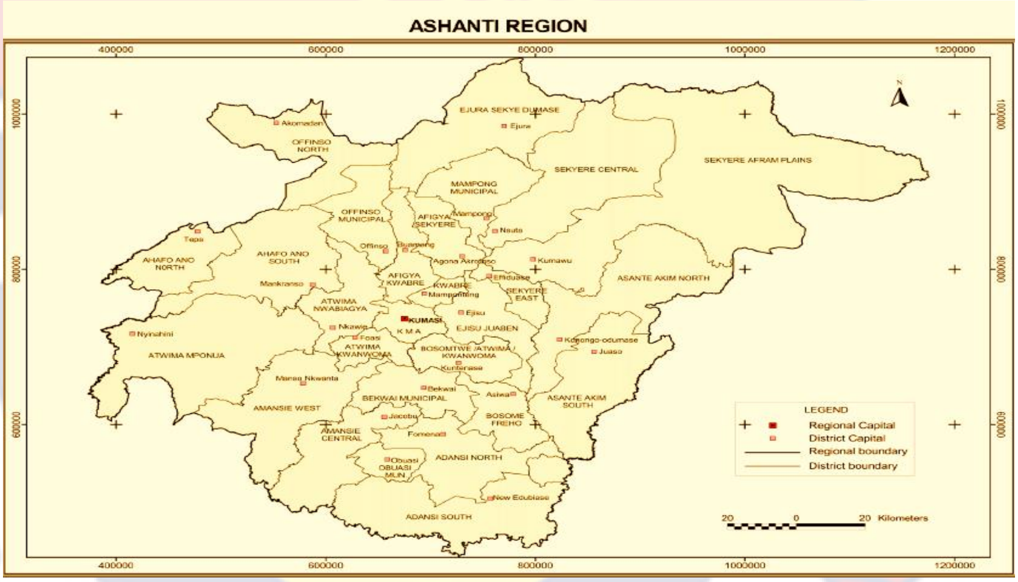


Figure 4: Map of Ashanti region (GSS, 2013)

Ashanti region has two public universities, eight public colleges of education (Transforming Teacher Education and Learning, 2018), 122 public senior high schools (GES, 2019), and 6,598 public basic schools (GSS, 2018). With the 122 public senior high schools spread over the 43 metropolitan, municipal and district educational directorates [MMDEDs], Ashanti region has the highest number of public senior high schools in Ghana.

Population

The target population for this study was 33,154 second-year senior high school (SHS) students for the 2020/2021 academic year (GES, 2019) as well as the mathematics teachers teaching core mathematics in the public SHS in Ashanti region. The sampling frame, this constituted second-year students and core mathematics teachers from six senior high schools within the three MMDEDs in the Ashanti Region. These MMEDEDs were Kumasi Metro, Kwabre East Municipal, and Adansi South District. The six schools were selected based on the GES categorisation of senior high schools.

Using the GES categorisation ensured a representation of all the region's public senior high schools in the study. Besides, the selection criteria provided a fair ground to generalise the results of this study. Second-year students were used for this study for two main reasons. First, the students have been exposed to secondary school teaching and learning experiences which abled them to evaluate the quality of classroom instruction in core mathematics. Secondly, the second-year students have been taught equations and inequalities.

Sampling Procedure

The multi-stage sampling technique (Cohen, Manion & Marrison, 2007; Sedgwick, 2015) was applied in the selection of students. In enacting the multi-stage sampling, the following four stages were undertaken.

In stage one (stratification), Ashanti region was stratified into 43 MMDEDs. That is 24 districts, 18 municipals and one metropolitan assembly (GWSA, 2019). Simple random sampling was used to select one educational directorate from each of the districts, municipals and metropolitan assemblies. In doing this, the legislative instrument number of each assembly was entered in an MS Excel spreadsheet. Thereafter, the RANDBETWEEN function was executed which resulted in three numbers representing Kumasi Metro, Kwabre East Municipal and Adansi South District being selected. Altogether, there were 19 senior high schools in the three sampled MMDEDs. Kumasi metro had 11 SHSs, Kwabre East had six SHSs, and two SHSs in Adansi South district.

In the second stage (selection of SHSs) of the multistage sampling technique, the 19 SHSs from the three selected MMDEDs were stratified according to the GES categorisation. There were three category A schools, nine category B schools and seven category C schools. Afterward, simple random sampling technique (random number generator in MS Excel) was used to sample two schools from each category. The selection of two schools from each category ensured equal representation of categories A, B, and C schools in the study.

Eventually, in stage three, that is the selection of classes in selected schools, School A1 and School A2 were randomly selected from category A schools. School B1 and School B2 were also randomly selected from category B schools. Furthermore, School C1 and School C2 were randomly selected from category C schools. The distribution of the second year students and their mathematics teachers from these six schools (A1, A2, B1, B2, C1, and C2) is presented in Table 2. (Note: For confidentiality and anonymity, names used for the schools are pseudonyms).

Table 2: Distribution of second-year students and mathematics teachers in six sampled senior high schools based on GES categorisation

School Category	SHS	MMDED	Number of Students	Number of teachers teaching Core mathematics
A	School A1	Kumasi Metro	1,778	32
	School A2	Kumasi Metro	1,342	32
B	School B1	Kumasi Metro	1,278	26
	School B2	Adansi South	733	15
C	School C1	Kwabre East	754	18
	School C2	Kwabre East	1,214	24
Total	6	3	7099	147

Source: Field data (Taley, 2022)

From each of these six schools, five second-year classes were sampled through a simple random technique. Notably, all schools were operating within their second track. However, it was observed that one of the six schools had only five classes. To maintain consistency and equal representation across all schools, the decision was made to use the five classes from the school with fewer classes as the benchmark. This adjustment ensured a uniform and fair representation of the number of classes from each school, facilitating a balanced and comprehensive analysis in the study. The random number generator in MS Excel was used to sample the five classes in each of the six schools.

After selecting the classes, in the fourth stage (Sampling students) of this sampling technique, an equal number of students from the sampled classes were selected. Mugenda and Mugenda (2003) have established in simulation studies that a 10% sample is a good representation of a population. With a total accessible population of 7,099 SS2 students from the six selected schools (Table 2) (GES, 2019), the minimum sample of 10% was therefore, 710 (that is, 119 students from each of the six schools). However, to address non-response items, a sample of 787 was chosen (that is, an addition of 10 responses from each school). Subsequent rounding up of decimals during the calculation increased the sample sizes to 787 (approximately, 131 students were drawn from each school). A tabular summary of the number of students sampled from each class is presented in Appendix A.

The application of the random number generator in MS Excel was utilized to determine the number of students selected from each chosen class. All students in the selected classes were assigned numbers and the RANDBETWEEN function was run to select participants for the study. This process was replicated in all the 30 selected classes of the six schools.

After the analysis of the quantitative data, the purposive criterion sampling technique was used to select four of the six sampled schools (Cohen et al., 2007; Onwuegbuzie & Collins, 2007). The selection of the four schools was based on students' performance in the word problem test (School A1 and School B2) and their rating of instructional quality (School B1 and School C2). From these four schools, the voluntary convenience sampling technique (Onwuegbuzie & Collins, 2007) was used to select 16 (that is, four from each SHS) of the students who answered the test and instructional quality questionnaire. Also, 12 second-year teachers teaching core mathematics (that is, three from each SHS) were sampled using the voluntary convenience sampling technique for interview.

Data Collection Instruments

Three instruments were used to collect data in this study. Questionnaires, named as students' perceptions of instructional quality questionnaire [SPIQQ] and achievement tests, referred to as word problem achievement test [WPAT] were used to collect quantitative data. Additionally, interview guide were also used to collect qualitative data.

Student perception of instructional quality questionnaire

The students' perception of instructional quality questionnaire, SPIQQ (Appendix C) was structured in three sections: Part A elicited students' demographic data on gender and school category. Part B had two sections – instructional quality in word problems questionnaire and technology-integrated teaching questionnaire.

Part B: Instructional quality in word problems questionnaire

The instructional quality in word problems scale had two scales – Content-dependent construct (Cognitive Activation) and content-independent construct (Individual Learning Support). The content-dependent scale as adapted from Kunter and Baumert (2006); Peña-López (2012); and Schlesinger et al. (2018) had 18 items. The 18-item scale was developed to measure students' perception of the quality of instruction in activating cognition.

The 18 items measuring the content-dependent scale were grouped into four subscales. These were challenging levels of mathematics word problem tasks (five items), and the relevance of word problem tasks (five items). The other subscale was the ability of an instruction to draw on and activate students' prior knowledge (five items). The last subscale was the capability of an instruction to elicit students' thinking through explanation (three items).

The content-independent scale measured students' perception of the quality of instruction in providing the needed support to facilitate cognitive activation (Kunter & Baumert, 2006; Peña-López, 2012). The content-independent scale also had two subscales which were measured with 12 items. These are the teachers' feedback to students (six items), and the adaptive support provided during instruction (six items).

Altogether, the instructional quality in word problem scale encompassed 30 closed-ended items on a four-point Likert scale (Appendix C). Each item had a response option from 1= strongly disagree, 2 = disagree, 3 = agree, to 4 = strongly agree which indicated the extent to which a student approved each statement. The original items were slightly modified to reflect classroom instruction in mathematics word problems since the original items were developed to study the quality of instruction in general mathematics.

The instructional quality in word problem scale was pre-tested among 110 second-year students of St. Joseph's senior high seminary school (JOSS), Mampong on 25th January 2021. The pre-test showed that the instructional quality in word problem scale was reliable. The internal consistency of students' responses in the pre-test of the instructional quality in word problem scale verified using Cronbach alpha for content-dependent scale ($\propto$= .734) and content-independent scale ($\propto$= .883) was above 0.7 (Sahdra, Ciarrochi, Parker, & Scrucca, 2016; Tavakol & Dennick, 2011). Besides, the Cronbach alpha for each of the six sub-constructs of instructional quality in word problem scale were within acceptable ranges: Teacher feedback ($\propto$=.507), Challenging level of task ($\propto$=.706), Adaptive support ($\propto$=.539), Prior knowledge activation ($\propto$=.694), Relevance of task ($\propto$=.379), and Explanations ($\propto$=.854).

Additionally, the level of agreement was indicative that the modifications made to the items did not distort the quality of the scale.

Part C: Technology-integrated teaching questionnaire

Similarly, the technology-integrated teaching scale (Kirkwood & Price, 2016) was developed to measure students' perception of teachers' use of technology tools in enhancing the quality of instruction in mathematics word problems. The technology-enabled learning scale by Kirkwood and Price (2016) was adapted to measure this scale. The technology-integrated teaching scale had eight items. Each item had a response rating from 1= strongly disagree, 2 = disagree, 3 = agree, to 4 = strongly agree. The response rating indicated the extent to which a student approved each statement. The original items were slightly modified to reflect classroom instruction in mathematics word problems.

The technology-integrated teaching scale was pre-tested among 110 second-year students of St. Joseph's Senior High Seminary School, Mampong on 25th January 2021. The pre-test showed that the technology-integrated teaching scale was reliable. This is because the internal consistency of students' responses in the pre-test of the technology-integrated teaching scale was verified. Furthermore, the Cronbach alpha for pre-test of the technology-integrated teaching scale ($\propto = .848$) was above 0.7 (Sahdra, Ciarrochi, Parker, & Scrucca, 2016; Tavakol & Dennick, 2011). Since the technology-integrated teaching scales was reliable, the modifications made to Kirkwood and Price (2016) items did not distort the quality of the scale.

Validity and Reliability of Students Perceived Instructional Quality Questionnaire

To ensure the face validity of the SPIQQ, the SPIQQ was aligned to the instructional quality framework. This made the student perception of instructional quality questionnaire look similar to the validated questionnaires in structure and format (Walkowiak et al., 2014). The reliability and internal consistency of students' responses to the SPIQQ were verified using Cronbach alpha and construct reliability (CR) (Sahdra, Ciarrochi, Parker, & Scrucca, 2016; Tavakol & Dennick, 2011).

Prior to testing the reliability of the SPIQQ, an exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were undertaken to confirm the robustness of SPIQQ. The results of these analysis are presented in chapter four. Subsequently, the Cronbach alpha and CR for each of the six sub-constructs of instructional quality in word problem scale showed that the scale was reliable and consistent (Hair, Black, Babin & Anderson, 2019). Teacher feedback ($\propto$=.885, CR=.905), Challenging level of task ($\propto$=.876, CR=.904), Adaptive support ($\propto$=.783, CR=.828), Prior knowledge activation ($\propto$=.740, CR=.864), Relevance of task ($\propto$=.795, CR=.821), and Explanations ($\propto$=.800, CR=.865).

Additionally, the technology-integrated teaching scale had a Cronbach Alpha and CR ($\propto$=.851, CR=.885) indices high, above 0.7 indicating a reliable and consistent scale (Hair et al., 2019) (Appendix D). The convergent validity and discriminant validity of the SPIQQ were respectively computed using the average variance extracted [AVE] and the square root of the AVE procedure (Civelek, 2018; Kline, 2010; Zainudin, 2012). The AVE provided an estimation of the convergence among the battery of items that represented a measured latent construct. It also pointed out the average percentage of the variance among the items of the underlying construct (Hair et al., 2019).

According to Hair et al. (2019) and Zainudin, (2012), an AVE should be at least 0.5. The convergent validity (proxy by AVE) for each of the seven factors extracted was computed. Technology-integrated teaching (.564), Teacher feedback (.655), Challenging level of task (.703), Prior knowledge activation (.614), Relevance of task (.536) and Explanations (.682) met the cut-off point. Conversely, the AVE of Adaptive support (.494) violated the criteria though it was relatively high.

Discriminant validity was achieved for all seven scales within SPIQQ. As depicted in Table 3, the square root of AVEs (diagonal values) are greater than the respective correlations among the constructs of instructional quality in word problems as well as the technology-integrated teaching construct.

Table 3: Discriminant validity index summary

	1	2	3	4	5	6	7
1. Technology-integrated teaching	.751						
2. Teacher feedback	.121	.807					
3. Challenging level of task	.096	.223	.832				
4. Adaptive support	.085	.368	.299	.698			
5. Relevance of task	.206	.130	.268	.270	.780		
6. Activation of prior knowledge	.774	.085	.072	-.003	.154	.723	
7. Mathematics explanations	.153	.183	.217	.248	.189	.093	.825

Source: Field data (Taley, 2022)

Word problem achievement test

The second instrument used to gather data in this study was the word problem achievement test [WPAT] (Appendix E). Ahmed and Moalwi (2017) have described tests as an instrument that can be used to evaluate instructional quality. In this regard, WPAT became a measure of instructional quality in mathematics word problems and students' mastery in solving mathematics word problems (Thorndike & Thorndike-Christ, 2010). The achievement test had two sections, B1 and B2.

Section B1 (word problem test) was used to explore students' ability to solve mathematics word problems. There were eight items made up of four multiple-choice questions (MCQ) and four open-ended question questions. The combination of MCQs and short answer type questions was in line with the form and structure of mathematics test (Svinivki & McKeahie, 2014; Torres, Lopes, Babo, & Azevedo, 2009). The questions for the word problem test were adapted from existing validated instruments of Latu (2005), Bullock (2015), Core mathematics syllabus (MoE, 2010), and WASSCE core mathematics past question (WAEC, 2017). The modifications to the questions allowed for the replacement of foreign names and symbols with Ghanaian names and symbols.

Section B2 (Mathematics language competency test) had four matching type and five fill-in type questions. The fill-in question type was used to minimise students' tendency at guessing correct answers whilst making the scoring process more objective. (Medawela, Ratnayake, Abeyasinghe, Jayasinghe & Marambe, 2018). The questions in this section were used to examine students' comprehension of instructional terms as well as their ability to explain mathematics vocabulary.

The word problem achievement test was pre-tested and the items modified before the actual research was carried out. The pre-test of the WPAT questions was important for the following reasons; to check the clarity of the questions, instructions and layout. It was also necessary to identify omissions, redundant and irrelevant questions, to check the item difficulty and discrimination power of the test, and also to check for the reliability of the answers (Cohen et al., 2007). Since the questions were modified, my experienced supervisors and mathematics teachers had to review the test items to ensure content validity.

The pre-test of the 17-item WPAT was administered on 54 second-year students of St. Joseph's senior high/seminary school students on 17th February and 8th March 2021. On both occasions of the pre-test, students completed the test between 23 minutes and 34 minutes. Item analysis – item difficulty, item discrimination and test reliability indices of the pre-test result showed that WPAT could be used on similar and larger study sample. As noted by Ahmed and Moalwi (2017, p. 42), "item analysis improves exams and gives it reliability and validity, which functions as implement to evaluate students and instructional quality".

To minimise overestimation of reliability in test-retest due to memory effect (Ary, Jacobs, Sorensen & Razavieh, 2009; Robert & Saccuzzo, 2008), 19 days interval between the test times (Garson, 2013; Mccowan & Mccowan, 1999; Rudner & Schafer, 2006) was allowed. Furthermore, reshuffled questions on WPAT were reshuffled during the second test time. The Pearson correlation value for the WPAT between time T1 and time T2 was $r = .843$. The correlation showed that WPAT was stable (Kneebone & Dewar, 2017; Lee, Yim, & Kim, 2018) hence, my conviction to perform the item difficulty and discrimination analyses on the retested scores only.

Validity and Reliability of Word Problem Achievement Test

To ensure that WPAT was suitable for assessing SHS students' ability to solve word problems, expert opinion of my supervising mathematics and ICT education professors was solicited. The format of the word problem test and mathematics language competency test were respectively crafted to replicate the format of WASSCE past questions and the validated instruments of Latu (2005) and Sepeng and Madzorera (2014).

Construct validity for the word problem achievement test and mathematics language competency test was realised. This is because the item-total correlations for the mathematics word problem test (between .207 and .699) (Appendix F) and mathematics language competency test (between .265 and .497) (Appendix F) were robust enough to the extent that deleting any item further, did not drastically improve Cronbach's alpha. Besides, entries in the inter-item correlation matrix (Appendix G) were all positive which indicated that the items within each section of the WPAT measured the same scale.

Mathematics teacher and student interview

Both the mathematics teacher interviews and students' interviews were semi-structured interview protocol (Appendix H). The interview protocol guided my interaction with the mathematics teachers and students. The semi-structured nature of the interview engendered a conversation that enabled me to probe deeper for clarity and detailed descriptions on issues regarding the enactment of instructional quality in mathematics word problem (Baumbusch, 2010; Gibson & Brown, 2009; Zohrabi, 2013). Similarly to the observations of Merriam (1998), the use semi-structured interviews was an opportunity to explore classroom instructional activities which could not be observed directly because of Covid 19 restrictions.

Student interview generally allowed me to triangulate and explain the questionnaire results (Creswell & Plano Clark, 2018; Lincoln & Guba, 1986). Notably, responses from teacher interviews were used to validate student-sided information. Again, the interviews with the teachers enabled me to access a deep description of mathematics teachers' experience in enacting quality instruction in word problems (Morse, 2001). There were six and eight similar questions in the student and teacher interviews respectively.

Trustworthiness of the interview

Strategies suggested by Lincoln and Guba (1985; 1986) were followed to increase the trustworthiness of the data and findings of student and teacher interviews. A pre-test of the interview protocol was administered on two students and two teachers of St. Joseph's Senior High/Seminary School. The pre-test of the interview protocol facilitated the examination of pertinent lines of questioning, enabling the simplification of interview questions and estimation of the duration of each interview session.

During the interview, the interviewee responses were regularly rehashed so as not to wrongly quote the respondents. After transcribing the interviews, the transcripts were returned to the interviewees for member checking. This helped in reducing the threat to credibility.

To ensure a dependable result, the interview protocol was systematically followed in all interviews. Furthermore, the transcription of all recorded interviews were personally transcribed by me. As a result, dependability expressed in uniformity and consistency in managing the interview data were guaranteed (Gibbs, 2007; Lincoln & Guba, 1986).

For the confirmability of results, that is the likelihood of obtaining a similar result by other researchers, two approaches of triangulation (method and source of data) were implemented (Lincoln & Guba, 1986). Silverman (2014) has indicated that using alternative methods or other sources may produce more credible and objective findings. Because of this, the thematic summaries of the interview responses were compared with students' ratings of instructional quality in word problems. Moreover, the students' interview responses were validated with information gathered from the mathematics teachers.

Ethical Issues

All protocols of the Institutional Review Board of the University of Cape Coast (UCCIRB) were followed and approval of the study was granted by UCCIRB, the Department of Mathematics & ICT Education and my principal supervisor (Appendix B). In all six schools from which data was collected, all ethical protocols were discussed with the mathematics teachers and students taking part in the study.

At the briefing with the students, the purpose of the study was explained to them. The students were made aware of the absence of financial rewards in participating in this study. In addition, the students were assured of the confidentiality of the information they provided even though their participation in the study was voluntary. The consent/agreement form of all 787 students was witnessed by form teachers.

At a briefing session with the teachers teaching mathematics, the purpose of the study was explained to them, and the interview procedure discussed. The teachers were made aware of the absence of financial rewards in participating in this study. Furthermore, the teachers were assured of the confidentiality of the information they provided during the discussion and that nowhere in my report will their names or identity be revealed. Additionally, the teachers were made aware of their right to voluntarily participate in and/or exit from the study.

Data Collection Procedures

Four instances of quantitative data were collected from students in the study. The first quantitative data was students' perception of instructional quality in mathematics word problem. The second data was students' perception of mathematics teacher's integration of technology in teaching word problems. The third data was students' word problem performance, and the fourth data was students' mathematics language competence. The SPIQQ and WPAT questionnaires were used to collect four quantitative data. In addition to the quantitative data, qualitative data were collected through the interview responses of teachers and students.

Data collection for this study span five months, that is, from February – June 2021. Two months (February – March 2021) were devoted to obtaining approval from heads of the six schools sampled (Schools A1, A2, B1, B2, C1 and C2). The heads of the mathematics department of the six schools were also engaged on ethical issues, the appropriate period for the data collection, the selection of classes, and the level of mathematics teachers' engagement in the study.

The next one month (April 2021) was used to collect the quantitative data from the students. Distance between school location and period for reflection were the main reasons for the spread in period for gathering this data. Interview with mathematics teachers was conducted between May and June 2021.

Quantitative data from students were the first to be collected. During the quantitative data collection phase, students were made to respond to the SPIQQ before the WPAT was administered. The students spent 60 minutes to respond to the SPIQQ and WPAT (that is, 30 minutes for each session). Together with a field assistant the SPIQQ and WPAT were administered. My presence during the administration of the SPIQQ and WPAT helped me to clarify any form of misunderstanding some students had with items on the instruments (Zohrabi, 2013).

Based on students' rating of instructional quality and their word problem test scores, School B1 (Mean = 2.696, SD =.456) and School C2 (Mean = 2.526, SD =.426) respectively had the highest and lowest average rating in instructional quality. Similarly, School A1 (Mean = .973, SD =.447) and School B2 (Mean = .621, SD = .509) respectively had the highest and lowest average word problem test scores. The ranking of schools based on students' instructional quality perception rating and their word problem test scores at the school level is presented in Table 4.

Table 4: School-level students' perception of instructional quality and their word problem achievement test performance

Performance level	Instructional quality	Word problem test
Strong	School B1	School A1
Weak	School C2	School B2

Source: Field data (Taley, 2022)

The four rated schools – Schools B1, A1, C2 and B2 (Table 4) were selected for the second phase of data collection. In this phase of data collection, interviews with mathematics teachers and students were conducted. The mathematics teachers interviewed were 12. That is, three from each of the four senior high schools. After interviewing nine teachers from three schools, it was realised that the respondents have provided similar responses to the interview questions. However, the interview was extended to the fourth school where three more teachers were interviewed because more information was needed from different sources and for the purpose of meeting the minimum number of interviews needed to reach saturation as suggested by Guest, Bunce and Johnson (2006) and Kuzel (1992). The responses received from the three additional teachers were like the earlier responses.

Each interview lasted an average of 15 minutes. A day before the interview, the interview protocol was given to all 12 teachers to minimise participants' difficulty in responding to the interview questions (Breen, 2006). Likewise, 16 students (that is, four students from each of the four SHSs) were interviewed. Before recording the interview, the details of the protocol were read to the students. Each interview lasted an average of 10 minutes. At the start of each interview session, the stage (statement of the purpose of the study, confidentiality, open discussion) was adequately prepared. In an attempt to create a good rapport with the interviewees (Charmaz, 2006; Creswell, 2014), a total disclosure about my identified as a postgraduate student at UCC and a mathematics tutor in a college of education was made.

Thereafter, the major and follow up questions were asked for responses as field notes (date and time of interview, facial and body gestures, context, key responses) were taken. At the end of the session, a summary of ideas that emanated from the discussion was disclosed and then interviewees were asked for a confirmation of the summary. Finally, appreciation was rendered to the interviewees (that is, the students and teachers) for taking part in the interview.

Both teacher and student interviews were audio-recorded and later transcribed. A recording of the conversation helped me to focus on conducting the interview rather than taking detailed notes. In agreement with Charmaz (2006), the recording also helped me to transcribe the interviews verbatim thereby reducing my over-reliance on memory since the interview data for referencing and constant comparative analysis could always be referred to.

Data Processing and Analysis

In accordance with the explanatory sequential mixed methods design (Creswell & Plano Clark, 2018; Finley et al., 2013; Guetterman, Fetters & Creswell, 2015), three stages of data processing were followed in this study. The first stage of data processing was on the quantitative data. The second stage was the processing of the interview responses. The third stage of data processing was the integration of both the survey results and interview responses.

Quantitative data processing

Both the SPIQQ and WPAT were answered by 787 second-year students in six SHSs in Ashanti region. A summary of the distribution of students who took part in the study is presented in Table 5. Each of the six schools sampled in this study was represented by five classes. As showed from Table 5, each school contributed a little below 17% of students in this study.

Table 5: Distribution of students in the study according to their schools

SHS	Class			Valid			
	N	E	SS	SPIQQ	WPAT	Accepted	%
School A1	5	249	130	130	130	130	16.8
School A2	5	232	131	129	131	129	16.7
School B1	5	235	131	131	131	131	16.9
School B2	5	228	132	131	130	129	16.7
School C1	5	200	131	131	130	130	16.8
School C2	5	236	132	128	129	125	16.1
TOTAL	30	1380	787	780	781	774	100

S = Number of classes sampled; E = Number of students enrolled in N; SS = students sampled in E; % = percentage of SS included in the study

Source: Field data (Taley, 2022)

Out of the 787 sampled students, 781 (99.1%) students provided complete responses on the SPIQQ, whereas, 780 (99.2%) answered the WPAT. Six cases in the SPIQQ were removed – that is, four did not complete the entire questionnaire (items 22 to 38 were not answered), and two provided multiple responses. Additionally, seven cases were rejected from the data because the students did not answer the WPAT though they completed the SPIQQ. Per the condition for full participation, 13 (1.7%) cases (School A2 (two), School B2 (three) School C1 (one), and School C2 (seven)) were deleted. Consequently, 774 (98.3%) responses were used for this study.

Students' responses to the instructional quality in word problems questionnaire and the technology-integrated teaching questionnaire were screened. The data was screened for unengaged responses and missing entries.

The variances in responses of all 774 respondents were checked for unengaged responses. The standard deviation values were above 0.47 which meant that the responses were fairly distributive.

However, some missing cases (attributable to non-responses) were observed. 60 (0.161%) missing data occurred among 27 (56.25%) variables excluding respondents' biodata. These missing values were encountered among 43 (5.56%) respondents in the survey. The pattern of the missing data could at best be described by Tabachnick and Fidell (2013) as missing completely at random since the missing data were scattered randomly. A pie chart distribution of the missing data alongside the pattern of the missing data is presented in Appendix I. Further analysis showed that School A2 had 34 missing values, School B2 had two missing values, whiles Schools B1, C2, C1 and A1 recorded six each of missing values.

To avoid risking statistical results though the missing data was less than 5% (Tabachnick & Fidell, 2013), a multiple imputation approach was used to replace the completely random missing data. Eekhout et al. (2014) have proposed that the best approach to handle missing data in a multi-item questionnaire is by multiple imputations. This assertion was corroborated by van Buuren (2012) who recommended multiple imputations for missing ordinal categorical data.

On the WPAT, students' scores on the WPAT were subjected to item difficult analysis. Literature has maintained that the quality of test used in educational measurement and evaluation of instructional quality depends on their difficulty index and discrimination index (Ahmed & Moalwi, 2017; Considine, Botti & Thomas, 2005; D'Sa & Visbal-Dionaldo, 2017; Sim &

Rasiah, 2006). By performing item difficulty analysis, Sim and Rasiah (2006) concluded that researchers can determine whether or not items in a test are difficult and/or whether items discriminate between high scorers and low scorers.

The difficulty levels of WPAT items are presented in Table 6 whiles the discrimination levels of WPAT are also presented in Table 7. The difficulty indices used in the analysis are those proposed by D'Sa and Visbal-Dionaldo, (2017) and Hotiu (2006). In item difficulty analysis, descriptors such as "Excellent," "Good," "Too easy," and "Too difficult" are used to categorize the difficulty levels of test items based on the performance of the test-takers. Items categorized as "Excellent" are typically those that a large proportion of test-takers answered correctly. These items are considered to be at an appropriate difficulty level, striking a balance between challenging the test-takers and allowing them to demonstrate their competence. "Good" items are moderately challenging. A reasonable number of test-takers answer them correctly, indicating a fair level of difficulty. These items contribute to distinguishing between individuals with varying levels of ability, providing a meaningful measure of performance. Items labelled as "Too easy" are those that a vast majority of test-takers answered correctly. These items may not effectively differentiate between individuals with different levels of ability, as they are perceived as being too straightforward for the intended skill or knowledge level. Conversely, "Too difficult" items are those that a large proportion of test-takers answered incorrectly. These items may be considered excessively challenging, potentially leading to frustration among test-takers and not providing a clear indication of their abilities.

Table 6: Item difficulty analysis of the word problem test and mathematics language competence items

Description	Word problem test		Maths language competence	
	f	%	f	%
Excellent	4	50.00	4	44.44
Good	3	37.50	4	44.44
Too easy	0	0.00	0	0.00
Too difficult	1	12.50	1	11.22
Total	8	100	9	99.99

Source: Field data (Taley, 2022)

The discrimination indices of Hopkins (1998) were used to determine how well WPAT discriminated between high scorers and low scorers in the word problem achievement test. In discrimination analysis, descriptors such as "Excellent," "Good," "Marginal," "Poor," and "Defective" are used to categorize the ability of a test item to discriminate between individuals with different levels of the trait being measured. An item categorised as an "Excellent discriminator" is one that effectively differentiates between individuals with high and low levels of the trait. Test-takers who possess the desired trait are more likely to answer the item correctly, while those lacking the trait are more likely to answer incorrectly. Items in this category contribute significantly to the overall discriminatory power of the test. A "Good discriminator" is an item that demonstrates reasonable effectiveness in distinguishing between individuals with different levels of the trait. While not as strong as an excellent discriminator, a good discriminator still contributes positively to the test's ability to measure individual differences. Items categorized as "Marginal discriminators" have limited effectiveness in discriminating between individuals with varying levels of the trait. These items may not provide a strong indication of the test-taker's standing in relation to the trait being measured. A "Poor discriminator" is an item that shows little ability to differentiate between individuals with high and low levels of the trait. Poor discriminators may not contribute meaningfully to the assessment of individual differences and might need reconsideration or revision. Items labelled as "Defective discriminators" are those that perform poorly in discriminating between individuals. These items may be flawed in design or may not effectively tap into the targeted trait. Consideration should be given to revising or removing defective discriminators from the test.

Table 7: Discrimination analysis of the word problem test and mathematics language competence items

Description	Word problem test		Maths language competence	
	f	%	f	%
Excellent	3	37.50	2	22.22
Good	3	37.50	3	33.33
Marginal	0	0.00	3	33.33
Poor	2	25.00	1	11.11
Defective	0	0.00	0	0.00
Total	8	100	9	99.99

Source: Field data (Taley, 2022)

From Table 6, seven (87.5%) word problem test items and eight (88.9%) mathematics language competence items were acceptable for assessing students (Quaigrain & Arhin, 2017). Also, from Table 7, six (75%) word problem test items and eight (88.9%) mathematics language competence items were fit for purpose (Brown, 1983; Crocker & Algina, 1986; Hopkins, 1998). By inspection of Tables 7 and 8, two items Q6 ($IDI = 7.7\%, DI = .05$) and Q16 ($IDI = 19\%, DI = .13$) were found to be very difficult and discriminated very poorly. Whereas, Q3 ($IDI = 84.2\%, DI = .14$) discriminated poorly though with a good difficulty level (Appendix J). To this end, Q3, Q6 and Q16 were subject for removal.

Furthermore, the overall means and standard deviation scores of the item difficulty index ($M = 49\%, SD = 19.82$) and discrimination index ($M = 0.27, SD = 0.11$) confirmed a generally acceptable difficulty level which discriminated optimally among the test takers. Moreover, the Pearson correlation between item difficulty index and the discrimination index (Ahmed & Moalwi, 2017) for the scores on the 17-item WPAT showed a medium positive correlation ($r = .348$) (Cohen, 1988). This shows that the difficulty level of the items had the power to discriminate among the test takers moderately (Ahmed & Moalwi, 2017; D'Sa & Visbal-Dionaldo, 2017).

Likewise, the test of homogeneity of the collective items in assessing word problem performance and mathematics language competence was conducted (Kline, 1986). Five items (Q3, Q4) and (Q15, Q16, Q17) were not internally consistent and they also violated construct validity under word problem test and mathematics language competency test respectively. Conclusively, the five items were removed because they did not correlate well with their respective scales.

Therefore, six questions of the word problem test which were internally consistent were retained. Furthermore, the six questions which correlated well on the mathematics language competency scales were retained. Scores on these 12 items were used in subsequent analysis.

Normality and outliers for students' perception of instructional quality rating

A visual inspection of the histogram, box plot and normal Q-Q plot showed that the quality of instruction rating was generally normally distributed. However, a Shapiro-Wilk's test ($p<.05$) (Razali & Bee Wah, 2011; Shapiro & Wilk, 1965) failed the univariate normality test. Nonetheless, Field (2009), Pallant (2007) and Tabachnick and Fidell (2013) assert that a large sample of at least 200 is sufficient to avert any statistical complications. Even though the instructional quality scores were generally skewed (-.458, SE = .088), no outlier was found in the data set. A further check of the descriptive statistics showed a noticeable similarity between the mean score (2.610) and the 5% Trimmed mean (2.620) which did not any warrant further action.

Besides, a visual inspection of the histogram, box plot and normal Q-Q plot, and Shapiro-Wilk's test ($p<.05$) (Razali & Wah, 2011; Salkind, 2015; Villasenor & Estrada, 2009) showed that the mean rating of students' perception of teachers' integrating technology into teaching word problems was generally not normally distributed. More so, the skewness (1.139, SE = .088) and kurtosis (1.714, SE = .176) of the results revealed that the z-score of the skewness was beyond the three standard deviation thresholds (± 3.29) (Tabachnick & Fidell, 2013). Despite the non-normality in the distribution, the sample size was sufficient to avert any statistical complications (Field, 2009; Pallant, 2007; Tabachnick & Fidell, 2013).

Following the result of the normality test of the technology-integrated teaching rating, a check for the presence of possible outliers in the data was carried out. Pallant (2007) admits that outliers can cause a given data set to skew, kurtotic and affect some statistical analysis. A total of 16 (2.1%) cases with a mean score above 2.82 were moderate outliers (that is, 1.5-unit points above the upper whisker). A further check of the descriptive statistics showed a noticeable difference between the mean score (1.546) and the 5% Trimmed mean (1.498). Therefore, the scores on the technology-integrated teaching rating were transformed.

The square root transformation was carried out (no negative entry) (Field, 2009). The transformed data were found to be free of outliers. A normality test was then carried out again. A visual inspection of the box plot and the normal Q-Q plot showed that the transformed technology-integrated teaching rating was relatively normal.

Normality and outliers of word problem test scores

Univariate normality of the word problem test was assessed. A Shapiro-Wilk's test ($p<.05$) (Razali & Bee Wah, 2011; Shapiro & Wilk, 1965) univariate normality test and a visual inspection of the histogram, box plot and normal Q-Q plot as presented in Appendix K, showed that the word problem test scores were generally not normally distributed. More so, the skewness (1.243, SE = .088) and kurtosis (.784, SE = .176) of the word problem test scores revealed that the z-score of the skewness was beyond the three standard deviation thresholds ($\pm$3.29) (Tabachnick & Fidell, 2013). Irrespective of the non-normality in the distribution, Field (2009), Pallant (2007) and Tabachnick and Fidell (2013) assert that a large sample of at least 200 is sufficient to avert any statistical complications.

Following the result of the normality test of word problem test scores, a check for the presence of possible outliers in the data was carried out since

Pallant (2007) admits that outliers can cause a given data set to be skewed, kurtotic and affect some statistical analysis. A total of 26 (3.4%) cases with a mean score above 2.89 were moderate outliers (that is, 1.5-unit points below the lower whisker and above the upper whisker) (Appendix K). A further check of the descriptive statistics showed a noticeable difference between the mean score (.875) and the 5% Trimmed mean (.792). Therefore, the scores on the word problem test were transformed (Field, 2009).

The transformed data were found to be free of outliers. A normality test was then carried out again. A visual inspection of the box plot and the normal Q-Q plot showed that the transformed word problem test score was relatively normal. Besides, the skewness (.241, SE = .088) and kurtosis (-.681, SE = .176) showed that the z-score of skewness were within three standard deviation thresholds ($\pm$3.29). No noticeable difference between the mean score (.787) and the 5% Trimmed mean (.775) was found.

Normality and outliers of mathematics language competence test

Univariate normality of the mathematics language competence test was assessed. Even though, a Shapiro-Wilk's test ($p<.05$) (Razali & Bee Wah, 2011; Shapiro & Wilk, 1965) univariate normality test was not met, a visual inspection of the box plot and normal Q-Q plot as presented in Appendix K, showed that the mathematics language competence test scores were relatively normally distributed. More so, the largeness of the sample size was sufficient to avert any statistical complications (Pallant, 2011; Tabachnick & Fidell, 2013). Even though the mathematics language scores were generally skewed, no outlier was found in the data set. A further check of the descriptive statistics showed a noticeable similarity between the mean score (.653) and the 5% Trimmed mean (.674) which did not any warrant further action.

Qualitative data processing

Interview responses

Twenty-eight interviews were conducted in this study. Sixteen of the respondents were second-year students whiles 12 were teachers teaching core mathematics. Besides, 14 respondents (that is, eight students and six teachers) were selected based on students' performance in the word problem test. Similarly, 14 respondents (that is, eight students and six teachers) based on students' rating of the quality of word problem instruction were selected. Further breakdown of respondents' characteristics is presented in Table 8.

Table 8: Attributes of respondents

Status	Attribute	f	%
Student	Male	11	68.75
	Female	5	31.25
	Positively inclined to word problems	10	62.50
	Negatively inclined to word problems	6	37.50
Teacher	Male	12	100
	Female	0	0.00
	1 – 3 years of experience	3	25.00
	4 – 9 years of experience	7	58.33
	10 and more years of experience	2	16.67

Source: Field data (Taley, 2022)

The processing of the interview data generated in this study was prepared, analysed and presented as suggested by Creswell (2012). After all the interviews had been conducted, the recorded interviews were transcribed them verbatim. While transcribing the responses, all identifying information (name, school, class) were removed to maintain confidentiality. Alpha numeric codes were therefore assigned to participants. The data were dated and uniquely identified according to the date of interview and category (student or teacher).

Moreover, the accuracy of the transcriptions were guaranteed because the recorded interviews were systematically replayed and transcribed. Consequently, as opined by Lincoln and Guba (1985), with acquittance with the data, a thorough familiarity with the data was gained. To member check the credibility of the transcripts, the transcripts to the interviewees (teachers) were returned (through their e-mails) for the confirmation of their responses. Students interviewed were already on vacation and could not be contacted for confirming their thoughts.

Subsequently, Braun and Clarke's (2006, p. 87) deductive coding strategy and the guide provided by Schlesinger et al. (2018) were applied to deductively develop codes from the interview transcripts. Furthermore, the qualitative data analysis programme, NVivo 12 (Creswell, 2012) was used to organise and manage the codes into themes. Finally, the emerging themes were used to explain the survey results.

Data Analysis Plan

To answer research question one, which involved examining instructional quality based on instructional activities, students' perception of instructional quality questionnaire data was analysed using the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The appropriateness of the dimensionality of instructional quality in word problems was further tested using the fitness of CFA models (Bellens et al., 2019; Scherer, Nilsen & Jansen, 2016). Besides, students' responses to interview questions, thematic analysis of the codes (Braun & Clarke, 2012) were generated and a joint display table used to link the qualitative findings with the quantitative results interspersed.

In research question two, descriptive statistics (means, standard deviations, and coefficients of variations) and Pearson correlation were used to determine the correlation between students' word problem test scores and their instructional quality perception rating. The extent of the correlation was determined based on Cohen's (1988) guidelines. Cohen's (1988) benchmark indicated small ($r = .1$), moderate ($r = .3$) and large ($r = .5$) correlations.

Research question three was answered using qualitative interview responses. Codes were developed from teacher and student interviews to verify the presence of the dimensions of instructional quality in the teaching of word problems. More so, interview responses from teachers and students were used to confirm and explain the relation between instructional quality and students' performance in word problems.

To answer research question four, standard multiple regression was performed to establish the predictability of word problem test performance from the content-dependent and content-independent dimensions of instructional quality. Additionally, the predictability of instructional quality on word problem test scores was further assessed by regressing word problem test performance on instructional quality. The effect of predictors R^2 was estimated using Cohen's (1988) guidelines. Cohen (1988) suggested ($R^2 = .02$) for small, ($R^2 = .15$) for medium and ($R^2 = .35$) large effect sizes.

Research question five was answered using standard and sequential multiple regression to verify the statistical influence of technology-integrated teaching and students' mathematics language competence on the relation between instructional quality (predictor variables) and students' word problem performance (outcome variable).

To answer the qualitative research question six, that is expalining how students' mathematics language competence and technlogy-integrated teaching affected their performance in word problems, the interview data were grouped according to the interview questions and responses. Research question six was answered based on students' responses to interview questions. Content and thematic analysis of the codes (Braun & Clarke, 2012) were used to link the qualitative findings with the quantitative results interspersed with quotations from the transcripts.

Research question seven was answered by exploring the interaction effects of students' mathematics language competence and technology-integrated teaching with instructional quality. Subsequently, the extent to which the interaction effect influenced students' performance in word problems test was analysed using PROCESS v4.0 (Hayes, 2018).

The research hypothesis was tested using a one-way multivariate analysis of variance. MANOVA was used to simultaneously examine the potential differences in the quality of instruction provided by mathematics teachers as well as students' performance in solving word problem tasks concerning GES categorisation. The extent of the differences was determined based on Cohen's (1988) criteria. Cohen (1988) considered effect sizes of ($\eta^2 = .10$) as small, ($\eta^2 = .25$) as medium and ($\eta^2 = .40$) as large. Students' perception of instructional quality and their word problem test scores were the outcome variables whiles school categories were the predictor variables. The mean rating of instructional quality was interpreted based on Tekin's formula (as cited in Deringol, 2018) as follows: the mean score of 1.00-1.33 meant 'Low rating', 1.34-2.67 meant 'Medium rating' and 2.68-4.00 meant 'High rating'. The interpretation of instructional quality as low, medium, and high are inline with the descriptions put forward by Marzano, Pickering, and Pollock (2001).

Chapter Summary

This chapter described the methods and procedures used to explore the effect of instructional quality on senior high students' ability to solve word problems. The study was based on the sequential explanatory mixed methods design underpinned in the pragmatist research paradigm. In using multistage sampling technique, both quantitative and qualitative data from 787 students and 12 mathematics teachers. The data gathered included students' perception of instructional quality, their perception about technology-integrated teaching, their mathematics language competence, and their ability in solving word problem tasks.

Prior to data collection, the validity of the research instruments (SPIQQ, WPAT and interview protocols) were ensured. After collecting the data, it was duly screened. Subsequently, Cronbach alpha, composite reliability and the average variance extracted were used to prove the reliability of the quantitative data. Also, the guidelines of Lincoln and Guba (1985; 1986) were used to establish the trustworthiness of the interview data. Descriptive statistics (mean and standard deviation), inferential statistics (SEM, correlation and regression analysis) and themes were used to answer the research questions and hypothesis.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results and discussion of this study are presented in this chapter. The current study explored how the quality of instruction affect the performance of senior high school students in solving mathematics word problem tasks.. Specifically, students' perception about instructional quality in mathematics word problems, their perception about teachers' integration of technology tools in teaching word problems, their mathematics language competence and their ability to solve word problem tasks were examined. Additionally, mathematics teachers' experiences in teaching mathematics word problems were explored.

IBM SPSS Statistics version 21 package, AMOS, and NVIVO 12 software were used to analyse the data. Descriptive analysis (means, standard deviations, coefficients of variations, and percentages), and inferential analysis (correlation, regression and MANOVA) were used to analyse the data. Sequel to the data screening, the final sample for this study was 774. The final sample size was categorised into three independent groups according to GES categorisation of schools; category A (N = 259), category B (N = 260), and category C (N = 255).

The results have been presented based on the research questions and hypothesis formulated in chapter one. Also presented in this chapter are the exploratory and confirmatory factor analyses to ascertain robustness of the instructional quality perception questionnaire and the factor structure of instructional quality in mathematics word problems.

Results

Instructional activities that define the quality of instruction in the teaching of mathematics word problems

The quantitative data on students' perception of instructional quality as well as the qualitative data from interviews conducted with students and teachers were systematically used to answer research question one (RQ1) – What instructional activities define the quality of instruction in the teaching of mathematics word problems? Using the quantitative data, both exploratory factor analysis and confirmatory factor analysis were used to examine the factor structure of the instructional quality in the word problems. Furthermore, the results of the exploratory and confirmatory factor analyses were validated with interview responses from the students and teachers.

Exploratory factor analysis

An exploratory factor analysis (EFA) was conducted to obtain a parsimonious factor structure of instructional quality in mathematics word problems. Principal Component Analysis (PCA) was used to ascertain the factorability of the instructional quality in the word problems data set. Compared to other extraction methods, PCA was applied because as explained by Timm (2004), PCA requires no distributional assumptions and it is more tolerable to produce solutions even on data that violates multivariate normality.

Based on literature (George & Mallery, 2003; Hair et al., 2019), the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for all items (.833) was adequate. The KMO for individual items (Appendix L) was also adequate. Additionally, the Bartlett's Test of Sphericity was equally significant (Chi-Square= 9068.224, df = 435, Sig = .000). An inspection of the communalities indicated that two items (CA1 and CA10) had communalities below 0. 4 whiles 28 items had at least a moderate factorable communality (> .4).

By using the Varimax with Kaiser Normalisation, seven factors with factor loadings above 0.3 and Eigenvalues greater than one was achieved. Orthogonal rotation method was used because the oblique rotation method produced a weak correlation matrix among the factors. The seven factors explained about 60.65% of the variance in the data distribution. A visual inspection of the corresponding Scree plot confirmed the extraction of seven factors. The SPSS output tables for the communalities, component correlation matrix, total variance explained, and rotated component matrix together with the Scree plot are presented in Appendix M.

Further exploration with a Monte Carlo parallel analysis (Watkins, 2000) produced six factors that represented the six scales contained in the dimensions of instructional quality in this study. Figure 5 is the graphical representation of the parallel analysis. The table of the Monte Carlo PCA parallel output is also presented in Appendix N.

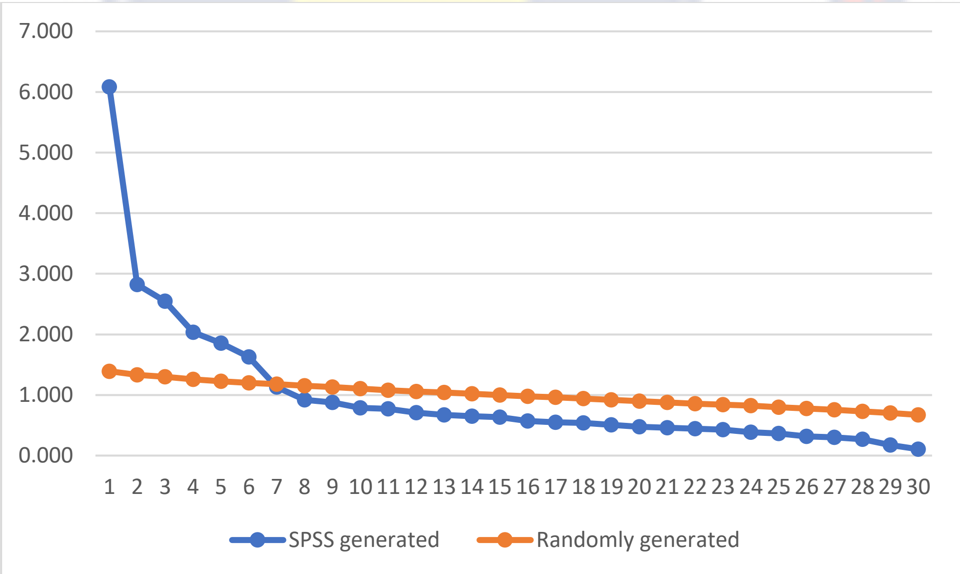


Figure 5: Parallel analysis results of the number of factors to retain

The six factors extracted from 25 items explained about 64.6% of the variance. Five items that did not meet the convergence criteria were deleted. Specifically, item CA1 was deleted because it loaded on two factors. Likewise, four items (SS25, CA 10, CA11 and SS19) were also deleted because they had low factor loadings.

Based on previous research (Baumert & Kunter, 2013; Bellens et al., 2019b; Fauth et al., 2014; Praetorius et al., 2014; Praetorius et al., 2018) the six factors extracted were accordingly named. The factors extracted are teacher feedback, challenging level of task, adaptive support, prior knowledge activation, the relevance of task, and mathematical explanations. The factor loadings for the six factors are presented in Appendix D. Following the EFA, confirmatory factor analysis (CFA) was conducted to confirm the factor structure of the quality of instruction in mathematics word problems.

Confirmatory factor analysis

Based on Kline's (2005) procedure, a three-order confirmatory factor analysis (CFA) was conducted to confirm the factor structure of the quality of word problem instruction. CFA order one illustrated how the 25 items loaded into corresponding measured variables. CFA order two and three were used to validate how sub-constructs loaded into dimensions of instructional quality as theoretically postulated. The incremental and parsimonious fit indices (Appendix O) as summarised by Zainudin (2012) were used to justify the fit of CFA models. Accordingly, the fit indices for CFA models 1, 2, 3 and 4 are presented in Table 9.

Table 9: Fitness of instructional quality CFA models

	First-order	Second-order		Third-order
Index	Model 1	Model 2	Model 3	Model 4
SRMR	.0356	.0404	.0414	.0414
RMSEA	.030	.037	.036	.036
GFI	.946	.946	.948	.948
AGFI	.935	.934	.937	.937
CFI	.972	.965	.967	.967
TLI	.968	.906	.963	.963
Chisq/df	1.686	2.072	2.009	2.009

Source: Field data (Taley, 2022)

The first order CFA (Model 1, Table 9, Appendix P) had factor loadings between .13 to .99. As directed by Zainudin (2012), items that loaded below .50 were systematically deleted. A second-order model CFA model (Model 2, Table 9, Appendix Q) though had good fit indices, the standard regression weights among the constructs of instructional quality varied remarkably between r = .01 and r = .41. Besides, the model did not conform to the proposed conceptual structure of instructional quality.

A restructured second-order model CFA (Model 3, Table 9, Appendix R) with two dimensions: content-dependent and content-independent dimensions also had good model fit indices. Since model 2 was nested within model 3, a chi-square difference test was conducted (Brown, 2006). A chi-square difference test of the difference in the chi-squares and degrees of freedom of the models 2 and 3 showed a statistically significant difference between them ($\propto = .01, \chi^2(1, N = 774) = 18.662, p = .000016$) (Stangroom, 2018). Since model 3 had a lower chi-square (χ^2=532.433) and enhanced fit indices, model 3 was deemed appropriate for the data from the six schools.

Based on the theoretical consideration that instructional quality is a holistic construct with varying dimensions (Lipowsky et al., 2009; Praetorius et al., 2014), a third-order model (Model 4, Table 9, Appendix S) was formulated. In model 4, instructional quality was defined in terms of content-dependent and content-independent dimensions.

The construct of instructional quality is seen as a constituent of two sub-constructs. This idea fitted well with the conceptual framework underpinning this study. The indices of the third-order CFA model fit (Model 4, Table 9) were excellent since CFI > 0.95, SRMR < 0.08 and RMSEA < 0.06 (Gaskin & Lim, 2016; Zainudin, 2012). In summary, the quality of mathematics word problem instruction can be defined in terms of content-dependent and content-independent dimensions.

Furthermore, the views of students about instructional activities that define the quality of instruction during the teaching and learning of word problems were explored. Consequently, the views of the students were validated with interview responses from teachers. Deductive coding was used to confirm the six sub-themes (that is, the sub-scales of instructional quality). The sub-themes were further grouped into two themes, that is, content-dependent and content-independent dimensions of instructional quality. The six sub-themes as extracted earlier from the exploratory factor analysis were activation of previous knowledge, challenging level of tasks, mathematical explanations, the relevance of tasks and materials, adaptive support, and feedback.

About 67% of the sub-themes ($N = 4$), that is, activation of previous knowledge, challenging level of tasks, mathematical explanations, and relevance of tasks and materials defined content-dependent theme. Furthermore, about 33% of the sub-themes ($N = 2$), that is, adaptive support and feedback also defined the content-independent theme. A summary of the evidence and sources of these codes are presented in Appendix T.

About 57.1% (N = 16) of respondents indicated the importance of activating students' previous knowledge in defining the quality of instruction. For example, DST2 said "Sometimes, he [teacher] makes reference to what we [students] have learnt before" and this helps them to connect what they know to what they do not know. Besides, about 35.7% (N = 10) of the respondents identified the importance of teachers' feedback in defining the quality of instruction. Students saw feedback as an opportunity to correct their errors. For instance, DST4 said that "when he [teacher] marks our exercises, he [teacher] will call us to show us our mistake". FST2 also corroborated DST4 saying that "I called him to see my solution and said I got the right answer and I was happy".

Approximately 89% ($N = 25, 89.3\%$) of the respondents also identified a friendly student-teacher relationship as an important activity that makes students go to their teachers for assistance and support during their learning. For example, AST1 implied that quality instruction "involves not only the teaching of particular academic skills but as importantly, the fostering of students' self-esteem, reinforcing self-esteem in the classroom is associated with increased motivation and learning of word problems". Eighteen ($N = 18, 64.3\%$) of the respondents premised the quality of word problem on the relevance of the tasks and learning materials to students' context. AST 3 noted that the teacher "he [teacher] links the word problem questions to real-life problems like buying and selling rice, sugar and books". DST 2 also added that the teacher "brings tools that help us to get the real thing".

Altogether, there were 190 references from all 28 transcripts to define the quality of word problem instruction. All 28 (100%) participants cited evidence of content-dependent activities. Also, 25 (89.3%) participants provided evidence of content-independent instructional activities. Furthermore, it was possible to code 124 (65.3%) references of content-dependent activities and 66 (34.7%) references of content-independent activities.

The summary of the evidence in this thematic analysis suggest that teachers spend most of their instructional period dealing with content related structures as evident in a student's submission that "He [teacher] starts with the introduction and then we start solving examples and afterwards, he gives trial questions" CST 1. The perception held by the students was corroborated by a teacher DTR 3 who remarked:

> to be frank with you, we always go according to the syllabus and the time allocated for the teaching of a particular topic … if you stay on one topic forever, you have a problem since that is not the only topic.

This indicates that teachers' focus was on the teaching of the syllabus and not students' understanding.

The result of RQ1 shows that instructional activities that define the quality of instruction in the teaching of mathematics word problems can be placed in two dimensions. These are content-dependent and content-independent dimensions of instructional quality. Consequently, a joint display table of results connecting the quantitative analysis of the dimensions of instructional quality and interview findings of are presented in Table 10.

Table 10: Joint display summary for defining instructional quality in mathematics word problems

	M	SD	Cases	%	Student and teacher evidence
Content-dependent	2.63	.43	28	100	
Challenging level of task	3.07	.70	23	82	"teacher sometimes solves past questions with us. I like the past questions because they are challenging" (DST3, student) "give tasks which are easier to the complex ones" (FTR2, teacher)
Prior knowledge activation	2.17	.65	16	57	"teacher tries to compare the problem that we have with other problems and previous problems that we have solved" (FST1, student) "I look at their previous knowledge, then I move forward to what I really want them to know" (FTR3, teacher)
Relevance of tasks and materials	2.63	.70	18	64	"word problems that are really related to the business word attract me" (AST1, student) "relating word problems to their everyday life situations" (ATR3, teacher)
Mathematical explanations	2.67	.78	12	43	"he also allows us to explain how we got our equations… solution on the board and explains" (FST2, student) "the students explain the statement and try to use variables to represent the statement they have written" (DTR1, teacher)
Content-independent	2.58	.58	25	89	
Adaptive support	2.92	.65	25	89	"more times, he goes round the class. The last time, I called him to see my solution" (FST2, student) "I attend to students individually. I try to solve their problems for he/she to understand. Once you get the concept, that is it." (FTR1, teacher)
Teacher feedback	2.24	.74	10	36	"teachers should make an effort to isolate misconception and correct it" (CST1, student) "let students know how well they are doing, it helps the serious ones" (DTR1, teacher)

Source: Field data (Taley, 2022)

Merging the survey and interview results (Table 10), the study has shown that content-dependent instructional activities (M=2.63, SD=.43, cases=100%) are mostly present in mathematics word problem instruction. The incidence of content-independent instructional activities was generally minimal (M=2.58, SD=.58, cases=89%). Furthermore, teacher feedback and developing mathematics language were the least referenced (35.7%). This means, teachers' efforts at providing constructive feedback were not obvious to the students. Evidence from Table 10 confirmed that even though teachers espoused the importance of feedback (DTR1), such activities were not manifested (CST1). Based on the survey result of the dimensions of instructional quality and evidence adduced from the interview responses, the structure of instructional quality described on the data from the six schools was presented in Figure 6. This framework (Figure 6) supported the conceptual framework underpinning this study.

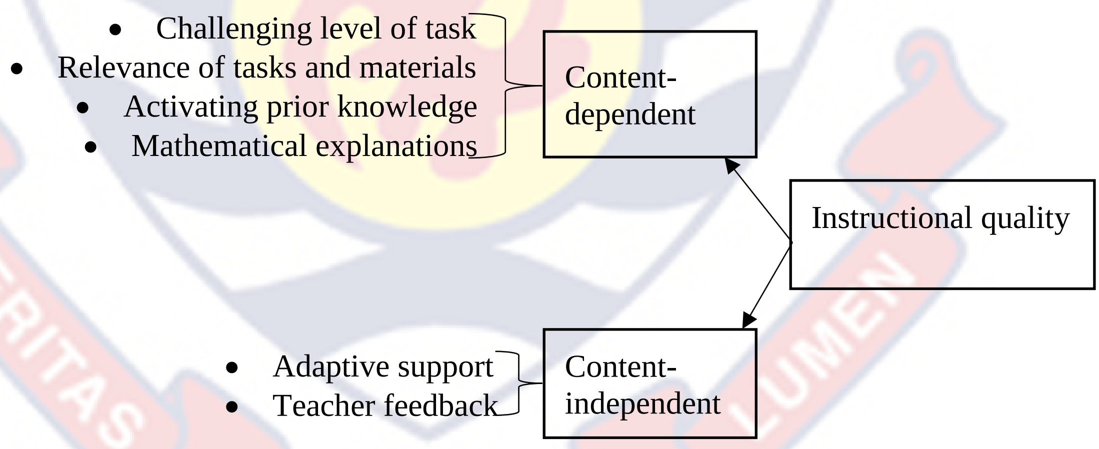


Figure 6: Conceptual structure of dimensions of instructional quality in mathematics word problems

Relating Students' Performance in Word Problem Tasks and their Perception about Instructional Quality

Research question two (RQ2), sought to explore how students' perception of instructional quality correlated to their performance in word problem tasks. To answer this question, a correlational analysis between students' word problem tests scores and instructional quality perception ratings was performed. Using the Pearson product-moment correlation coefficient, the level of correlation between word problem performance and instructional quality was determined.

Preliminary analyses performed showed that the assumptions of normality, linearity and homoscedasticity were not violated. Figure 7 presents a scatter plot illustrating the distribution of students' word problem test scores and their perception of instructional quality. As observed from Figure 7, there was a relative linear distribution between the variables.

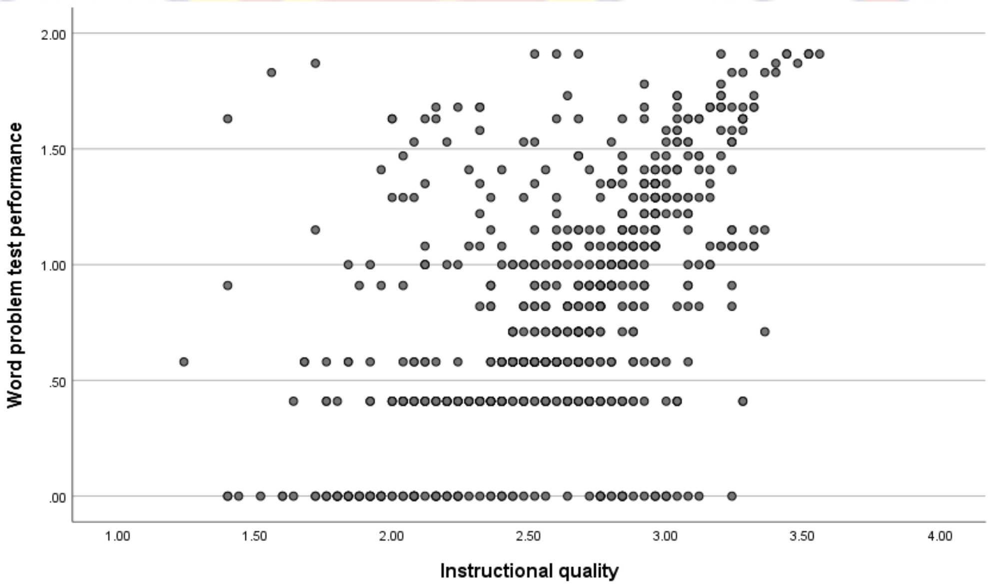


Figure 7: Scatter plot distribution of word problem performance and instructional quality data

The correlation between students' word problem performance and their perception of instructional quality at 0.01 (2-tailed) level of significance was positive and statistically significant ($r = .542, N = 774, P < .001$). This is an indication that increasing the quality of instruction results in higher word problem test performance. Based on Cohen's (1988) criteria, the correlation between instructional quality and students' word problem performance was strong.

The correlation at 0.01 (2-tailed) level of significance showed that the correlation was statistically significant but varied across the categories of schools. In category A schools, $r = .112$, for category B schools, $r = .825$ and in category C schools, $r = .583$. The Fisher's r ($Z_{observed}$) also showed that the comparisons between category A and B schools ($Z_{observed} = -11.959$), between category A and C ($Z_{observed} = -6.209$), and between B and C ($Z_{observed} = 5.696$) were statistically significant.

In category A schools, the correlation was small and weak but was large and strong in categories B and C schools. This shows that to a small extent, the quality of word problem instruction directly reflected students' word problem performance test scores for category A schools. To a large extent, the quality of mathematics word problem instruction directly reflected students' word problem test performance for category B and C schools.

In summary, there was a statistically significant correlation between students' word problem performance and their perception of instructional quality in the six schools. Reverting to the interview responses, the views of students on how the quality of word problem instruction related to their performance in solving word problem tasks were explored.

Explaining the Relationship between Instructional Quality and Performance in Mathematics Word Problems

To answer research question three (RQ3), which sort to explore how students' view about the quality of word problem instruction explain their survey results of the relationship between instructional quality and performance, a total of 38 codes were deduced from the transcripts of 25 respondents. For students' transcripts, 20 (52.6%) codes from 15 (60%) respondents were captured. About 93.3% (N = 14 of 15) of the students held the view that the quality of instruction related to their ability to solve word problems correctly. For instance, DST 2 opined that "we [students] answer the questions according to how the teachers teach us". The opinion of this student was corroborated by the teachers who affirmed the association between instructional quality and students' performance saying "it correlates. The way we teach is the result we yield" CTR 1. These evidence show that the quality of instruction impacts students' learning.

Nonetheless, less than seven percent (that is, 6.7%, N = 1 of 15) of the students held on to the view that the quality of word problem instruction was not related to their performance in word problem tests. For example, CST 2 claimed that "for me, I don't like it. Me dea [sic], I don't like it no matter what or how the teacher will do". The assertion of this student was corroborated by the teachers who for example claimed that "for some students, it does not matter the quality of your instruction or teaching they are just redundant" CTR 2.

The analysis of the transcripts in answering RQ3 have provided evidence in support of the survey result of RQ2. Consequently, an examination of how students rated the quality of instruction in relation to their word problem test scores and interview responses was conducted. Students' rating of the quality of word problem instruction showed a moderate mean rating (M=2.610, SD=.403). With regards to the interview analysis, 20% (4 of 20 codes) of the students' views endorsed the quality of word problem instruction. For example, FST1 indicated that "My teacher also makes word problems questions easier and understandable" thus, recognising teachers' ability to making tasks clearer.

Nonetheless, about 80% (16 of 20 codes) of the students' views pointed to a dissatisfied with the quality of instruction provided by their teachers. As an illustration, CST2 impugned teachers' method of instruction saying, "the instructions given by the teacher often, we the students don't understand what exactly he is asking". Equally, CST4 was not enthused about the absence of cordial teacher-learner relationship saying "certain times when teachers come to the class may be will be annoyed or with a harsh attitude and that most students will just put off their minds from learning that time."

Affirming the students' submissions, it was deduced that teachers discussed only a few examples in class (CST2, DST 4, FST 4) and/or teachers did not consider students' ability and individual differences (DST 4, ATR1, CTR 2). More so, it was realised that teachers did not make lessons practical (DST 2, CTR 3, ATR 2, ATR 3), and/or some teachers entirely skip the teaching of word problems (DTR 1, CTR 3, ATR 1).

Students' performance in the solving word problem tasks showed that 11 students scored the maximum score of 22 and a 102 scored the minimum least mark of 0. The average score (M = 5.25, SD = 5.397; using the transformed data, M = .875, SD = .899) was rather low. The results showed that 86% of the students scored at most 50% on the test. Inferring from the interview results, both students and teachers alluded to students' low ability in solving word problems. DST1 indicated "… it's really challenging to some of us, students". In corroborating, a teacher remarked that "students' ability to answer word problem tasks is that it is very abysmal" DTR 3.

Effect of Instructional Quality Dimensions on Student Performance in Mathematics Word Problems

This research question four (RQ4) explored the unique contribution of instructional quality and the dimensions of instructional quality (that is, content-dependent and content-independent) in predicting students' word problem test scores. To answer this question, a standard multiple regression analysis was performed to establish the predictability of students' word problem test scores from the instructional quality and its dimensions. The means, standard deviations (SD) and coefficients of variation (CV) for word problem test scores, instructional quality and its dimensions are presented in Table 11. Also included in Table 11 are the correlations among students' word problem test scores, instructional quality, content-dependent dimension of instructional quality and the content-independent dimension of instructional quality.

Table 11: Means, standard deviations, coefficients of variation and correlations among dimensions of instructional quality and word problem performance

Variables	Mean	SD	CV%	1	2	3	4
1. Word problem score	0.787	.502	63.8	1			
2. Instructional quality	2.610	.403	15.4	.542*	1		
3. Content-dependent	2.632	.432	16.4	.451*	.746*	1	
4. Content-independent	2.576	.575	22.3	.380*	.737*	.351*	1

** Correlation is significant at p < 0.01 level (2-tailed).*

Source: Field data (Taley, 2022)

From Table 11, students in the schools rated content-dependent structures (M = 2.632, SD = .432) higher than content-independent structures

(M = 2.576, SD = .575). The correlations among all four variables were significant and positive. This means that there existed direct correlations among the four variables. More so, students' score in the word problem test was significant and positively correlated with instructional quality and its dimensions statistically.

After evaluating the correlation analysis, students' word problem test scores were regressed on instructional quality and its dimensions. The regression analysis was carried in two phases. This is because, the correlation between instructional quality and its dimensions exceeded .7 (a subject of multicollinearity as suggested by Iacobucci, Schneider, Popovich and Bakamitsos (2016)). The first regression analysis was between the dimensions of instructional quality and word problem test scores. The second regression analysis was between instructional quality and word problem test scores.

A standard multiple regression analysis was performed for the regression of word problem test scores on the dimensions of instructional quality. Multiple regression assumptions were tested and no significant violations were committed. A visual inspection of the Q-Q plots and box plots (see Appendix U) showed that the data on word problem test scores, students' perception about content-dependent and content-independent dimensions of instructional quality were relatively normally distributed. Ten outliers were present in the word problem test scores. Nonetheless, literature (Field, 2009; Pallant, 2007; Tabachnick & Fidell, 2013) exhort that large sample sizes can avert any distortions in the statistical results.

Multicollinearity among the predictor variables was absent since the Tolerance for content-dependent dimension (Tolerance = .877) and content-independent dimension (Tolerance=.877) was greater than .2 as suggested by Garson (2012). The result of the standard regression model is presented in Table 12.

Table 12: Model summary of multiple regression of word problem test scores on dimensions of instructional quality

Variables	Coefficients			t	*p*	95% CI	Tol.
	B	SE	β				
Intercept	-.89	.10		-8.59	.000	±41	.88
Content-dependent dimension	.42	.04	.36	10.96	.000	±15	.88
Content-independent dimension	.22	.03	.25	7.63	.000	±11	.88
Model fit							
R^2	.260						
Adjusted R^2	.258						
R^2 Change	.002						
Durbin Watson	1.624						
F	132.252						
P	.000*						

Note: SE=standard error; CI=Confidence interval; Tol.=Tolerance
**Significant at* $p < .05$
Source: Field data (Taley, 2022)

The results in Table 12 showed that the regression model for the word problem test was statistically significant ($F(2, 771) = 132.252, p < .001$). The combined effect of content-dependent and content-independent dimensions explained about 26% (R^2 = .260, Adjusted R^2 = .258) of variance in word problem test scores. The result means that the model was moderately medium. The Durbin Watson value produced by the model was approximately 2 (that is, 1.624) which as recommended by Garson (2012) met the independence of errors assumption. From Table 12, both content-dependent and content-independent dimensions positively contributed to predicting word problem test scores. However, the contribution of content-dependent ($\beta = .421, t = 10.959, p < .001$) was larger than content-independent dimensions ($\beta = .220, t = 7.632, p < .001$).

The regression model between word problem test scores (y) and the predictors, that is, content-dependent dimension (x) and content-independent dimension (z) based on standard coefficients are represented in Equation 1.

$$y = -.889 + .421x + .220z \ldots \ldots \ldots \ldots \ldots . . \text{Equation } 1.$$

From Equation 1, a unit increase in the content-dependent dimension of instructional quality (when the content-independent dimension is zero) leads to approximately 42% improvement in students' word problem test scores. Also, a unit increase in the content-independent dimension of instructional quality (when the content-dependent dimension is zero) leads to about 22% improvement in students' word problem test scores.

Besides analysing the relationship between word problem test scores and the dimensions of instructional quality, the predictability of instructional quality on word problem test scores was also assessed. The corresponding model summary and significance of instructional quality in the simple linear regression is presented in Table 13.

Table 13: Model summary and significance of instructional quality

Variables	Coefficients			t	*p*	95%CI
	B	SE	β			
Intercept	-.97	.10		-9.79	.000	±39
Instructional quality	.68	.04	.54	17.91	.000*	±15
Model fit						
R^2	.294					
Adjusted R^2	.293					
R^2 Change	.001					
Durbin Watson	1.581					
F	320.814					
P	.000*					

Note: SE=standard error; CI=Confidence interval
**Significant at* $p<.05$
Source: Field data (Taley, 2022)

From Table 13, the linear regression of instructional quality on word problem test scores showed that the model was positive ($\beta = .542, t = 17.911, p < .001$) and statistically significant $F(1{,}772) = 320.814, p < .001$. The model summary showed that instructional quality accounted for about 29% of the variance in word problem test scores (R^2 = .294, Adjusted R^2 = .293). The result means that the model was moderate. The Durbin Watson value produced by the model was approximately 2 (that is, 1.581) which as recommended by Garson (2012) met the independence of errors assumption.

The regression model of word problem test scores (y) on instructional quality (x) based on standard coefficients was represented in Equation 2.

$$y = -.974 + .675x \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 2.}$$

From Equation 2, a unit increase in instructional quality leads to approximately 68% improvement in students' word problem test scores. From Table 12 and Table 13, the two dimensions of instructional quality predicted about 26% of the word problem test scores in the six schools. However, instructional quality alone predicted about 29% of the word problem test scores in the six schools was explained. A conclusion can be drawn that the quality of instruction in mathematics word problems is a significant determinant of how well students in the six schools perform in the word problem test.

The extent to which instructional quality affected students' word problem test scores were verified with interview responses to RQ8 (that is, how the quality instruction affected their performance in word problems test). A joint display summary connecting the survey results of RQ3 with interview responses of RQ8 was presented in Table 14.

Table 14: Joint display summary for the extent to which instructional quality affected word problem performance scores

	β	R^2%	Cases	Evidence	
InsQ	.542	29	26	Student	"some teachers don't teach well that is why some of my colleagues don't do well" (CST4)
				Teacher	"sometimes they don't get the understanding of the instruction we give. So, they are not able to handle the questions the way we expect from them" (ATR3)
C-dp	.353	26	16	Student	"most of the maths teachers teach without solving more examples with us so we hardly understand the concept of word problems" (CST2)
				Teacher	"if you don't make it real and you teach in abstract, the student might find it difficult dealing with word problems therefore, they may not want it" (ATR2)
C-ind	.253		10	Student	"if they … have the passion to teach us the students, we are also going to do whatever it takes to learn" (CST4)
				Teacher	"If we teach well, we have to attend to all students and they will do well" (DTR3)

InsQ=instructional quality; C-dp=Content-dependent; C-ind=Content-independent

Source: Field data (Taley, 2022)

From Table 14, both teachers and students agreed that the quality of instruction positively affected students' performance in solving word problem tasks. Experienced mathematics teachers such as CTR1 and ATR3 (both with over 12 years of high school mathematics teaching) underscored that

> We [teachers] don't use any practical thing to make the students get the true meaning of what the question demands. Aha, because of that, sometimes they [students] don't get the understanding of the instruction we give. So, they are not able to handle the questions the way we [teachers] expect from them [students] (ATR3, teacher)

A result of which CTR1 remarked that "The way we [teachers] teach is the result we yield".

The students were also of the view that when the quality of instruction is improved, the effect on students' word problem test scores will be higher ($\beta = .542, R^2 = 29\%$). Compared with teachers either attending to content related structures such as solving more examples with students ($\beta = .353, R^2 = 26\%$) or teachers attending to content-independent structures such as provide adaptive support to students ($\beta = .253, R^2 = 26\%$) alone. From this deduction, the conceptual framework relating instructional quality to word problem performance data in the six schools was presented in Figure 8. This framework (Figure 8) supported the conceptual framework underpinning this study.

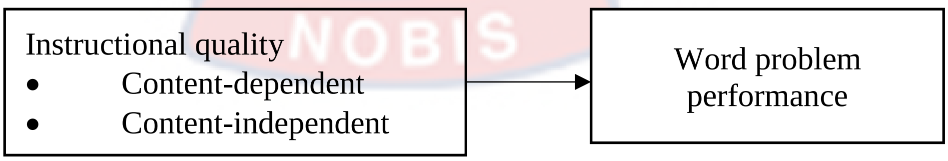


Figure 8: Conceptual structure of instructional quality predicting students' performance in mathematics word problems

Effect of Technology-integrated Teaching, Students' Mathematics Language Competence and Instructional Quality on Learning Outcomes

In this study, the extent to which mathematics word problem test was affected by systematically controlling for instructional quality, technology-integrated teaching and students' mathematics language competence was investigated. To answer the fifth research question (RQ5), standard and hierarchical multiple regression analyses were performed to examine the statistical effect of technology-integrated teaching, students' mathematics language competence and instructional quality on students' word problem test scores.

Multiple regression assumptions were tested and no significant violations were found (diagrams and tables underlying the multiple regressions assumptions are presented in Appendix V). A visual inspection of the Q-Q plots and box plots showed that the data on technology-integrated teaching, students' mathematics language competence, instructional quality and word problem test scores were relatively normally distributed. Outliers were absent in students' mathematics language competence, and instructional quality data, whiles few outliers were present in word problem test scores and technology-integrated teaching.

Additionally, a visual inspection of the scatter plot showed a linear relationship between the word problem test and the predictor variables. The correlation indices showed word problem test score correlated significantly with at least one of the predictor variables. Multicollinearity among the predictor variables was absent: Instructional quality (Tolerance = .957, VIF = 1.045), students' mathematics language competence (Tolerance = .954, VIF = 1.048) and Technology-integrated teaching (Tolerance = .989, VIF = 1.01) met collinearity conditions. The assumption of independence of residuals (Durbin-Watson = 1.541) was also not violated.

The result of the standard regression model was presented in Table 15.

Table 15: Model summary of multiple regression of word problem test scores on instructional quality, technology-integrated instruction and mathematics language competence

Variables	Coefficients			t	*p*	95% CI	Tol.
	B	SE	β				
Intercept	-1.16	.13		-9.02	.000	±.51	
Instructional quality	.62	.04	.496	16.60	.000*	±15	.96
Maths language competence	.38	.05	.218	7.29	.000*	±.21	.95
Tech. integrated instruction	.07	.08	.027	.92	.358	±.30	.99
Model fit							
R^2	.341						
Adjusted R^2	.338						
R^2 Change	.003						
Durbin Watson	1.544						
F	132.767						
p	.000*						

Note: SE=standard error; CI=Confidence interval; Tol.=Tolerance
**Significant at p*$<.05$

Source: Field data (Taley, 2022)

The results in Table 15 show that the regression model for the word problem test was statistically significant ($F(3, 770) = 132.767$, $p < .001$). The combined effect of instructional quality, technology enhance instruction and mathematics language competence explained about 34.1% ($R^2 = .341$, Adjusted $R^2 = .338$) of variance in word problem test scores. The result means that the model was medium. The Durbin Watson value produced by the model was approximately 2 (that is, 1.544) which as recommended by Garson (2012) met the independence of errors assumption. All three predictor variables contributed positively to predicting word problem test performance.

From Table 15, instructional quality was the largest significant contributor $(\beta = .496, t = 16.599, p < .001)$, followed by mathematics language competence $(\beta = .218, t = 7.285, p < .001)$. The contribution of technology-integrated instruction in predicting students' performance in word problem tests was not statistically significant $(\beta = .027, t = .919, p = .358)$.

The regression model between word problem performance (y) and the predictors (instructional quality $[w]$, mathematics language competence (x), and technology-integrated teaching (z)) based on standard coefficients is represented as

$$y = -1.164 + .618w + .384x + .069z \text{ ………………..Equation 3}$$

From Equation 3, a unit increase in instructional quality led to approximately 62% improvement in students' performance in word problem tests. Also, a unit increase in students' mathematics competence led to approximately 38% improvement in students' performance in word problem tests. Again, a unit increase in teachers' integrating technology in teaching word problems led to approximately 7% improvement in students' performance in word problem tests.

The analysis shows that the ability of technology-integrated teaching in predicting students' performance in word problem tests when examined together with instructional quality and mathematics language competence was not statistically significant. Therefore, a hierarchical regression was conducted to examine the capacity of technology-integrated teaching to predict students' word problem performance after controlling for the effect of instructional quality and mathematics language competence. Technology-integrated teaching was entered in block 1 and instructional quality and mathematics language competence in block 2 as presented in Table 16.

In model 1 (Table 16), technology-integrated teaching significantly explained .7% ($\beta = .082, t = 2.283, p = .023$) of variance in students' word problem test scores. However, in model 2 (Table 16), the total variance explained by the entire model was 34.1%, $F(3, 770) = 132.767$, $p < .001$. The two controlled predictor variables explained 33.4% variance in word problem performance, R square change = .334, F change $(2, 770) = 195.232$, $p < .001$. The result means that the model was medium. The Durbin Watson value produced by the model was approximately 2 (that is, 1.544) which as recommended by Garson (2012) met the independence of errors assumption.

Table 16: Model summary of the hierarchical regression of students' word problem test scores on instructional quality, mathematics language and technology-integrated teaching.

Variables	Model 1							Model 2						
	Coefficients			t	*p*	95%CI	Tol.	Coefficients			t	*p*	95%CI	Tol.
	B	SE	β					B	SE	β				
Intercept	.53	.11		4.63	.000	±.45		-1.16	.13		-9.02	.000	±.2.33	
Technology-integrated instruction	.21	.09	.08	2.28	.023	±.36	1.00	.07	.08	.03	.919	.358	±.30	.99
Instructional quality								.62	.04	.50	16.60	.000	±.15	.96
Mathematics language competence								.38	.05	.22	7.29	.000	±21	.95
Model fit														
R^2	.007							.341						
Adjusted R^2	.005							.338						
R^2 Change	.007							.334						
Durbin Watson	1.544							1.544						
F	5.212							132.767						
F Change	5.212							195.232						
p	.023*							.000*						

Note: SE=standard error; CI=Confidence interval; Tol.=Tolerance; **Significant at p*<. 05
Source: Field data (Taley, 2022)

The hierarchical multiple regression (Table 16) indicated that the coefficient of technology-integrated teaching was not statistically significant ($\beta = .027, t = .919, p = .358$). Nonetheless, the other two variables instructional quality ($\beta = .496, t = 16.599, p < .001$) and mathematics language competence ($\beta = .218, t = 7.285, p < .001$) were statistically significant. Notably, instructional quality was found to be a major significant predictor of students' performance in word problems in the final model. Since instructional quality and mathematics language competence were the statistically significant predictors of word problem performance, the regression model was presented in equation 4.

$$y = -1.164 + .618w + .384x \ldots\ldots\ldots\ldots\ldots\text{Equation 4}$$

Both the standard and hierarchical regression models have shown that instructional quality and mathematics language competence were the statistically significant predictors of students' word problem test scores in the six schools. Besides, the quality of teachers' instruction was the major predictor of students' ability in solving word problem tasks. In contrast, the use of technology tools in teaching word problems did not predict students' ability to solve word problems.

Effect of Mathematics Language Competence and Technology-integrated Teaching on Performance in Word Problems

In answering research question six (RQ6) that is how do students' mathematics language competence and use of technology tools in teaching affect students' performance in word problems, the interview responses from both students and teachers were analysed. The responses were deductively coded into two themes – the impact of mathematics language competence and the impact of technology-integrated teaching. A summary of the responses was presented in Table 17. As presented in Table 17, 70 codes from 27 respondents were analysed. Out of this number, 38 (54.3%) responses from 23 (85.2%) respondents were coded under the mathematics language competence theme. Likewise, 32 (45.7%) responses from 26 (96.3%) respondents were coded under the theme of technology-integrated teaching.

Table 17: Summary of respondents' view about the effect of mathematics language competence and technology-integrated teaching

Themes	Files	References	Evidence
Mathematics language competence	23	38	"so students who are masters in the maths language will be able to understand word problems and solve them" (CST3, student) "their ability to understand the language used in framing the word problem, then their ability to translate the English into maths" (ATR3, teacher)
Technology-integrated teaching	26	32	"when we watch videos on YouTube, we grab the understanding easily and we can remember how it was solved fast" (AST3, student) "we have to be able to come down to explain it more detail by the use of these technological tools" (CTR3, teacher)

Source: Field data (Taley, 2022)

All 38 codes analysed showed a direct relationship between mathematics language competency and students comprehension of instruction as well as their ability to solve word problem tasks. For example, the submissions by both students and teachers showed that language is an important factor in enacting quality mathematics word problem instruction. A student, DST4 suggested that "if you don't have a good understanding of the mathematics terms, you can not solve the word problem questions. That is why we cannot solve the past questions very well". Likewise, a teacher, FTR3 hazarded a guess that "For some, the problem has been their language. If they were to understand the terms, I think they wouldn't face challenges when it comes to solving story problems".

Respondents held divergent views about the effect of technology-integrated teaching on instruction and student performance. Twenty-two of 26 respondents (that is, about 84.6%) saw a positive effect of technology-integrated teaching on instruction and student performance. For instance, a student CST2 explained that "when the teachers use the technology tools, they [teachers] will not waste too much time explaining and drawing because we [students] can get that on the computer and the internet". Four (15.4%) respondents remained sceptical about the effect of technology-integrated teaching on instruction and student performance. For example, a teacher intimated that "when we use computers, calculators, it is good. But [sic] what it means is that when it is not there you [student] will be lacking" (ATR1).

The observation from RQ6 provided further explanations to the survey results of RQ5. In RQ5, unlike mathematics language, the statistical effect of technology-integrated teaching on students' word problem test scores was not significant. Similarly, the results of RQ6 suggested that teachers who are facilitators of instruction were uncertain about the positive effect of technology on students' performance. A joint display summary connecting survey results of RQ5 with interview responses of students and teachers in RQ6 was presented in Table 18.

Table 18: Joint display summary connecting word problem test scores to mathematics language and technology-integrated teaching

	M	SD	β	R^2	Evidence
TIT	1.23	.195	.082	.7%	"some of them, too, without computers or anything, any other machines they were able to learn" (AST2) "It might not be that helpful beginning it straight forward in the classroom. With some of our students, they will not try to think.it doesn't promote thinking. (DTR1)
InsQ	2.61	.403	.542	29.4%	"some teachers teach to our expectations that make them feel to like maths" (CST3) "let students know that maths is part of us…teach them based on what they know before what they do what they don't know…bring it to a real-life situation they like it" (ATR2)
MLC	.66	.285	.320	10.2%	"the higher your competence in the maths language will lead to a higher rate to grab the understanding of the lesson on word problems. Because I understand the lesson, I can also solve the word problem questions" (AST4) "To a large extent, I will go for the language because if you don't understand what you are dealing with, what you are doing, what is been written, how can you use technology. So, I think the language" (DTR2)

TIT=technology-integrated teaching, MLC=mathematics language competence, InsQ=instructional quality

Source: Field data (Taley, 2022)

From Table 18, the mean rating and effect of technology-integrated teaching were low. The positive effect of technology tools in the learning and teaching of word problems on students' ability to solve word problems was insignificant. Both students and teachers held the view that word problem instruction and solving word problem tasks could be reached with little or no technology tools. For instance, AST2 remarked that "some of the students … too, without computers or anything, any other machines they were able to learn very well … the thing on the board they catch it up and go by that". Similarly, CST3 also commented that "not all of us are interested in the ICT tools" whiles FST1indicated that "It is the same thing in the computer that he teaches on the board. so, it will not have any change" (FST1).

Likewise, a teacher opined that the use of technology could compromise students' ability to reason saying that

> Technology by itself might not be that helpful beginning it straight forward in the classroom. With some of our students, you thinking that you are using ICT but for example, some of them may come with calculators, and because of the calculators, even 1+1, they will not try to think.it doesn't promote thinking (DTR1)

As a result, teachers hardly integrated technology tools in their mathematics word problem instructions "For computers, pictures and projectors, I will say my teacher doesn't use them" (FST2).

Table 18 further showed that students' mathematics language competence was above average and its effect on students' performance was significant. The interview responses pointed to the fact that both students and teachers think students' ability to provide a meaningful solution to word problem tasks is anchored on their ability to make meaning of the tasks. A student said "the higher your competence in the maths language, will lead to a higher rate to grab the understanding of the lesson on word problems. Because I understand the lesson, I can also solve the word problem questions" (AST4).

Corroborating, an experienced teacher accentuated that "To a large extent, I will go for the language because if you don't understand what you are dealing with, what you are doing, what is been written, how can you use technology. So, I think the language" (DTR2). As a result, teachers deliberately taught the mathematics vocabulary as illustrated in the teacher's submission that

> you must help them in all terminologies when you are teaching word problems so that students will pick it from there. When this happens, and students have mastery over these terms, your teaching improves because you don't talk too much explaining yourself and students are able to solve word problem tasks right" (FTR2).

The joint display summary has explained why technology-integrated teaching did not significantly affect students' word problem test scores. The conceptual structure based on the finding that instructional quality and mathematics language competence were significant predictors of students' performance in word problem tests was presented in Figure 9. This structure (Figure 9) is however inconsistent with the conceptual framework conceived at the beginning of this study. Hitherto, it was conceived that instructional quality was the only predictor of students' performance in word problem tests.

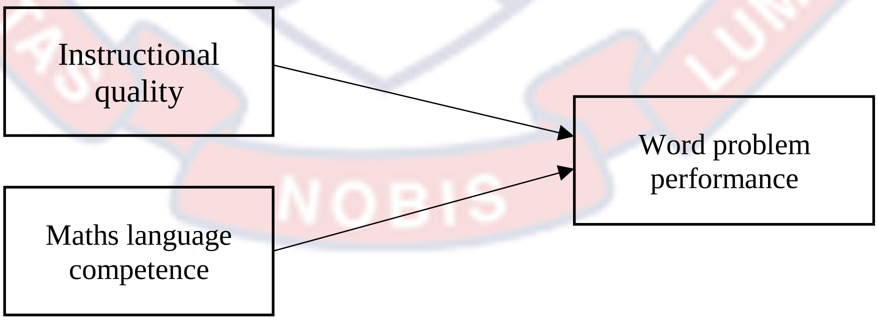


Figure 9: Conceptual diagram for instructional quality and mathematics language competence predicting word problem performance

Moderation Effect of Technology-integrated Teaching and Students' Mathematics Language Competence on Instructional Quality and Students' Performance Relationship

This study also sought to explore the extent to which the interaction of instructional quality with technology-integrated teaching and students' mathematics language competence affected students' performance in word problem tests. To answer this question, a moderation analysis with two interaction factors in line with methods applied by Hayes (2018) and Jose (2013) were performed. These are interaction factor 1, (interaction between instructional quality and students' mathematics language competence) and interaction factor 2, (interaction between instructional quality and technology-integrated teaching). Helm and Mark's (2012) pure moderation type was used to estimate how well the moderating variables changed the regression weight between instructional quality and students' performance in word problem tests.

Sensitivity analysis at $p \leq .25$ as proposed by Rezai, Cote, Cassidy and Carroll (2009), showed that both technology-integrated teaching ($p = .139$) and mathematics language competence ($p < .001$) were significant predictors of instructional quality. Therefore, three models were tested in this study. These are; Model 1 which had both interaction factors 1 and 2. Model 2 was made of interaction factor 1 only. Model 3 was also made of interaction factor 2 only.

For Model 1, the result of the unconditional interaction analysis was presented in Table 19.

Table 19: Test of highest order unconditional interactions – Model 1

	R^2-change	F	df1	df2	*p*
Interaction 1	.000	.00	1.00	768.00	.959
Interaction 2	.003	3.62	1.00	768.00	.058
Both	.003	1.82	2.00	768.00	.163

Source: Field data (Taley, 2022)

Comparatively, the significance of the coefficients of the main and interaction effects was presented in Table 20.

Table 20: Coefficients of main and interaction effects – Model 1

	B	SE	*t*	*p*	LLCI	ULCI
Intercept	-2.20	0.67	-3.30	.001	-3.51	-0.89
Instructional quality	1.03	0.25	4.08	.000	0.53	1.52
Maths language competence	0.35	0.33	1.06	.289	-0.30	1.00
Interaction 1	0.01	0.13	0.05	.959	-0.24	0.26
Tech integrated teaching	1.06	0.54	1.96	.051	-0.01	2.13
Interaction 2	-0.39	0.20	-1.90	.058	-0.78	0.01

Source: Field data (Taley, 2022)

From Table 19 and Table 20, both interactions, that is Interaction 1 ($B = .01$, $t = .051, p = .959$) and Interaction 2 ($B = -.385, t = -1.902, p = .058$) were statistically not significant in Model 1: R-square change =.03%, F change (2, 768) = .1.818, p = .163. This indicated that technology-integrated teaching and mathematics language competence were simultaneous, not significant moderators on the effect of instructional quality on students' word problem tests scores.

Regarding Model 2, the result of the Interaction 1 analysis was presented in Table 21.

Table 21: Model summary and coefficients of main and interaction effects – Model 2

Variables	Coefficients B	SE	t	p	95%CI
Intercept	-.97	.22	-4.34	.000	±.88
Instructional quality	.58	.09	6.54	.000	±.35
Maths Language competence	.42	.33	1.28	.202	±1.29
Interaction 1	-.02	.13	-.15	.884	±.50
Model fit					
R^2	.300				
R^2 Change	.000				
F	.021				
p	.884				

Note: SE=standard error; CI=Confidence interval
Source: Field data (Taley, 2022)

From Table 21, Interaction term 1 ($B = -.019,\ t = -.147, p = .884$) was statistically not significant in Model 2: R-square change =.00%, F change (1, 770) = .021, p = .884. This indicated that mathematics language competence was not a significant moderator on the effect of instructional quality on students' word problem tests scores.

Furthermore, the interaction analysis in Model 3 was presented in Table 22.

Table 22: Model summary and coefficients of main and interaction effects – Model 3

Variables	Coefficients		t	p	95%CI
	B	SE			
Intercept	-2.29	0.67	-3.42	.001	±.2.64
Instructional quality	1.14	0.25	4.53	.000	±.99
Tech. integrated instruction	1.20	0.56	2.16	.031	±2.18
Interaction 2	-0.42	0.21	-2.05	.041*	±.81
Model fit					
R^2	.263				
R^2 Change	.004				
F	4.186				
p	.041*				

Note: SE=standard error; CI=Confidence interval
*Significant at $p < .05$
Source: Field data (Taley, 2022)

From Table 22, the results of the interaction analysis of Model 3 showed that Interaction term 2 $(B = -.423,\ t = -2.046, p = .041)$ was statistically significant in the model 3: R-square = .4%, F change (1, 770) = 4.186, p = .041. This showed that technology-integrated teaching was a significant moderator on the effect of instructional quality on students' performance in word problem tests. Based on Table 22, the moderation model for the effect of instructional quality(x) on word problem performance (y) conditional to the level of technology-integrated teaching (m) is

$$y = -2.293 + 1.137x + 1.199m - .423xm \ldots\ldots\ldots\ldots\ldots \text{Equation 5}$$

From Equation 5, the interaction factor was negative. Based on Equation 5 and Table 26, the underlying statistical diagram is presented in Figure 20.

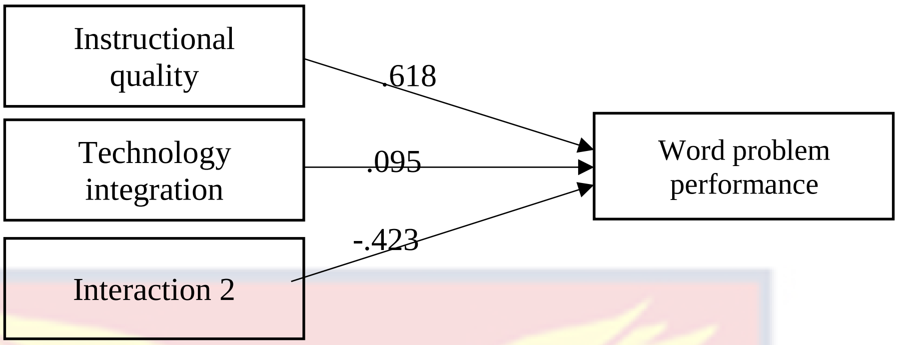


Figure 10: Statistical diagram for moderation variable technology-integrated teaching

The consequence of the significant result in Model 3 led me to examine the behaviour of Interaction 2 at three levels of the moderator variable (technology-integrated teaching). The three levels studied were at a low level of technology-integrated teaching (that is -1 standard deviation, -.196), at the mean level of technology-integrated teaching (that is zero standard deviation), and at a high level of technology-integrated teaching (that is 1 standard deviation, .196). Table 23 presented the conditional effects of the focal predictor (instructional quality) at the values of the moderator.

Table 23: Conditional effects of instructional quality at three levels of technology-integrated teaching

Tech integrated teaching	Effect	SE	*t*	*p*	LLCI	ULCI
-0.196	.701	.052	13.438	.000*	.598	.803
0	.618	.039	15.769	.000*	.541	.694
0.196	.535	.060	8.859	.000*	.416	.653

*SE = standard error; LLCI = lower level confidence interval ULCI = upper level class interval. *Significant at* $p<.05$

Source: Field data (Taley, 2022)

From Table 23, the conditional effects of instructional quality at values of the moderator showed that at a low level of integrating technology into teaching, the relationship between instructional quality and word problem test scores was positive and significant ($B = .701, t. = 13.438, p < .001$). Similarly, at the mean level of integrating technology into teaching, the relationship between instructional quality and word problem test scores was also positive and significant ($B = .618, t. = 15.769, p < .001$). Furthermore, at a high level of integrating technology into teaching, the relationship between instructional quality and word problem test scores was equally positive and significant ($B = .535, t. = 80859, p < .001$). There is no statistical evidence of the effect of instructional quality on word problem test scores at higher levels of technology-integrated teaching.

Nonetheless, the effect of the relationship diminished (B reduces) with increasing levels of integrating technology as shown in Table 23. This analogy was further amplified with Figure 11. From Figure 11, the three levels of technology-integrated teaching lines moved from the lower left to the upper right indicating a positive effect of instructional quality on word problem test scores. However, the higher level integration line decreased with increasing levels of technology-integrated teaching.

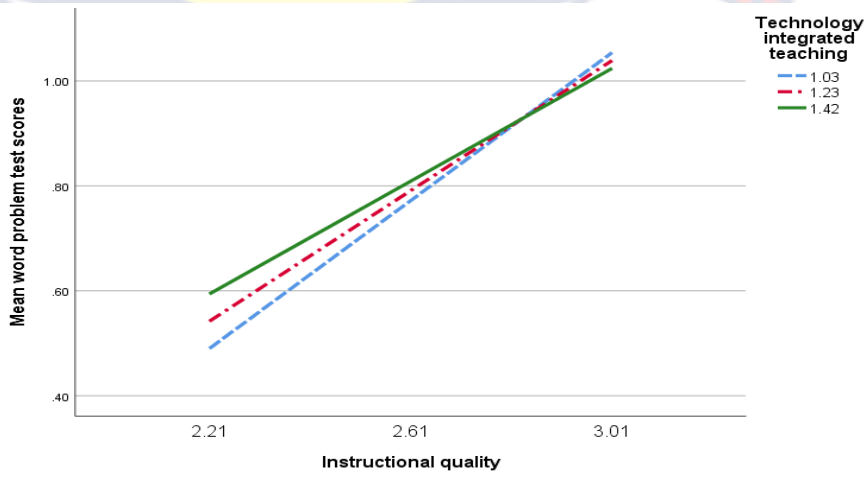


Figure 11: Line plot of the interaction of instructional quality and technology-integrated teaching on performance in word problem tests

An inspection of Figure 11 confirmed that technology-integrated teaching dampens the positive relationship between instructional quality and performance in word problem tests. The Johnson-Neyman output also showed how the slope (effect) between instructional quality and word problem test scores decreased over levels of technology-integrated teaching (Appendix W). From the deductions, the result of RQ7 was that technology-integrated teaching moderated the effect of instructional quality on word problem test scores in the six schools. Consequently, a joint display summary was used to connect the result of RQ7 with interview responses of students and teachers. The joint display summary for the result was presented in Table 24.

Table 24: Joint display summary connecting interaction of technology-instruction and interview responses

B	p	ΔR^2	Evidence
-.423	.041	.4%	"It makes lessons directly to us. But our teacher will be like, I wouldn't encourage you to always move around with technology because some of us will not use it for learning" (CST4, student) "if you watch television, it sticks in our minds than reading. So, if they use pictures and PowerPoint presentations, it will stick in our minds. But that one too is there. Some can use it for other things" (FST3, student) "we are in the modern world and everything is about technology" (DST4, student) "the more we try integrating technology will mean that we are giving way for students to use the phones. … fine sometimes they also turn to use those gadgets not for learning the maths" (CTR1, teacher) "students can do calculations as compared to mental work. … technology would go a long way to help students to solve word problems. Don't forget some of them can also use the same tools for other things. (DTR2, teacher)

Referring to Table 24, technology-integrated teaching moderated the positive effect of instructional quality on word problem performance. From Table 24, the extent of the moderation effect was minimal (.4%) but negative. Thus, a unit increase in the integration of technology in teaching could result in a reduction of the positive effect of instructional quality on word problem performance.

The interview responses suggested that teachers were pessimistic about the potential of the use of technology tools to enhance students' learning and ability to solve word problem tasks. The teachers impugn those students might not use the tools to learn mathematics. For example, a teacher said, "makes me [teacher] believe that technology would go a long way to help students to solve word problems. Don't forget some of them can also use the same tools for other things" (DTR2). The apprehension teachers harboured was exemplified by another teacher who shared an experience saying that students sometimes are attracted by the peripheries and not the mathematics concept being discussed. CTR2 said, "the attention they [students] gave to the telenovelas was extended to the projected lesson but sometimes they talked about how I was able to make it work".

Corroborating the stance of the teachers, some students agreed that students do use the technology tools, not for the learning of mathematics. These views were summed up in the submissions of CST4 and FST3: "It makes lessons directly to us. But our teacher will be like, I wouldn't encourage you to always move around with technology because some of us will not use it for learning" (CST4) "But that one too is there. Some can use it for other things" (FST3). It is not surprising to hear a student opine that "we are in the modern world and everything is about technology" (DST4). To such students, the educative effect was not the priority rather the mere presence of the technology tools.

Although the use of technology tools in word problem instruction could be desirous, the apprehension of teachers that students would not use the technology tools in the learning of mathematics word problems could derail the quality of instruction. Based on the finding that technology-integrated teaching moderated the effect of instructional quality on word problem test scores, the conceptual structure of the moderator was presented in Figure 12. The conceptual structure (Figure 12) partially fitted the conceptual framework that underpinned this study.

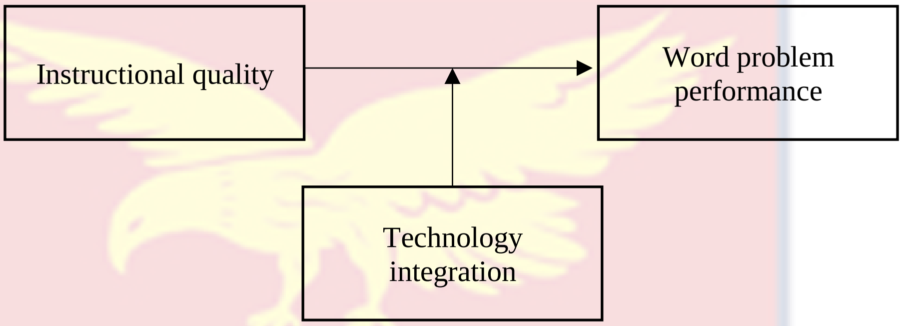


Figure 12: Conceptual structure of the moderation effect of technology-integrated teaching

Effect of School Categorisation on the Quality of Instruction and Students' Performance in Word Problems

This study also sought to verify whether the quality of instruction in a word problem and students' word problem test scores differed among the categories of schools. A one-way multivariate analysis of variance (MANOVA) was used to simultaneously examine the potential differences in the quality of instruction provided by mathematics teachers as well as students' word problem test scores. The students in this study were grouped into three independent groups according to GES categorisation (Cat. A, Cat. B and Cat. C). The sample size for each of the categories was adequately large – Cat A (N = 259), Cat B (N = 260) and Cat C (N = 255) according to Tabachnick and Fidell (2013). A chi-square test of difference in sample sizes was not statistically significant ($\chi^2(2) = .054, Sig = .973$).

A visual inspection of the box plots and Q-Q plots and scatter matrix (Appendix H) showed that the transformed word problem performance scores and instructional quality rating were approximately normally distributed and linear. Two cases of outliers with 14.768 and 14.505 Mahalanobis distance were above the critical value of 13.82. Multicollinearity was absent in category A and C ($r = .112$, Cat A; $r = .583$, Cat C) but violated in Cat B ($r = .825$). Test for homogeneity of variance-covariance matrices was significant ($p < .001$) and test of equality of error variances was also significant ($p < .05$). Pictorial and tabular evidence in support of assumption testing is provided in Appendix X.

The descriptive statistics for word problem performance and instructional quality is found in Table 25.

Table 25: Means, standard deviations and variance of variations in word problem performance and instructional quality by school category

	Word problem performance				Instructional quality			
	Cat A	Cat B	Cat C	Total	Cat A	Cat B	Cat C	Total
Mean	0.909	0.745	0.706	0.787	2.582	2.659	2.588	2.610
SD	0.444	0.527	0.510	0.502	0.348	0.461	0.388	0.403
CV (%)	48.8	70.7	72.3	63.8	13.5	17.4	15.0	15.4
N	259	260	255	774	259	260	255	774

Source: Field data (Taley, 2022)

From Table 25, the mean word problem test scores were similar for category B and C schools but relatively lower than the test scores for category A schools. The relative variability in the test scores was relatively similar for category B and C schools but relatively higher than the variability in category A schools.

With regards to the actual word problem test scores, the mean score was .875 ($SD = .899$). The scores obtained by the students ranged from a minimum of 0 ($N = 102, 13.2\%$) to a maximum of 24 ($N = 11, 1.4\%$). A total of 663 (86%) of the students scored at most half of the total score. Arguably, the scores were widely spread ($CV = 63.8\%$), an indication that the scores were not evenly distributive. The distribution of the scores across the categories of SHS further showed that about 83% ($N = 215$), 89% ($N = 260$) and 85% ($N = 217$) of students in category A, B and C respectively scored at most half of the total word problem score.

The mean ratings and variability for instructional quality were relatively similar across all three categories of schools: Category A ($M = 2.582, SD = .348$), Category B ($M = 2.659, SD = .461$) and category C ($M = 2.588, SD = .388$) (Table 25). Overall, the variability in instructional quality rating ($CV = 15.4\%$) was lower than variability in word problem performance score ($CV = 63.8\%$). The results of the one-way MANOVA was summarised in Table 26.

Table 26: Summary of MANOVA effect on word problem performance and instructional quality

Outcome variable	Multivariate F	Pillai's Trace	df	*p*	Partial Eta squared
Test scores Instructional quality	12.710	.064	4, 1542	.000*	.032

**Significant at* $p < .05$

Source: Field data (Taley, 2022)

Due to the violation in some assumptions, Tabachnick and Fidell (2013) suggest the use of Pillai's Trace to evaluate the MANOVA differences. As shown in Table 26, there was a statistically significant difference in mean scores among the categories of schools on the combined outcome variables of word problem test scores and instructional quality: $F(4, 1542) = 12.710, p < .001$, Pillai's Trace = .064, partial eta squared = .032. This result can be interpreted to mean the category of schools significantly affected students' word problem test scores and quality of instruction in word problems.

A follow-up univariate ANOVA test of between-subject effects of the outcome variables is summarised in Table 27 (see Appendix Y).

Table 27: Summary of the follow-up analysis of variance (ANOVA) results on the categorisation of schools

Outcome Variable	df	F	*p*	Partial Eta Squared	Observed Power[c]
Word problem performance	2	12.27	.000*	.031	.996
Instructional quality	2	2.95	.053	.008	.575

*c. Computed using alpha = .05; *Significant at adjusted p* $<.025$
Source: Field data (Taley, 2022)

The univariate ANOVA test results were evaluated at a Bonferroni adjustment alpha level of .025 because of the violations in MANOVA assumptions. Table 27 shows that differences in the mean scores of students' word problem test scores were statistically significant $F(2, 771) = 12.270, p < .001$. Thus, the category of a school had a main effect on students' word problem test scores. This effect accounted for 3% of the variances in word problem performance (partial eta squared = .031). In line with Cohen's (1988) guidelines, the effect size was moderate.

A Tukey HSD post hoc test of multiple comparisons with recourse to Table 25 further showed that the mean word problem test scores for category A schools ($M = .909, SD = .444$) were significantly different from category B schools ($M = .745, SD = .527$) and category C schools ($M = .706, SD = .510$). The mean word problem performance scores differences between category B schools ($M = .745, SD = .527$) and category C schools ($M = .706, SD = .510$) did not reach significance.

With respect to students' instructional quality rating, the differences in the mean rating of students' perception of instructional quality did not reach statistical significance $F(2, 771) = 2.950, p = .053$ (Table 27). Though, the data showed that the quality of instruction across the three categories was not the same, statistically, the categorisation of schools did not influence the quality of instruction in mathematics word problems.

Consequently, the null hypothesis was rejected. Thus, instructional quality was not statistically different among the categories of the six schools but students' word problem test scores in the six schools differed according to the categories of the schools. The joint display summary connecting hypothesis results and interview responses of students was presented in Table 28.

Table 28: Joint display summary for hypothesis result

School category	M	SD	Student evidence
	Instructional quality		
A	2.582	.348	“whether a teacher teaches a topic or not, due to the competition we students will try to learn them by ourselves” (AST1)
B	2.659	.461	“we have quality teachers here too, I don’t think if I was in a big school I will perform differently” (DST4)
C	2.588	.388	“I do vacation classes at OWASS and teachers teach like our teachers in this school. but there, I think they do more classes” (FST2)
	Word problem test scores		
A	.909	.444	“I would say it’s not about the school … the attitude of these students towards learning. …due to many us being good, there is usually intense competition” (AST1)
B	.745	.527	“categorisation of schools influences our performance … I have to put in the effort to make the name of my school big” (CST4)
C	.706	.616)	“it is not because I’m in this in Category C school that is why I’m not doing well. They say, we don’t learn that is why we are in category C” (FST3)

Source: Field data (Taley, 2022)

From Table 28, students’ views about the quality of instruction were similar across all three categories. The students neither experienced nor perceived any differences in the quality of instruction they received because of the category of school. The comparison made by students such as FST2 who attends a category C school that “I do vacation classes in a famous category A school (name of school not disclosed) and teachers teach like our teachers in this school. But [sic] there, I think they do more classes" confirmed the similarities in word problem instruction. These observations resonated with the students' instructional quality rating. Hence, from the six schools, the categorisation of schools did not influence the quality of instruction.

With regards to students' scores in the word problem test, the result in Table 28 showed a noticeable difference in the mean scores of students from category A and category C schools. The interview responses were varied. Some students from category A and category C schools suggested that categorising schools did not impact their performance (AST1, FST3). Nonetheless, some students in category B and category A schools acceded to the impact of categorising schools on students' performance (CST4, AST1). Overall, the classification of schools influenced students' test scores to the extent that students in well-endowed schools out-performed students in low-endowed schools.

Deducing from experiences of experienced teachers such as ATR1 (who has taught mathematics in different school categories within the past six years), it was found that categorisation played a role in students' performance and teaching. To ATR1, students in well-endowed schools; are generally good academically, can learn independent of the teacher, can use resources to their advantage. As such, teachers do not have to do so much to facilitate instruction. ATR1 added that in the under-resourced school, sometimes the teacher will explore all teaching styles and yet yield little or no result at all.

Discussion

The findings of investigation into the content relatedness of instructional quality have shown that in the six schools, both content-dependent and content-independent dimensions were strongly related to instructional quality in mathematics word problems ($r > .7$). This finding is consistent with that of Praetorius et al. (2014) who posited that instructional quality can be studied along content relatedness. The application of Praetorius et al's. (2014) content-related framework in this study confirmed major components of instructional quality that were specifically related to mathematics content and general instruction.

Nonetheless, it was evident in this study that the incidence of content-dependent instructional structures were more than content-independent activities. This indicated that mathematics teachers concentrated on content related instructional activities more than attending to the individual needs of students' learning. As observed by Charalambous and Praetorius (2018), mathematics teachers generally turn to prioritise content-dependent activities over content-independent activities as if the former is more important than the latter. The explanation for this finding could be that content-independent activities are the catalyst for cognitive activation but, the combination of both content-dependent and content-independent structures constitute high-quality instruction (Kunter et al., 2013)

This study was further set out to investigate the correlation between instructional quality and students' word problem solving ability. The finding has showed that instructional quality was positively and strongly correlated with students' word problem test scores. A correlation of .542 between students' perceived quality of instruction rating and their performance in word problem test per Cohen's (1988) formula suggested a strong correlation. Therefore, a highly rated instructional quality was indicative of higher word problem test scores among students in the six schools and vice-versa. This finding is consistent with previous studies (Bellens et al., 2019b; Lipowsky et al., 2009; Praetorius et al., 2018; Wagner, Göllner, Werth, Voss, Schmitz & Trautwein, 2016) which have concluded that higher instructional quality relates to higher achievement in secondary education.

Nevertheless, the degree of correlation was stronger in category B and C schools but weak among students in category A schools. Thus, the performance of students in less-endowed schools was more correlated with the quality of instruction provided by their mathematics teachers. In contrast, the performance of students in more endowed schools was not so much correlated to the quality of instruction provided by their mathematics teachers. This result reflects those of Chen and Zhang (2014) who noticed that students in underdeveloped regions acknowledged teachers as guides for effective learning compared with students in developed regions of China. Possible explanation for why students' performance did not correlate strongly with instructional quality in well-endowed schools could be that students in more endowed (category A) schools are academically self-dependent as alluded to in the qualitative results. Besides, the students had more learning opportunities: remedial teaching, access to more teachers, library facilities, and internet facilities for private learning.

More so, the study has shown that students depended so much on the classroom instruction of the mathematics teacher. This could be because students have so much trust in the ability of their teachers to provide quality instruction in mathematics word problems. Since the role of the teacher is to create a learning opportunity for students' cognitive engagement (Kunter & Voss, 2013), it is therefore not out of place to learn from this study that students in the six schools depended on the classroom instruction of their mathematics teachers. Therefore, if teachers' classroom instruction does not enhance students' learning and understanding in solving word problem tasks, they risk in providing faulty solutions.

The study has further shown that the quality of word problem instruction in the six schools was moderately rated (M=2.610, SD=.403). Buttressing the survey results, the interview analysis showed that over 78% of the students in the six schools were not satisfied with the quality of instruction provided by their teachers. The students did not find their teachers' method of instruction suitable (CST 2, FST 4). The students also undermined the quality of instruction based on the absence of a cordial teacher-learner relationship (CST 4, FST 4). Besides, other students were also worried about the rush for which teachers taught word problems (AST 1, FST2, FST 3). Students' rating of the quality of instruction in this study is comparable to the results of Ren and Yang (2017). Ren and Yang (2017) observed that students had a low sense of satisfaction of the quality of teaching they received.

Based on the students' ratings and their views regarding the quality of mathematics word problem instruction in the six schools, the performance of the students in the word problem test scores could not have been better since Bellens et al's. (2019) have opined that a higher instructional quality score indicated better teaching and a high possibility for students to learn. Also, 86% of the students in the six schools obtained low scores (at most 50% of the total score) in the word problem test. The low scores could be because the quality of word problem instruction needed to adequately activate students' cognition was deficient (Pearce et al., 2013). Therefore, Junker et al's. (2005) submission that students' low achievement is attributable to teachers' inability to modify their classroom instruction was corroborated in this study.

As found in the chief examiners report, the performance of the students in the six schools in this study was low (WAEC, 2012; 2013; 2014; 2016; 2017; 2018). The low performance of the students in the word problem test further confirms previous studies (Adu et al., 2015; Bullock, 2015; Chapman, 2002; Sepeng & Madzorera, 2014) which reported that that high school students have difficulty solving mathematics word problems. Interestingly, the mathematics teachers in this study also indicated that students have difficulty in solving word problem tasks (DST1, DTR3).

Despite students' low ability in solving word problem tasks, this study has showed that students in category A schools outperformed their peers in category C schools. That is, students in well-endowed schools outclassed their peers in less-endowed schools. By deduction, the level at which schools are endowed with resources determine the ability of students in solving word problem tasks. This result is consistent with previous studies (Bernal et al., 2016; Davis, 2010; Jenkins & Love, 2021; Olatunde & Otieno, 2010; Yusif et al., 2011). For example, Jenkins and Love's (2021) found that there exist a positive relationship between school resource index and achievement. Additionally, Davis (2010) also noticed that learners in urban schools outperformed their peers in rural schools in word problem tests because the urban schools were better resourced with learning opportunities and support.

An unanticipated finding in this study was that unlike the word problem test scores, instructional quality was not statistically different among the categories of the six schools. Whereas Konte (2021) and Du and Hu (2008) have indicated that the quality of instruction was a function of the resources available for the enactment of instructional quality, this study has showed otherwise. By implication, students in the three categories received similar quality of instruction irrespective of the resources each school category had. The similarity in the quality of instruction could be attributed to teacher certification and teacher experience as deduced from earlier findings in this study (DST4) and in literature (Blömeke et al., 2016; Jenkins & Love, 2021). The participating teachers were all professionally trained degree holders in mathematics education who have being teaching mathematics for at least three years.

By comparing the quality of instruction and students' performance, the expectation that the difference in test scores should have emanated from differences in the quality of instruction was not observed. Therefore, drawing from Verschaffel et al. (2020) and Dixon et al. (2014), if the quality of instruction was similar as adduced from this finding, ceteris paribus, the performance of the students in the word problem test should have been similar among the students. This is because, this study has showed a positive correlation between the quality of instruction and students' performance in the test on word problems.

With respect to the question of the effect of instructional quality on test scores, this study has also shown that in the six schools, instructional quality affected word problem test scores more than either of the dimensions of instructional quality alone. Since both dimensions of instructional quality significantly predicted word problem test scores, Fauth et al's. (2014) conviction that word problem instruction engendered learner support and cognitive activation was confirmed. Nonetheless, the basis that the content-dependent dimension was the major contributor implied it had a major effect on students' performance.

Lipowsky et al. (2009) have shown that higher learning and understanding occur in classes where the content-dependent dimension is high. More so, Dixon et al. (2014) have also suggested that students develop a deep conceptual understanding of word problems when their teachers provide them with rich, and meaningful learning. Besides, earlier findings in this study have shown that word problem instruction was flooded with content-dependent instructional activities. Surprisingly, students' word problem test scores were low. Therefore, the depth of mathematics activities teachers provided during word problem instruction comes into question.

The results in this study further shows that instructional quality was statistically significant and positively predicted the performance of students in mathematics word problem tests. This result is in line with results of previous studies (Baumert et al., 2010; Bellens et al., 2019; Davis, 2007; Dixon et al., 2014; Kunter & Voss, 2013; Kuterbach, 2012; Munasinghe, 2013; Neubrand et al., 2013; Verschaffel et al., 2020) that instructional quality is a key determinant of students' learning outcomes in mathematics.

However, with about 29% of the variance in word problem test scores attributable to instructional quality, other factors could affect students' ability to solve word problem tasks. Such factors may include students' mastery of mathematics language and teacher's use of technology tools such as calculators and computers. Literature (Clements & Sarama, 2002; Eyyam & Yaratan, 2014; Fede, 2010; Harskamp & Suhre, 2007; Olsen & Chernobilsky, 2016) has shown that integrating technology in teaching enhances students' ability in solving mathematical tasks and improves students' performance. Similarly, other researchers (Agbenyega & Davis, 2015; Davis, 2010; Nortvedt et al., 2016; Sepeng & Madzorera, 2014; van der Walt, 2009) have established that students' mathematics performance is a function of their general knowledge of mathematical vocabulary.

The result in this study has further showed that besides instructional quality, the mathematics language competence of students was a significant predictor of word problem test scores. Instructional quality and students' mathematics language competence together explained about 33% of the variance in students' word problem test scores. Thus, the word problem test score of students was likely to improve if students' mastery in the mathematics language complemented the quality of instruction. In particular, Adelson et al. (2015), Sepeng and Madzorera (2014) and Riccomini et al. (2008) agree that mathematics language competence determines students word problem performance.

Generally, the mathematics language competence of students in the six schools was above average ($M = .656$, $SD = .285$). The relatively good performance of students in the word problem test matches with Latu's (2005) results about Pasifika high school student's performance on instructional language tests. In contrast, Adu et al. (2015) observed that students in a Ghanaian senior high school were unable to comprehend and interpret mathematics terms. Similar to Latu's (2005) observations, this study has showed that students' mathematics language competence was above average yet, their performance in the word problem test was generally weak. Therefore, a grip on the mathematics language did not necessarily translate into an ability to solve mathematics word problems correctly.

The present study was further designed to explore the interaction effect of technology-integrated teaching and mathematics language on word problem test scores. The results showed that the integration of technology in teaching posed a minimal but negative moderation effect on the positive effect of instructional quality on students' performance in word problem tests ($B = -.423,\ t = -2.046, p = .041$). That is, technology-integrated teaching dampened the positive relationship between instructional quality and performance in word problem tests. A unit increase in the integration of technology in teaching resulted in a reduction of the positive effect of instructional quality on word problem performance by almost .4%. This conclusion however contradicts the assertion in the literature that technology-integrated teaching improves students' performance (Eyyam & Yaratan, 2014; Fede, 2010; Harskamp & Suhre, 2007; Olsen & Chernobilsky, 2016) and instructional quality (Bijlsma et al., 2019).This result might imply that technology tools for teaching and learning mathematics were inappropriately used. As deduced from Eyyam and Yaratan (2014), wrong integration of technology or inappropriate use of technology in mathematics instruction may impact negatively on student achievement.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary, conclusions and recommendations of the study. The main findings of the study are also stated and suggestions for further studies based on the findings in this study are provided.

Summary

This study explored how the quality of instruction affect the performance of senior high school students in solving mathematics word problem tasks. Seven research questions and one hypothesis were formulated to guide this study. These are:

1. What instructional activities define the quality of instruction in the teaching of mathematics word problems?
2. How are students' performance in word problem tasks and their perception about instructional quality corelated?
3. In what ways do students' view about the quality of word problem instruction explain their survey results of the relationship between instructional quality and performance in word problems?
4. To what extent do instructional quality and its content-dependent and content-independent dimensions affect students' learning outcomes in mathematics word problems?
5. How well do technology-integrated teaching, students' mathematics language competence and instructional quality significantly add to predict learning outcomes?

6. How do students' mathematics language competence and use of technology tools in teaching affect students' performance in word problems?
7. How well do technology-integrated teaching and students' mathematics language competence interacting with instructional quality significantly moderate the prediction of students' performance in word problem tests?

H_0: There is no significant difference in the quality of instruction and students' word problems tests scores regarding the category of senior high school.

The sequential explanatory mixed methods research design was followed in executing this study. To answer the research questions and hypothesis, questionnaires, tests and interviews were administered. Multi-stage sampling was used to sample 774 second-year SHS students and 12 of their mathematics teachers from six senior high schools in the Ashanti region of Ghana. The quantitative data gathered were analysed using descriptive statistics (Mean, Standard Deviations, and coefficients of variation), and inferential statistics (correlation, regression and MANOVA) while the qualitative data were analysed using thematic analysis.

Key Findings

1. The study confirmed that structures in word problem instruction offered by mathematics teachers have the propensity to activate students' cognition and provide support for students through content-dependent and content-independent instructional activities respectively.

2. The quality of mathematics word problem instruction directly correlated with students' word problem test performance ($r = .542, P < .001$) to a large extent.
3. The quality of instruction of mathematics teachers generally affected students' ability to solve word problems correctly.
4. Instructional quality in mathematics word problems and its dimensions have an association with students' performance in word problem solving.
5. The combined effect of instructional quality, technology-integrated instruction and mathematics language competence explained about 34.1% of the variance in word problem test scores.
6. Students' mathematics language competence directly affected their performance in solving word problem tasks.
7. The simultaneous interaction of technology-integrated teaching and mathematics language competence on the positive association between instructional quality and students' word problem tests scores was not statistically significant, however, technology-integrated teaching was a negative and a significant moderator on the effect of instructional quality on students' performance in word problem tests.
8. The categorisation of schools had a main effect on students' word problem test scores.

Conclusions

The conclusions drawn from the findings of the study are:

1. Content-dependent instructional structures dominated instructional activities in mathematics word problem instruction. This finding is consistent with that of Charalambous and Praetorius (2018).
2. SHS students have low mathematics word problem solving ability and this confirms the WAEC Chief Examiner's reports on Core Mathematics (WAEC, 2012; 2013; 2014; 2016; 2017; 2018; 2019; 2020).
3. Instructional quality is a key determinant of students' performance in mathematics word problems. However, instructional quality may not always associate with students' mathematics achievement as observed in the multinational study of Blömeke et al. (2016).
4. Content-dependent structures predicted students' word problem test performance than content-independent structures. The dominance of content-dependent structures of instructional quality did not reflect in students' ability to solve word problem tasks.
5. The variances in students' word problem test scores are explained by both teachers' instructional quality and the students' mathematics language competence.
6. Mathematics teachers hardly integrate technology tools in the teaching of word problems.
7. The integration of technology tools did not positively affect students' ability to solve mathematics word problems.
8. Students' performance in the word problem test differed statistically among the various categories of schools (Category A, B and C).

However, instructional quality did not differ statistically among the categories of schools.

Recommendations

From the findings of the study, the following recommendations are suggested:

1. While content-dependent instructional activities are essential for building conceptual understanding and for the activation of students' cognition, it is important to maintain a balanced instructional approach. This because, content-dependent structures of instructional quality alone do not positively predict students word problem test scores. Teachers should consider integrating content-independent instructional activities, such as appreciating students, providing adaptive support, and praise, to enrich students' learning experiences and foster a comprehensive understanding of mathematical word problems. Besides, teachers should take up professional development opportunities that focus on equipping teachers with a repertoire of instructional strategies, encompassing both content-dependent and content-independent approaches. Consequently, teachers should be trained to seamlessly integrate various instructional activities based on the specific needs of their students and the nature of the mathematical word problems.
2. Schools should invest in continuous professional development for mathematics teachers. This can include workshops, training sessions, and collaborative opportunities to enhance their pedagogical skills, especially in the realm of mathematics word problem instruction. Additionally, teachers should be encouraged to implement evidence-

based teaching strategies that have proven effective in enhancing instructional quality. Moreso, schools can also establish mechanisms for feedback and evaluation of instructional practices. Encouraging a feedback loop where teachers receive constructive feedback on their teaching methods, allowing for reflective practice and refinement of instructional approaches can go a long way to improve on their quality of instruction.

3. Mathematics teachers should endeavour to develop the mathematics language competence of their students when enacting instruction in mathematics rather than teaching mathematics terms in isolation. Teachers can also strengthen students' mathematics language skills by incorporating mathematics-specific vocabulary exercises and improving communication about mathematical concepts. While at it, teacher training institutions should make efforts to enhance teachers' pedagogical skills in nurturing students' proficiency in the language of mathematics.
4. Mathematics teachers should endeavour to explore effective strategies to integrate appropriate technology tools such as visual aids, manipulatives, and models in teaching word problems. By so doing, it can help students visualize and comprehend complex problems.
5. To promote the relevance of mathematics word problems, mathematics teachers should make their instructions practical and relate the problems to real-life situations.

Suggestions for Further Research

1. Further work should be undertaken to investigate the effect of instructional quality using observation in addition to the questionnaires and interviews to ascertain the merits of the findings of this study. This is because this study did not include observation in the collecting data.
2. Students perceived instructional quality questionnaire was adapted from several researchers. Further study is required to validate the adapted questionnaire on similar populations.
3. The best model in predicting students' ability to solve mathematics word problem tasks in this study accounted for only 34.1%. Despite this promising result, further studies will be needed to find other factors that could account for students' ability to solve mathematics word problem tasks.

REFERENCES

Adam, S. (2004). Using learning outcomes. *Report for United Kingdom Bologna Seminar*, 1–2.

Adelson, J., Dickinson, E., & Cunningham, B. (2015). Differences in the reading–mathematics relationship: A multi-grade, multi-year statewide examination. *Learning and Individual Differences*, *43*(0), 118–123. https://doi.org/10.1016/j.lindif.2015.08.006

Adu, E., Assuah, C. K., & Asiedu-Addo, S. K. (2015). Students' errors in solving linear equation word problems: Case study of a Ghanaian senior high school. *African Journal of Educational Studies in Mathematics and Sciences*, *11*, 17–30.

Afshari, M., Bakar, K. A., Fooi, W. S. L., Samah, B. A., & Say, F. (2009). Factors affecting teachers' use of information and communication technology. *International Journal of Instruction*, *2*(1), 77–104.

Agbenyega, J. S., & Davis, E. K. (2015). Exploring the Intersection of the English Language as the Medium of Instruction and Inclusive Pedagogy in Primary Mathematics Classrooms in Ghana Examining the impact of teacher knowledge and inquiry on inclusive practices in different cultural contexts V. *International Journal of Whole Schooling*, *11*(2), 45–64.

Ahmed, A. I. M., & Moalwi, A. A. (2017). Correlation between difficulty and discrimination indices of MCQs type A in formative exam in anatomy. The Impact of COVID-19 on teaching anatomy; faculty and student perspective View project. *IOSR Journal of Research & Method in Education*, *7*(5), 28–43. https://doi.org/10.9790/7388-0705042843

Al-Agili, M. Z. B., Mamat, M. B., Abdullah, L., & Maad, H. A. (2013). Path analysis of the factors influencing students' achievement in mathematics. *Australian Journal of Basic and Applied Sciences*, *7*(4), 437–442.

Andam, E., Okpoti, C., Obeng–Denteh, W., & Atteh, E. (2015). The Constructivist Approach of Solving Word Problems Involving Algebraic Linear Equations: The Case Study of Mansoman Senior High School, Amansie West District of Ghana. *Advances in Research*, *5*(1), 1–12. https://doi.org/10.9734/air/2015/13932

Ary, D., Jacobs, L. ., Sorensen, C., & Razavieh, A. (2009). *Introduction to research in education* (8th edn). Wadsworth Publishing.

Asiamah, N., Mends-Brew, E., & Boison, B. K. T. (2019). A spotlight on cross-sectional research: Addressing the issues of confounding and adjustment. *International Journal of Healthcare Management*, 1–14. https://doi.org/10.1080/20479700.2019.1621022

Asiedu, P. (2013). *Core mathematics for senior high schools in West Afruca*. Aki-ola publications.

Atlay, C., Tieben, N., Hillmert, S., & Fauth, B. (2019). Instructional quality and achievement inequality: How effective is teaching in closing the social achievement gap? *Learning and Instruction*, *63*, 101211. https://doi.org/10.1016/j.learninstruc.2019.05.008

Awofala, A. O. A. (2011). Effect of Personalized, Computer-Based Instruction on Students' Achievement in Solving Two-Step Word Problems. *International Journal of Mathematics Trends and Technology*, *2*(2), 5–10. https://doi.org/10.16949/turkbilmat.267339

Ayieko, R. A., Gokbel, E. N., & Nelson, B. (2017). Does computer use matter? The influence of computer usage on eighth-grade students' mathematics reasoning. *FIRE: Forum for International Research in Education*, *4*(1), 66–87.

Baek, Y., Jung, J., & Kim, B. (2008). What makes teachers use technology in the classroom? Exploring the factors affecting facilitation of technology with a Korean sample. . . *Computers & Education*, *50*(1), 224–234.

Baier, F., Decker, A., Voss, T., Kleickmann, T., Klusmann, U., & Kunter, M. (2019). What makes a good teacher? The relative importance of mathematics teachers' cognitive ability, personality, knowledge, beliefs, and motivation for instructional quality. *British Journal of Educational Psychology*, *89*(4), 767–786. https://doi.org/10.1111/bjep.12256

Bao, R. (2017). *A sociocultural approach to understanding classroom interaction in teaching and learning a sociocultural approach to understanding classroom interaction in teaching and learning Chinese as a foreign language: Implications for Chinese language education* [Aalborg Universitetsforlag]. https://doi.org/10.5278/vbn.phd.hum.00014

Baumbusch, J. (2010). Semi-structured interviewing in practice-close research. *Search.Proquest.Com*, *15*(3), 255–258. https://doi.org/10.1111/j.1744-6155.2010.00243.x

Baumert, J., & Kunter, M. (2013). The COACTIV model of teachers' professional competence. In *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers: Results from the COACTIV Project* (pp. 25–48). Springer US. https://doi.org/10.1007/978-1-4614-5149-5_2

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y.-M. (2010). Teachers' Mathematical Knowledge, Cognitive Activation in the Classroom, and Student Progress. *Journals.Sagepub.Com*, *47*(1), 133–180. https://doi.org/10.3102/0002831209345157

Baumert, J., Kunter, M., Blum, W., Klusmann, U., Krauss, S., & Neubrand, M. (2013). Professional competence of teachers, cognitively activating instruction, and the development of students' mathematical literacy (COACTIV): A research program. In *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers: Results from the COACTIV Project* (pp. 1–21). Springer US. https://doi.org/10.1007/978-1-4614-5149-5_1

Bell, C. A., Dobbelaer, M. J., Klette, K., & Visscher, A. (2019). Qualities of classroom observation systems. *School Effectiveness and School Improvement*, *30*(1), 3–29. https://doi.org/10.1080/09243453.2018.1539014

Bellens, K., Van Damme, J., Van Den Noortgate, W., Wendt, H., & Nilsen, T. (2019a). Instructional quality: catalyst or pitfall in educational systems' aim for high achievement and equity? An answer based on multilevel SEM analyses of TIMSS 2015 data in Flanders (Belgium), Germany, and Norway. *Large-Scale Assessments in Education*, *7*(1), 1–27. https://doi.org/10.1186/s40536-019-0069-2

Bellens, K., Van Damme, J., Van Den Noortgate, W., Wendt, H., & Nilsen, T. (2019b). Instructional quality: Catalyst or pitfall in educational systems' aim for high achievement and equity? An answer based on multilevel SEM analyses of TIMSS 2015 data in Flanders (Belgium), Germany, and Norway. *Large-Scale Assessments in Education*, *7*(1), 1–12. https://doi.org/10.1186/s40536-019-0069-2

Bennett, R. E. (2015). The Changing Nature of Educational Assessment. *Review of Research in Education*, *39*(1), 370–407. https://doi.org/10.3102/0091732X14554179

Bernal, P., Mittag, N., & Qureshi, J. A. (2016). Estimating effects of school quality using multiple proxies. *Labour Economics*, *39*, 1–10.

Bernardo, B. (1999). Overcoming obstacles to understanding and solving word problems in mathematics. *Educational Psychology*, *19*(2), 149–163. https://doi.org/10.1080/0144341990190203

Berry, R. Q., & Ritz, J. M. (2004). Technology education-A resource for teaching mathematics. *Technology Teacher*, *63*(8), 20-24.

Bettini, E., Park, Y., Benedict, A., Kimerling, J., & Leite, W. (2016). Exceptionality a special education journal situating special educators' instructional quality and their students' outcomes within the conditions shaping their work. *Exceptionality*, *24*(3), 176–193. https://doi.org/10.1080/09362835.2015.1107831

Biggs, J. (1993). From Theory to practice: A cognitive systems approach. *Higher Education Research & Development*, *12:1, 73-85*, *12*(1), 73–85. https://doi.org/http://dx.doi.org/10.1080/0729436930120107

Bijlsma, H. J. E., Visscher, A. J., Dobbelaer, M. J., & Veldkamp, B. P. (2019). Does smartphone-assisted student feedback affect teachers' teaching quality? *Technology, Pedagogy and Education*, *28*(2), 217–236. https://doi.org/10.1080/1475939X.2019.1572534

Blömeke, S., Olsen, R. V., & Suhl, U. (2016). Relation of student achievement to the quality of their teachers and instructional quality. *Teacher Quality, Instructional Quality and Student Outcomes*, *2*, 21–50.

Bloom, B. B. . (1956). *Human characteristics and school learning*. McGraw-Hill.

Blumenthal, D., & McGinnis, J. (2015). Measuring Vital Signs: an IOM report on core metrics for health and health care progress. *Jama*, *313*(19), 1901–1902. https://doi.org/10.1001/jama.2015.4862

Bowen, P., Rose, R., & Pilkington, A. (2017). Mixed methods-theory and practice. Sequential, explanatory approach. *International Journal of Quantitative and Qualitative Research Methods*, *5*(2), 10–27.

Braun, V., & Clarke, V. (2012). Thematic analysis. In *APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological.* (pp. 57–71). American Psychological Association. https://doi.org/10.1037/13620-004

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Breen, R. L. (2006). A practical guide to focus-group research. *Journal of Geography in Higher Education*, *30*(3), 463–475. https://doi.org/ 10.1080/03098260600927575

Brown, F. G. (1983). *Principles of educational and psychological testing* (3rd ed.). Holt, Rinehart and Winston.

Brown, T. A. (2006). *Confirmatory Factor Analysis for Applied Research*. Guilford Press.

Bruner, J., & Bruner., J. S. (1966). Toward a Theory of Instruction. In *The bulletin of the National Association of Secondary School Principals* (59th ed., Vol. 59). Belknap Press. https://doi.org/10.1177/019263656605030929

Bullock, G. P. (2015). *Algebra in words presents: word problems decoded* (1st ed.). SAGE Publications Inc.

Bulut, O., & Cutumisu, M. (2018). When technology does not add up: ICT use negatively predicts mathematics and science achievement for Finnish and Turkish students in PISA 2012. *Journal of Educational Multimedia and Hypermedia*, *27*(1), 25–42.

Burton, L., Falk, L., & Jarner, S. (2004). Too much, too seldom. *International Journal of Mathematical Education in Science and Technology*, *35*(2), 219–226.

Caruth, G. D. (2013). Demystifying mixed methods research design: A review of the literature. *Melvana International Journal of Education*, *3*(2), 112–122. https://doi.org/10.13054/mije.13.35.3.2

Chan, C. E. M. (2005). Language Proficiency and Rewording of Semantic Structures in P5 Pupils ' Mathematical Word Problem solving '. *Mathematics Educator*, *9*(1), 84–99. https://doi.org/https://repository.nie.edu.sg/bitstream/10497/76/1/TME-9-1-84.pdf

Chapman, O. (2006). Classroom practices for context of mathematics word problems. *Educational Studies in Mathematics*, *62*(2), 211–230. https://doi.org/10.1007/s10649-006-7834-1

Chapman, O. (2002). High school mathematics teachers' perspectives of mathematical word problems. In S. Elaine & B. Davis (Eds.), *Proceedings of the 2002 Annual Meeting of the Canadian Mathematics Education Study Group* (pp. 91–98). CMESG/GCEDM.

Chapman, O. (2003). Teachers' Conceptions of Mathematical Word Problems: A Basis for Professional Development. *International Group for the Psychology of Mathematics Education*, *2*(0), 194–197.

Charalambous, C. Y., & Praetorius, A. K. (2018). Studying mathematics instruction through different lenses: setting the ground for understanding instructional quality more comprehensively. *ZDM - Mathematics Education*, *50*(3), 355–366. https://doi.org/10.1007/s11858-018-0914-8

Charmaz, K. (2006). *Constructing grounded theory: A practical approach through qualitative analysis*. Sage Publications, Thousand Oaks.

Chen, G., & Zhang, J. (2014). A case study of factors influencing the learning of engineering students. *World Trans. Eng. Technol. Educ*, *12*(2), 176–180.

Chinnappan, M. (2006). Role of Digital Technologies in supporting Mathematics Teaching and Learning: rethinking the terrain in terms of schemas as epistemological structures. In J. B. L. and C. H. Le Hung Son, Nathalie Sinclair (Ed.), *In Proceedings of the Seventeenth Study Conference of the International Commission on Mathematical Instruction* (pp. 98–104). Hanoi Institute of Technology.

Civelek, M. E. (2018). Comparison of covariance-based and partial least square structural equation modeling methods under non-normal distribution and small sample size limitations. *Eurasian Academy of Sciences Eurasian*

Econometrics, Statistics & Emiprical Economics Journal, *10*, 39–50. https://doi.org/10.17740/eas.stat.2018-V10-03

Clements, D. H., & Sarama, J. (2002). The role of technology in early childhood learning. *Teaching Children Mathematics*, *8*(6), 340–343.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. In *New York* (2nd Ed). Lawrence Erlbaum Associates.

Cohen, L., Manion, L., & Marrison, K. (2007). Research methods in education. In *Routledge: New York.* (6th ed.).

Cohen, Louis, Manion, L., & Morrison, K. (2007). *Research methods in education.* (6th ed.). Routledge. https://doi.org/10.1111/j.1467-8527.2007.00388_4.x

Considine, J., Botti, M., & Thomas, S. (2005). Effect of a self-directed learning package on emergency nurses' knowledge of assessment of oxygenation and use of supplemental oxygen. *Nursing and Health Sciences*, *7*(3), 199–208. https://doi.org/10.1111/j.1442-2018.2005.00236.x

Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). SAGE.

Costley, K. C. (2014). The Positive Effects of Technology on Teaching and Student Learning. *Online Submission*.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research. In *Thousand Oaks, California: SAGE Publications Inc.* (3rd ed.). SAGE Publications Inc.

Creswell, J W. (2014). Research design: Qualitative, quantitative and mixed methods approaches. In *Sage Publications, Inc.* (4th ed.). https://doi.org/10.1007/s13398-014-0173-7.2

Creswell, John W. (2012). *Educational research : planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Education Limited.

Crocker, L., & Algina, J. (1986). Introduction to classical and modern test theory. In *Eric*. Holt, Rinehart and Winston.

Croteau, E. A., Heffernan, N. T., & Koedinger, K. R. (2004). Why are algebra word problems difficult? Using tutorial log files and the power law of learning to select the best fitting cognitive model. *International Conference on Intelligent Tutoring Systems*, 240–250.

D'Sa, J. L., & Visbal-Dionaldo, M. L. (2017). Analysis of multiple choice questions: Item difficulty, discrimination index and distractor efficiency. *International Journal of Nursing Education*, *9*(3), 109. https://doi.org/10.5958/0974-9357.2017.00079.4

Danielson, C. (2013). The framework for teaching evaluation instrument, 2013 instructionally focused edition. In *Teachscape*.

Daroczy, G., Wolska, M., Meurers, W. D., & Nuerk, H. C. (2015). Word problems: A review of linguistic and numerical factors contributing to their difficulty. *Frontiers in Psychology*, *6*, 339–348. https://doi.org/10.3389/fpsyg.2015.00348

Davis, E. K. (2010). Linguistic influences on children's mathematical word problem solving strategies: Case study of two Average primary schools in Ghana. *Journal of Counselling, Education and Psychology*, *2*(1), 189–198.

Davis, H. A. (2003). Conceptualizing the role and influence of student–teacher relationships on children's social and cognitive development. *Educational Psychologist*, *38*(4), 207–234.

https://doi.org/http://dx.doi.org/10.1207/S15326985EP3804_2

Davis, S. E. (2007). *Effects of motivation, preferred learning styles, and perceptions of classroom climate on achievement in ninth and tenth grade math students*. University of Florida.

Decristan, J., Kunter, M., Büttner, G., Fauth, B., Hertel, S., & Hardy, I. (2016). *What role does instructional quality play for elementary school children's science competence? A focus on students at risk*. *8*(1), 66–89.

Deng, R., Benckendorff, P., & Gannaway, D. (2020). Linking learner factors, teaching context, and engagement patterns with MOOC learning outcomes. *Journal of Computer Assisted Learning*, *36*(5), 688–708. https://doi.org/10.1111/jcal.12437

Depaepe, F., Corte, E. De, & Verschaffel, L. (2007). Unraveling the culture of the mathematics classroom: A video-based study in sixth grade. *International Journal of Educational Research*, *46*(5), 266–279. https://doi.org/10.1016/j.ijer.2007.10.008

Depaepe, F., De Corte, E., & Verschaffel, L. (2010). Teachers' approaches towards heuristic and metacognitive skills and its relationship with students' beliefs and problem-solving skills. *ZDM—International Journal on Mathematics Education*, *42*, 205–218.

Deringol, Y. (2018). Mathematics teaching anxiety of classroom teachers. In I. Koleva, A. H. Basal, M. Tufan, & E. Atasoy (Eds.), *Educational Sciences Research in the Globalizing World*. St. Kliment Ohridski University Press.

Dettmers, S., Trautwein, U., Lüdtke, O., Kunter, M., & Baumert, J. (2010). Homework works if homework quality is high: Using multilevel modeling to predict the development of achievement in mathematics. *Article in*

Journal of Educational Psychology, *102*(2), 467–482. https://doi.org/10.1037/a0018453

Dixon, J. K., Andreasen, J. B., Avila, C. L., Bawatneh, Z., Deichert, D. L., Howse, T. D., & Turner, M. S. (2014). Redefining the whole: Common errors in elementary preservice teachers' self-authored word problems for fraction subtraction. *Investigations in Mathematics Learning*, *7*(1), 1–22.

Donnelly, R., & Fitzmaurice, M. (2005). Designing modules for learning. In G. O'Neill, S. Moore, & B. McMullin (Eds.), *Emerging issues in the practice of university learning and teaching* (pp. 99–110). All Ireland Society for Higher Education (AISHE).

Dorfner, T., Förtsch, C., & Neuhaus, B. (2018). Effects of three basic dimensions of instructional quality on students' situational interest in sixth-grade biology instruction. *Learning and Instruction*, *56*, 42–53. https://doi.org/10.1016/j.learninstruc.2018.03.001

Du, Y., & Hu, O. (2008). Student academic performance and the allocation of school resources: Results from a survey of junior secondary schools. *Chinese Education & Society*, *41*(5), 8–20. https://doi.org/10.2753/CED1061-1932410501

Dunkin, M., & Biddle, B. (1974). *The study of teaching*. Holt, Rinehart & Winston Inc.

Ebner, D. (2002). *Math word problems: The easy way*. Barron's Educational Series, Inc.

Edwards, A. R., Esmonde, I., Wagner, J. F., & Beattie, R. L. (2011). Learning mathematics. In *Handbook of research on learning and instruction*. https://doi.org/10.4324/9780203839089.ch4

Eekhout, I., de Vet, H. C. W., Twisk, J. W. R., Brand, J. P. L., de Boer, M. R., & Heymans, M. W. (2014). Missing data in a multi-item instrument were best handled by multiple imputation at the item score level. *Journal of Clinical Epidemiology*, *67*(3), 335–342. https://doi.org/10.1016/j.jclinepi.2013.09.009

Eickelmann, B., Gerick, J., & Koop, C. (2016). ICT use in mathematics lessons and the mathematics achievement of secondary school students by international comparison: Which role do school level factors play? *Educ Inf Technol*. https://doi.org/10.1007/s10639-016-9498-5

Ekwueme, C., & Ali, A. (2012). Process Error and Students' Academic Achievement in Senior Secondary Certificate Examination in Mathematics in Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies*, *3*(4), 60–73.

Eyyam, R., & Yaratan, H. S. (2014). Impact of use of technology in mathematics lessons on student achievement and attitudes. *Social Behavior and Personality: An International Journal*, *42*(1), 31S-42S. https://doi.org/10.2224/sbp.2014.42.0.s31

Fan, L., & Zhu, Y. (2000). Problem solving in Singaporean secondary mathematics textbooks problem solving in Singaporean secondary mathematics textbooks. *The Mathematics Educntor*, *5*(1/2), 117–141.

Fauth, B. ;, Decristan, J. ;, Rieser, S. ;, Klieme, E. ;, & Büttner, G. (2014). Student ratings of teaching quality in primary school. *Learning and Instruction*, *29*, 1–9. https://doi.org/http://dx.doi.org/10.1016/j.learninstruc.2013.07.001

Fede, J. L. (2010). *The effects of gosolve word problems math intervention on* *applied problem solving skills of low performing fifth grade students*. University of Massachusetts Amherst.

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). SAGE Publications Ltd.

Finley, P. E., Pugh, A. J., Lanham, H. J., Leykum, K. L. K., Cornell, J., Veerapaneni, P., & Parchman, L. M. (2013). Relationship quality and patient-assessed quality of care in VA primary care clinics: Development and validation of the work relationships scale. *The Annals of Family Medicine*, *11*(6), 543–549. https://doi.org/10.1370/afm.1554

Fowler Jr., F. J. (2014). Survey Research Methods (5th edition). In *Sage Publications, Inc*.

Fox, B. (2007). Teaching through technology: Changing practices in two universities. *International Journal on E-Learning*, *6*(2), 187–203.

Fuchs, L. S., Fuchs, D. S., Compton, D. L., Hamlett, A. C. L., & Wang, Y. Y. (2015). Is word-problem solving a form of text comprehension? *Scientific Studies of Reading*, *19*(3), 204–223. https://doi.org/10.1080/10888438.2015.1005745

Garson, G. D. (2012). *Testing statistical assumptions* (Blue Book). Statistical Associates Publishing.

Garson, G. D. (2013). *Validity and reliability*. Statistical Associates Publishers.

Gaskin, J., & Lim, J. (2016). *Model fit measures: AMOS Plugin*.

Geiger, V. (2006). More than tools: Mathematically enabled technologies as partner and collaborator. In C. Hoyles, J.-B. Lagrange, L. H. Son, & N. Sinclair (Eds.), *Technology Revisited: Digital Technologies; Rethinking the Terrain: Proceedings of the 17th ICMI Study Conference* (pp. 182–

189). International Commission on Mathematical Instruction.

George, D., & Mallery, P. (2003). *Reliability analysis. SPSS for Windows, step by step: a simple guide and reference* (4th ed.). Allyn & Bacon.

Ghana Education Service, [GES]. (2019). *Computerised Schools Selection and Placement System [CSSPS]*.

Ghana Education Service [GES]. (2019). *Ghana senior high schools. Annual Digest 2018/2019.*

Ghana Statistical Service, [GSS]. (2013). *2010 Population and housing census. Regional analytic report. Ashanti Region.*

Ghana Statistical Service, [GSS]. (2018). *Education Statistics: Tracking progress in Ghana's basic level education across the districts 2010 – 2016.*

Ghana Statistical Service, [GSS]. (2020). *Land area in Ghana as of 2021, by region(in square kilometers*)

Ghana Water and Sanitation Agency, [GWSA]. (2019). *Profile of the Ashanti Region: Map of Ashanti region showing metropolitan, municipal and districts*.

Gibbs, G. R. (2007). Thematic coding and categorizing. *Analyzing Quantitative Data*, *7*(3), 38–56. https://doi.org/10.4135/9781849208574.n4

Gibson, W., & Brown, A. (2009). *Working with qualitative data*. SAGE Publications Inc.

Good, R. (1991). Context in teaching and learning. *Journal of Research in Science Teaching*, *28*(10), 883–884. https://doi.org/10.1002/tea.3660281002

Good, T. L., & Grouws, D. A. (1977). Teaching Effects: A Process-Product Study in Fourth-Grade Mathematics Classrooms. *Journal of Teacher*

Education, *28*(3), 49–54. https://doi.org/10.1177/002248717702800310

Grammer, J. K., Coffman, J. L., Sidney, P., & Ornstein, P. A. (2016). Linking Teacher Instruction and Student Achievement in Mathematics: The Role of Teacher Language. *Journal of Cognition and Development*, *17*(3), 468–485. https://doi.org/10.1080/15248372.2015.1068777

Grossman, P., Cohen, J., & Brown, L. (2015). Understanding Instructional Quality in English Language Arts. *Designing Teacher Evaluation Systems*, 303–331. https://doi.org/10.1002/9781119210856.CH10

Groth, R. E. (2013). *Teaching mathematics in grades 6-12: Developing research-based instructional practices.* SAGE Publications.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough?: An experiment with data saturation and variability. *Field Methods*, *18*(1), 59–82. https://doi.org/10.1177/1525822X05279903

Guetterman, C. T., Fetters, D. M., & Creswell, W. J. (2015). Integrating quantitative and qualitative results in health science mixed methods research through joint displays. *The Annals of Family Medicine*, *13*(6), 554–561. https://doi.org/10.1370/afm.1865

Haghverdi, M., & Wiest, L. R. (2016). The effect of contextual and conceptual rewording on mathematical problem-solving performance. *The Mathematics Educator*, *25*(1), 56–73.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (7th ed.). Prentice-Hall.

Harskamp, E., & Suhre, C. (2007). Schoenfeld's problem solving theory in a student controlled learning environment. *Computers & Education*, *49*(3), 822–839. https://doi.org/10.1016/j.compedu.2005.11.024

Hartsell, T., Herron, S. S., Fang, H., & Rathod, A. (2010). Improving teachers' self-confidence in learning technology skills and math education through professional development. *International Journal of Information and Communication Technology Education*, *6*(2), 47–61.

Hayes, F. A. (2018). *Introduction to mediation, moderation and conditional process analysis. A regression-based approach* (D. L. Todd (ed.); 2nd ed.). Guilford Press.

Helm, R., & Mark, A. (2012). Analysis and evaluation of moderator effects in regression models: State of art, alternatives and empirical example. *Review of Managerial Science*, *6*(4), 307–332.

Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of Educational Psychology*, *105*(3), 774. https://doi.org/http://dx.doi.org/10.1037/a0032198

Hopkins, K. (1998). *Educational and psychological measurement and evaluation*. Allyn & Bacon, A Viacom Company.

Hotiu, A. (2006). *The relationship between item difficulty and discrimination indices in multiple-choice tests in a physical science course (Doctoral dissertation)*. Florida Atlantic University.

Hu, L. tze, Bentler, P. M., & Kano, Y. (1992). Can test statistics in covariance structure analysis be trusted? *Psychological Bulletin*, *112*(2), 351–362. https://doi.org/http://dx.doi.org/10.1037/0033-2909.112.2.351

Huitt, W. (2003). A transactional model of the teaching/learning process. In *Educational Psychology Interactive.* Valdosta State University.

Iacobucci, D., Schneider, M. J., Popovich, D. L., & Bakamitsos, G. A. (2016).

Mean centering helps alleviate "micro" but not "macro" multicollinearity. *Behavior Research Methods*, *48*(4), 1308–1317. https://doi.org/10.3758/s13428-015-0624-x

Igo, L. B., Riccomini, P. J., Bruning, R. H., & Pope, G. G. (2006). How should middle-school students with LD approach online note taking? A mixed methods study. *Learning Disability Quarterly*, *29*, 89–100. https://doi.org/10.2307/30035537

Jantjies, M., Moodley, T., & Maart, R. (2018). Experiential learning through virtual and augmented Reality in Higher Education. *Proceedings of the 2018 International Conference on Education Technology Management*, 42–45. https://doi.org/10.1145/3300942.3300956

Jenkins, P., & Love, K. (2021). Examining the relationship between charter competition, teacher quality, and school resources on Ohio's reading achievement. *American Journal of Educational Research*, *9*(3), 133–141. https://doi.org/10.12691/education-9-3-7

Jentsch, A., & Schlesinger, L. (2017). Measuring instructional quality in mathematics education. *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education (CERME10, February 1 – 5, 2017).*

Johnson, B., & Turner, L. A. (2003). Data collection strategies in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook on mixed methods in the behavioral and social sciences* (Eds, pp. 297–320). Sage Publications, Thousand Oaks.

Jose, E. P. (2013). *Doing statistical mediation and moderation* (D. L. Todd (ed.)). The Guilford Press.

Junker, B., Matsumura, L. C., & Crosson, A. C. (2005). *Overview of the instructional quality assessment text discussions for reading comprehension: Online professional learning view project The social and psychological process of classroom talk view project*. https://doi.org/10.1037/e644942011-001

Kadijevich, D. M. (2015). A dataset from TIMSS to examine the relationship between computer use and mathematics achievement. *British Journal of Educational Technology*, *46*(5), 984–987.

Kaiser, G. (2017). The teaching and learning of mathematical modeling. In *Compendium for research in mathematics education* (Vol. 267, pp. 267–291). National Council of Teachers of Mathematics.

Kelcey, B., Hill, H. C., & Chin, M. J. (2019). Teacher mathematical knowledge, instructional quality, and student outcomes: a multilevel quantile mediation analysis. *School Effectiveness and School Improvement*, *30*(4), 398–431. https://doi.org/10.1080/09243453.2019.1570944

Kim, J. (2016). *EFL learners' perceptions of learning context, writing achievement, and gender*.

Kirkwood, A., & Price, L. (2016). *Technology-enabled learning implementation handbook*. https://doi.org/10.4337/9781784714802.00016

Klieme, E., Pauli, C., & Reusser, K. (2009). The Pythagoras study: Investigating effects of teaching and learning in Swiss and German mathematics classrooms. The power of video studies in investigating teaching and learning in the classroom. *ORBIS SCHOLAE*, *3*(2), 137–160. https://doi.org/10.14712/23363177.2018.216

Kline, P. (1986). *A Handbook of test construction: Introduction to psychometric* *design*. Methuen & Co. Ltd.

Kline, R. (2010). *Promise and pitfalls of structural equation modeling in gifted research*. https://doi.org/10.1037/12079-007

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). Guilford.

Kneebone, I. I., & Dewar, S. J. (2017). Reliability and validity of the Attributional Style Questionnaire-Survey in people with multiple sclerosis. *Therapeutic Advances in Neurological Disorders*, *10*(1), 33–40. https://doi.org/10.1177/1756285616673515

Ko, J., Sammons, P., & Bakkum, L. (2013). *Effective teaching: A review of research and evidence*. CfBT Education Trust.

Konte, M. (2021). How do education resources respond to the quality of local governance in Africa? *Review of Development Economics*, *25*, 1538–1557. https://doi.org/10.1111/rode.12770

Kounin, J. (1970). *Discipline and group management in classrooms*. Holt, Rinehart & Winston.

Krauss, S., Jü, A. E., Ae, B., & Blum, W. (2008). Secondary mathematics teachers' pedagogical content knowledge and content knowledge: validation of the COACTIV constructs. *ZDM*, *40*(5), 873–892. https://doi.org/10.1007/s11858-008-0141-9

Kunter, M., & Baumert, J. (2006). Who is the expert? Construct and criteria validity of student and teacher ratings of instruction. *Learning Environments Research*, *9*(3), 231–251. https://doi.org/10.1007/s10984-006-9015-7

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A.

(2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology*, *105*(3), 805. https://doi.org/10.1037/a0032583

Kunter, M., & Voss, T. (2013). The model of instructional quality in COACTIV: A multicriteria analysis. In *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 97–124). Springer. https://doi.org/sci-hub.tw/10.1007/978-1-4614-5149-5

Kuterbach, J. M. (2012). *A model of academic enablers and academic performance among postsecondary learners*.

Kuzel, A. (1992). Sampling in qualitative inquiry. In B. Crabtree & W. Miller (Eds.), *Doing qualitative research* (pp. 31–44). SAGE.

Lantolf, J. (2006). *Sociocultural theory and the genesis of second language development*. Oxford University Press.

Lantolf, J. P., Thorne, S. L., & Poehner, M. E. (2015). Sociocultural Theory and Second Language Development. *An Introduction*, *1*, 207–226.

Latu, V. F. (2005). Language factors that affect mathematics teaching and learning of Pasifika students. In P. Clarkson, A. Dmvntown, D. Gronn, M. Horne, & G. A. McDonough (Eds.), *Theory, research and practice. Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia, 2* (pp. 483–490). MERGA.

Lavicza, Z. (2008). *A comparative analysis of academic mathematicians' conceptions and professional use of computer algebra systems in university mathematics*. University of Cambridge.

Lee, C. Y., & Chen, M. J. (2015). Effects of Worked Examples Using Manipulatives on Fifth Graders' Learning Performance and Attitude toward Mathematics. *Educational Technology & Society*, *18*(1), 264–275.

Lee, H. S., Linn, M. C., Varma, K., & Liu, O. L. (2010). How do technology-enhanced inquiry science units impact classroom learning? *Journal of Research in Science Teaching*, *47*(1), 71–90. https://doi.org/10.1002/tea.20304

Lee, J., Yim, M. H., & Kim, J. Y. (2018). Test-retest reliability of the questionnaire in the Sasang constitutional analysis tool (SCAT). *Integrative Medicine Research*, *7*(2), 136–140. https://doi.org/10.1016/j.imr.2018.02.001

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publications, Inc.

Lincoln, Yvonna S., & Guba, E. G. (1986). But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. *New Directions for Program Evaluation*, *1986*(30), 73–84. https://doi.org/http://dx.doi.org/10.1002/ev.1427

Lipowsky, F., Rakoczy, K., & Pauli, C. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*(6), 527–537. https://doi.org/10.1016/j.learninstruc.2008.11.001

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*(6), 527–537.

Loewenberg-Ball, D. B., Hyman, B., & Hill, H. C. (2011). Measuring the mathematical quality of instruction: Learning Mathematics for Teaching

Project. *Journal of Mathematics Teacher Education*, *14*(1), 25–47. https://doi.org/10.4135/9781483329857.n6

Macrae, M. (2008). *Mathematics for senior high schools* (Students'). Pearson Education Limited.

Mahn, H., & Fazalehaq, H. M. (2012). Vygotsky and Second Language Acquisition. In *The Encyclopedia of Applied Linguistics* (pp. 1–8). Blackwell Publishing Ltd. https://doi.org/http://dx.doi.org/10.1002/9781405198431.wbeal1272

Mandal, S., & Naskar, S. K. (2019). Solving arithmetic mathematical word problems: A review and recent advancements. *Information Technology and Applied Mathematics*, *699*, 95–114. https://doi.org/http://dx.doi.org/10.1007/978-981-10-7590-2_7

Marzano, R. J., Pickering, D., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Ascd.

Matsumura, L. C., Garnier, H. E., Cadman, S. S., & Boston, M. D. (2008). Toward Measuring Instructional Interactions. *Educational Assessment*, *13*(4), 267–300. https://doi.org/http://dx.doi.org/10.1080/10627190802602541

Mccowan, R. J., & Mccowan, S. C. (1999). Item Analysis for criterion-referenced tests. In *ERIC*.

McIlrath, D., & Huitt, W. (1995). The teaching-learning process: A discussion of models. *Educational Psychology Interactive*, 45–49.

McIntyre, B. K. (2011). Teachers' beliefs and practices regarding the role of technology in literacy instruction: A mixed methods study. In *libres.uncg.edu*. The University of North Carolina.

Medawela, R. S. H. B., Ratnayake, D. R. D. L., Abeyasinghe, W. A. M. U. L., Jayasinghe, R. D., & Marambe, K. N. (2018). Effectiveness of "fill in the blanks" over multiple choice questions in assessing final year dental undergraduates. *Educación Médica*, *19*(2), 72–76. https://doi.org/10.1016/j.edumed.2017.03.010

Meggiolaro, S. (2017). Information and communication technologies use, gender and mathematics achievement: evidence from Italy. *Soc Psychol Educ*. https://doi.org/10.1007/s11218-017-9425-7

Merriam, S. (1998). *Qualitative research and case study applications in education. Revised and expanded from" Case Study Research in Education."*. Jossey-Bass Publishers.

Ministry of Education [MoE]. (2010). *Core mathematics syllabus*. Curriculum Development and Research Division.

Mohd Razali, N., & Bee Wah, Y. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. In *Journal of Statistical Modeling and Analytics* (Vol. 2, Issue 1).

Moon, J. (2002). *The module & programme development handbook: A practical guide to linking levels, learning outcomes & assessment*. Psychology Press.

Moore, P., & Fitz, C. (1993). Gestalt theory and instructional design. *Journal of Technical Writing and Communication*, *23*(2), 137–157. https://doi.org/10.2190/g748-by68-l83t-x02j

Morettini, B. W. (2012). *Reasons to Teach: Prospective Teachers, Low Performing Schools, and Alternative Preparation*. University of Maryland, College Park.

Morgan, C. (2014). Mathematical language. In S. (Ed. . Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 388–391). Springer. https://doi.org/10.1007/978-94-007-4978-8_99

Morgan, D. L. (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of Mixed Methods Research*, *1*(1), 48–76. https://doi.org/10.1177/2345678906292462

Morse, J. M. (2001). Using shadowed data. *Qualitative Health Research*, *11*(3), 291–292. https://doi.org/10.1177/104973201129119091

Moschkovich, J. (2012). Mathematics, the Common Core, and language: Recommendations for mathematics instruction for ELs aligned with the Common Core. *Commissioned Papers on Language and Literacy Issues in the Common Core State Standards and Next Generation Science Standards*, *96*(3), 418–431.

Mugenda, O. M., & Mugenda, A. G. (2003). *Quantitative and qualitative approaches*. ACTS Press.

Munasinghe, D. M. W. (2013). A study on error patterns in “Addition” in primary school children (7 years old children). *Merit Research Journal of Education and Review*, *1*(7), 154–158.

Mutai, B. K. (2000). *How to write quality research proposal: A complete and simplified recipe*. Egerton University.

National Council of Teachers of Mathematics, [NCTM]. (2000). Principles and Standards for School Mathematics. In *The National Council of Teachers of Mathematics*.

National Council of Teachers of Mathematics, [NCTM]. (2012, February). *Closing the opportunity gap in mathematics education*. National Council of Teachers of Mathematics. https://www.nctm.org/Standards-and-Positions/Position-Statements/Closing-the-Opportunity-Gap-in-Mathematics-Education/

National Council of Teachers of Mathematics, [NCTM]. (2014). *Principles to Action*. Author.

National Council of Teachers of Mathematics, [NCTM]. (2015). *A Position of the National Council of Teachers of Mathematics on the strategic use of technology in teaching and learning mathematics.* National Council of Teachers of Mathematics [NCTM]. https://www.nctm.org/Standards-and-Positions/Position-Statements/Strategic-Use-of-Technology-in-Teaching-and-Learning-Mathematics/

Neubrand, M., Jordan, A., Krauss, S., Blum, W., & Löwen, K. (2013). Task analysis in COACTIV: Examining the potential for cognitive activation in German mathematics classrooms. In *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers: Results from the COACTIV Project* (pp. 125–144). Springer US. https://doi.org/10.1007/978-1-4614-5149-5_7

Nieswandt, M., & McEneaney, E. H. (2009). Approaching classroom realities: The use of mixed methods and structural equation modeling in science education research. In *Quality Research in Literacy and Science Education: International Perspectives and Gold Standards* (pp. 189–211). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8427-0_10

Nilsen, T., & Gustafsson, J.-E. (2016). Teacher quality, instructional quality and student outcomes: relationships across countries, cohorts and time. *Springer Nature*, 166. https://doi.org/10.1007/978-3-319-41252-8

Nortvedt, G. A., Gustafsson, J. E., & Lehre, A. C. W. (2016). The importance of instructional quality for the relation between achievement in reading and mathematics. *Eacher Quality, Instructional Quality and Student Outcomes*, 97–113. https://doi.org/sci-hub.tw/10.1007/978-3-319-41252-8_5

Ocak, M. (2006). Solving Word problems with Literacy Activities: Investigation of Changes in Two Mathematics Teachers' Practices. *GÜ, Gazi Eğitim Fakültesi Dergisi,* , *26*(1), 113–124.

Olatunde, P. Y., & Otieno, K. O. (2010). Teaching/learning resources and academic performance in mathematics in secondary schools in Bondo District of Kenya. *Asian Social Science, 6*(12), 126. https://doi.org/10.5539/ass.v6n12p126

Olsen, A. K., & Chernobilsky, E. (2016). The effects of technology on academic motivation and achievement in a middle school mathematics classroom. *TNERA Conference Proceedings 2016*, *2*, 1–17.

Onwuegbuzie, A. J., & Collins, K. M. T. (2007). A Typology of mixed methods sampling designs in social science research. *The Qualitative Report*, *12*(2), 281–316.

Organisation for Economic Co-operation and Development (OECD). (2014). *PISA 2012 results: Creative problem solving: Students' skills in tackling real-life problems (Volume V): Vol. V*. OECD.

Ottmar, E. R., Decker, L. E., Cameron, C. E., Curby, T. W., & Rimm-Kaufman, S. E. (2014). Classroom instructional quality, exposure to mathematics instruction and mathematics achievement in fifth grade. *Learning Environments Research*, *17*(2), 243–262. https://doi.org/10.1007/s10984-013-9146-6

Paisal, M. (2019). Learners through understanding gestalt learning theory: Classroom implementation experience individual-based approach. *E-Tech: Jurnal Ilmiah Teknologi Pendidikan*, *7*(2), 1–6. https://doi.org/10.24036/et.v7i2.107078

Pallant, J. (2007). A step by step guide to data analysis using SPSS for windows. SPSS Survival manual. In *Allen & Unwin*.

Pallant, Julie. (2011). SPSS survival manual 4th ed. In *Allen & Unwin*.

Parrish, D. R. (2009). *Students' perceptions of what instructors do to help students learn in the classroom*. University of Wisconsin Oshkosh.

Pearce, D. L., Bruun, F., Skinner, K., & Lopez-Mohler, C. (2013). What teachers say about student difficulties solving mathematical word problems in grades 2-5. *International Electronic Journal of Mathematics Education*, *1*, 3–19.

Peña-López, I. (2012). *Pisa 2012 assessment and analytical framework. Mathematics, reading, science, problem solving and financial literacy*. https://doi.org/10.1787/9789264190511-en

Phelps, G., & Howell, H. (2016). Assessing mathematical knowledge for teaching: The role of teaching context. *The Mathematics Enthusiast*, *13*(1), 52–70.

Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher*, *38*(2), 109–119.

https://doi.org/10.3102/0013189X09332374

Pianta, R., Paro, K. La, & Hamre, B. (2008). *Classroom Assessment Scoring System^{TM}: Manual K-3*. Paul H Brookes Publishing.

Pitkäniemi, H., & Häkkinen, K. (2018). The instructional quality of classroom processes and pupils' mathematical attainment concerning decimal fractions. *Zugriff Am, 3*.

Powers, R., & Blubaugh, W. (2005). Technology in mathematics education: Preparing teachers for the future. *Contemporary Issues in Technology and Teacher Education*, *5*(3), 254–270.

Praetorius, A. K, Pauli, C., Reusser, K., Rakoczy, K., & Klieme, E. (2014). One lesson is all you need? Stability of instructional quality across lessons. *Learning and Instruction*, *31*, 2–12. https://doi.org/10.1016/j.learninstruc.2013.12.002

Praetorius, A., Lenske, G., & Helmke, A. (2012). Observer ratings of instructional quality: Do they fulfill what they promise? *Learning and Instruction*, *22*(6), 387–400. https://doi.org/10.1016/j.learninstruc.2012.03.002

Praetorius, Anna Katharina, Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: the German framework of Three Basic Dimensions. *ZDM - Mathematics Education*, *50*(3), 407–426. https://doi.org/10.1007/s11858-018-0918-4

Proitz, T. S. (2010). Learning outcomes: What are they? Who defines them? When and where are they defined? *Educational Assessment, Evaluation and Accountability*, *22*(2), 119–137. https://doi.org/10.1007/s11092-010-9097-8

Quaigrain, K., & Arhin, A. K. (2017). Using reliability and item analysis to evaluate a teacher-developed test in educational measurement and evaluation. *Cogent Education*, *4*(1), 130111. https://doi.org/10.1080/2331186X.2017.1301013

Ren, S. J., & Yang, X. J. (2017). A survey on satisfaction degree of teaching quality of colleges and universities: Based on the data from 752 undergraduates at four colleges in H Province. *Journal of Higher Education Research*, *1*.

Rezai, M., Cote, P., Cassidy, J. D., & Carroll, L. (2009). The association between prevalent neck pain and health-related quality of life: a cross-sectional analysis. *European Spine Jornal*, *18*(3), 371–381. https://doi.org/10.1007/s00586-008-0823-6

Riccomini, P. J., Sanders, S., & Jones, J. (2008). The Key to Enhancing Students' Mathematical Vocabulary Knowledge. *Journal on School Educational Technology*, *4*(1), 1–7. https://doi.org/10.26634/jsch.4.1.627

Riccomini, P. J, Smith, G. W., Hughes, E. M., & Fries, K. M. (2015). *The language of mathematics: The importance of teaching and learning mathematical vocabulary*. *31*(3), 235–252. https://doi.org/10.1080/10573569.2015.1030995

Richards, J. C., & Farrell, T. S. (2011). *Practice teaching: A reflective approach*. Cambridge University Press.

Robert, M. K., & Saccuzzo, P. D. (2008). *Psychological testing: Principles, applications, and issues* (7th ed). Wadsworth Publishing.

Ronhovde, F. E. (2009). Making Sense of Word Problems. In *Part of the Science and Mathematics Education Commons Ronhovde*.

Rudner, L. M., & Schafer, W. D. (2006). Reliability. *ERIC Digest. ED458213*, 1–7.

Salkind, N. (2015). Shapiro-Wilk test for normality. In *Encyclopedia of Measurement and Statistics*. Sage Publications, Inc. https://doi.org/10.4135/9781412952644.n404

Salkind, N. J. (2010). *Encyclopedia of research design* (1st ed.). SAGE Publications. https://doi.org/10.4135/9781412961288

Scherer, R., Nilsen, T., & Jansen, M. (2016). Evaluating individual students' perceptions of instructional quality: An investigation of their factor structure, measurement invariance, and relations to educational outcomes. *Frontiers in Psychology*, *7*, 110. https://doi.org/10.3389/fpsyg.2016.00110

Schlesinger, L., & Jentsch, A. (2016). Theoretical and methodological challenges in measuring instructional quality in mathematics education using classroom observations. *ZDM*, *48*(1–2), 29–40. https://doi.org/10.1007/s11858-016-0765-0

Schlesinger, L., Jentsch, A., Kaiser, G., König, J., & Blömeke, S. (2018). Subject-specific characteristics of instructional quality in mathematics education. *ZDM - Mathematics Education*, *50*(3), 475–490. https://doi.org/10.1007/s11858-018-0917-5

Schoenfeld, A. H. (2013). Classroom observations in theory and practice. *ZDM*, *45*(4), 607–621. https://doi.org/10.1007/s11858-012-0483-1

Schunk, D. . (2012). *Learning theories: An educational perspective* (6th ed.). Pearson.

Sedgwick, P. (2015). Multistage sampling. *BMJ (Online)*, *351*, 1–2. https://doi.org/10.1136/BMJ.H4155

Seel, N. M. (2012). Gestalt psychology of learning. In *Encyclopedia of the sciences of learning* (Eds, pp. 1366–1371). Springer International Publishing. https://doi.org/10.1007/ 978-1-4419-1428-6

Seethaler, P. M., Fuchs, L. S., Star, J. R., & Bryant, J. (2011). The cognitive predictors of computational skill with whole versus rational numbers: An exploratory study. *Learning and Individual Differences*, *21*(5), 536–542. https://doi.org/10.1016/j.lindif.2011.05.002

Sepeng, P., & Madzorera, A. (2014). Sources of difficulty in comprehending and solving mathematical word problems. *International Journal of Educational Sciences*, *6*(2), 217–225. https://doi.org/10.1080/09751122.2014.11890134

Sepeng, P., & Sigola, S. (2013). Making sense of errors made by learners in mathematical word problem solving. *Mediterranean Journal of Social Sciences MCSER Publishing*, *4*(13), 325. https://doi.org/10.5901/mjss.2013.v4n13p325

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3–4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Sheffield, L., & Cruikshank, D. (2000). *Teaching and learning mathematics prekindergarten through middle school* (5th ed.). JohnWiley & Sons.

Silverman, D. (2014). *Interpreting Qualitative Data* (5th ed.). SAGE.

Sim, S. M., & Rasiah, R. I. (2006). Relationship between item difficulty and discrimination indices in true/false-type multiple choice questions of a para-clinical multidisciplinary paper. *Annals-Academy of Medicine Singapore*, *35*(2), 67.

Skryabin, M., Zhang, J., Liu, L., & Zhang, D. (2015). How the ICT development level and usage influence student achievement in reading, mathematics, and science. *Computers & Education*, *85*, 49–58.

Stangroom, J. (2018). *Quick P Value from Chi-Square Score Calculator*. EZSPSS>COM. https://www.socscistatistics.com/tests/chisquare2/default2.aspx.

Stefanou, C. R., Perencevich, K. C., Dicintio, M., & Turner, J. C. (2010). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership. *Educational Psychologist*, *39*(2), 97–110. https://doi.org/10.1207/s15326985ep3902_2

Sutton, J., & Krueger, A. (2002). *EDThoughts: What We Know about Mathematics Teaching and Learning*.

Svinivki M., & McKeahie J. W. (2014). *Teaching tips: Strategies, research and theory for college and university teachers*. Wadsworth.

Tabachnick, B. G., & Fidell, l. S. (2013). *Using multivariate statistics* (6th ed.). Pearson.

Tambychik, T., & Meerah, T. S. M. (2010). Students' difficulties in mathematics problem-solving: What do they say? *Elsevier*, *8*, 142–151. https://doi.org/10.1016/j.sbspro.2010.12.020

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53. https://doi.org/10.5116/ijme.4dfb.8dfd

Thompson, C. J., & Davis, S. B. (2014). Classroom observation data and instruction in primary mathematics education: Improving design and rigour. *Mathematics Education Research Journal*, *26*(2), 301–323.

https://doi.org/10.1007/s13394-013-0099-y

Thorndike, R., & Thorndike-Christ, T. (2010). *Measurement and evaluation in psychology and education*. Pearson.

Timm, N. H. (2004). Principal component, canonical correlation, and exploratory factor analysis. In *Applied multivariate analysis II* (pp. 446–514). Springer. https://doi.org/10.1007/978-0-387-22771-9_8

Tong, D. H., & Loc, N. P. (2017). Students' errors in solving mathematical word problems and their ability in identifying errors in wrong solutions. *European Journal of Education Studies, 3*(6), 226–241. https://doi.org/10.5281/zenodo.581482

Torres, C., Lopes, A. P., Babo, L., & Azevedo, J. (2009). *Developing multiple-choice questions in mathematics*.

Transforming Teacher Education and Learning, [T-TEL]. (2018). *College of education network*. https://www.t-tel.org/coes-network

van Buuren, S. (2012). *Flexible imputation of missing data*. Chapman & Hall/CRC.

van de Grift, W. (2007). Quality of teaching in four European countries: A review of the literature and an application of an assessment instrument. *Educational Research, 49*(2). https://doi.org/www.tandfonline.com/doi/abs/10.1080/00131880701369651

van der Walt, M. (2009). Study orientation and knowledge of basic vocabulary in Mathematics in the primary school. *Journal of Science and Technology, 28*(4), 378–392. https://doi.org/10.4102/satnt.v28i4.73

Vander Weele, T. J., & Shpitser, I. (2013). On the definition of a confounder.

Annals of Statistics, *41*(1), 196–220. https://doi.org/10.1214/12-aos1058

Verschaffel, L, Depaepe, F., & Van Dooren, W. (2014). Word problems in mathematics education. In *Encyclopedia of mathematics education* (pp. 641–645). https://doi.org/https://b-ok.cc/book/2467975/976530

Verschaffel, L., Greer, B., & De Corte, E. (2000). *Making sense of word problems*. Swets & Zeitlinger.

Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM - Mathematics Education*, *52*(1), 1–16. https://doi.org/10.1007/s11858-020-01130-4

Villasenor Alva, J. A., & Estrada, E. G. (2009). A generalization of Shapiro-Wilk's test for multivariate normality. *Communications in Statistics - Theory and Methods*, *38*(11), 1870–1883. https://doi.org/10.1080/03610920802474465

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the Development of Children*, *23*(3), 34–41.

Wagemans, J. (2018). Perceptual organization. In *Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience* (2nd ed., pp. 1–70). John Wiley & Sons, Inc. https://doi.org/10.1002/9781119170174.epcn218

Wagner, W., Göllner, R., Werth, S., Voss, T., Schmitz, B., & Trautwein, U. (2016). Student and teacher ratings of instructional quality: Consistency of ratings over time, agreement, and predictive power. *Journal of Educational Psychology*, *108*(5), 705–721. https://doi.org/http://dx.doi.org/10.1037/edu0000075

Walkington, C., & Bernacki, M. (2015). Students authoring personalized "algebra stories": Problem-posing in the context of out-of-school interests.

The Journal of Mathematical Behavior, *40*, 171–191. https://doi.org/10.1016/j.jmathb.2015.08.001

Walkowiak, T. A., Berry, R. Q., Meyer, J. P., Rimm-Kaufman, S. E., & Ottmar, E. R. (2014). Introducing an observational measure of standards-based mathematics teaching practices: Evidence of validity and score reliability. *Educational Studies in Mathematics*, *85*(1), 109–128. https://doi.org/10.1007/s10649-013-9499-x

Watkins, M. W. (2000). *Monte Carlo PCA for Parallel Analysis (Computer Software)... - Google Scholar*. Ed & Psych.

Waxman, H. C., Hilberg, R. S., & Tharp, R. G. (2004). Future directions for classroom observation research. In H. C. Waxman, R. G. Tharp, & R. S. Hilberg (Eds.), *Observational research in U.S. classrooms. New approaches for understanding cultural and linguistic diversity* (Eds, pp. 266–277). Cambridge University Press. Webb, N.

Weinert, F. E., Schrader, F. W., & Helmke, A. (1989). Quality of instruction and achievement outcomes. *International Journal of Educational Research*, *13*(8), 895-914. https://doi.org/10.1016/0883-0355(89)90072-4

West African Examination council [WAEC]. (2012). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council, [WAEC]. (2013). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council [WAEC]. (2014). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council, [WAEC]. (2016). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council, [WAEC]. (2017). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council, [WAEC]. (2018). *Chief examiner's report for core mathematics in WASSCE*.

West African Examination council, [WAEC]. (2019). *Chief examiner's report for core mathematics in WASSCE.*

West African Examination council, [WAEC]. (2020). *Chief examiner's report for core mathematics in WASSCE.*

West, R., & Graham, C. (2005). Five powerful ways technology can enhance teaching and learning in higher education. *Educational Technology*, *45*(3), 20–27.

Wijaya, A., den Heuvel-Panhuizen, V., Doorman, M., & Veldhuis, M. (2018). Opportunity-to-Learn to Solve Context-Based Mathematics Tasks and Students' Performance in Solving these Tasks–Lessons from Indonesia. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(10), 1–20. https://doi.org/10.29333/ejmste/93420

Willingham, D. T. (2010). Have technology and multitasking rewired how students learn? *American Educator*, *34*(2), 23.

Wilmot, E. M., Davis, E. K., & Ampofo, C. B. (2015). Why are non-routine mathematics word problems difficult?: Lessons from preservice basic school teachers in Ghana. *Researchgate.Net*, *1*, 1–28.

Winne, P. (1987). Why process-product research cannot explain process-product findings and a proposed remedy: The cognitive mediational paradigm. *Teaching and Teacher Education*, *3*(4), 333–356. https://doi.org/10.1016/0742-051x(87)90025-4

Wisniewski, B., Zierer, K., Dresel, M., & Daumiller, M. (2020). Obtaining secondary students' perceptions of instructional quality: Two-level structure and measurement invariance. *Learning and Instruction*, *66*(101303.), 1–12. https://doi.org/10.1016/j.learninstruc.2020.101303

Yusif, H. M., Yussof, I., & Noor, A. H. S. M. (2011). Determinants of Students Academic Performance in Senior High Schools: A Binary Logit Approach. *Journal of Science and Technology (Ghana)*, *31*(3), 107–117. https://doi.org/10.4314/just.v31i3.12

Zainudin, A. (2012). Structural equation modeling using AMOS graphic. In *Shah Alam: Universiti Teknologi MARA Publication Centre (UPENA)*. Shah Alam: Universiti Teknologi MARA Publication Centre (UPENA).

Zhang, D., & Liu, L. (2016). How does ICT use influence students' achievements in math and science over time? Evidence from PISA 2000 to 2012. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(9), 2431–2449. https://doi.org/10.12973/eurasia.2016.1297a

Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory & Practice in Language Studies*, *3*(2). https://doi.org/10.4304/tpls.3.2.201-208

APPENDICES

Appendix A: Distribution of students in the survey

SHS	Sampled classes				Total (%)
	Class	Enrolled	Prop. sampled	Selected	
School A1	Sc 3	50	25.9	26	130 (16.5)
	Sc 4	50	25.9	26	
	Sc 7	50	25.9	26	
	Sc 8	50	25.9	26	
	At 3	49	25.4	26	
SUB-TOTAL		249	129.0		
School A2	He 1	36	20.0	20	131 (16.6)
	Sc 2	50	27.8	28	
	Sc 3	50	27.8	28	
	Bs 4	49	27.2	28	
	Vs 3	47	26.1	27	
SUB-TOTAL		232	129.0		
School B1	Sc 1	50	27.4	28	131 (16.6)
	Sc 2	50	27.4	28	
	Sc 4	50	27.4	28	
	Bs 1	51	28.0	28	
	Bs 3	34	18.7	19	
SUB-TOTAL		235	129.0		
School B2	Bs 1	45	25.5	26	132 16.8)
	Bs 3	43	24.3	25	
	Bs 4	45	25.5	26	
	At 3	50	28.3	29	
	At 4	45	25.5	26	
SUB-TOTAL		228	129.0		
School C1	At 2	33	21.3	22	131 (16.6)
	At 4	36	23.2	24	
	At 5	42	27.1	27	
	Vs 1	45	29.0	29	
	Vs 2	44	28.4	29	
SUB-TOTAL		200	129.0		
School C2	At 1	50	27.3	28	132 (16.8)
	At 4	46	25.1	26	
	At 5	47	25.7	26	
	At 6	44	24.1	25	
	Vs 1	49	26.8	27	
SUB-TOTAL		236	129.0		
TOTAL		1394	774	787	787

Sc, At, HE, Vs, and Bs respectively represent Science, Arts, Home Economics, Visual, and Business classes (Using a multiplier coefficient of 129). Source: Field Survey (2021)

Appendix B: Letters of Approval - UCCIRB

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/857
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

9TH DECEMBER, 2020

Mr. Isaac Bengre Taley
Department of Mathematics and I.C.T Education
University of Cape Coast

Dear Mr. Taley,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2020/94)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research titled **The Effects of Instructional Quality on Students' Learning Outcomes in Mathematics Word Problems.** This approval is valid from 9th December, 2020 to 8th December, 2021. 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

Appendix B: Letters of Approval - Department and Supervisor

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF MATHEMATICS AND I.C.T EDUCATION

Telephone: 0332096951
Telex: 2552, UCC, GH
Telegrams & Cables: University, Cape Coast
Email: dmicte@ucc.edu.gh

University Post Office
Cape Coast, Ghana

Your Ref:

Our Ref: DMICTE/P.3/V.1/053

Date: 19th February, 2021

Dear Sir,

RESEARCH VISIT

The bearer of this letter, **Mr Isaac Bengre Taley,** with registration number **ET/DME/18/0008** is a PhD. (Mathematics Education) student of the Department of Mathematics and ICT Education, College of Education Studies, University of Cape Coast.

As part of the requirements for the award of a doctorate degree, he is required to undertake a research visit at your outfit with the purpose of collecting data on the topic **"THE EFFECTS OF INSTRUCTIONAL QUALITY ON STUDENTS' LEARNING OUTCOMES IN MATHEMATICS WORD PROBLEMS"**.

I would be grateful if you could give him the necessary assistance he may need.

Thank you for your usual support.

Yours faithfully,

Dr Kofi Ayebi-Arthur
SUPERVISOR

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF MATHEMATICS AND I.C.T EDUCATION

Telephone: 0332096951
Telex: 2552, UCC, GH
Telegrams & Cables: University, Cape Coast
Email: dmicte@ucc.edu.gh

University Post Office
Cape Coast, Ghana

Your Ref:

Our Ref: DMICTE/P.3/V.1/053

Date: 19th February, 2021

Dear Sir,

RESEARCH VISIT

The bearer of this letter, **Mr Isaac Bengre Taley,** with registration number **ET/DME/18/0008** is a PhD. (Mathematics Education) student of the Department of Mathematics and ICT Education, College of Education Studies, University of Cape Coast.

As part of the requirements for the award of a doctorate degree, he is required to undertake a research visit at your outfit with the purpose of collecting data on the topic **"THE EFFECTS OF INSTRUCTIONAL QUALITY ON STUDENTS' LEARNING OUTCOMES IN MATHEMATICS WORD PROBLEMS"**.

I would be grateful if you could give him the necessary assistance he may need.

Thank you for your usual support.

Yours faithfully,

Dr (Mrs) Christina Boateng
HEAD

Appendix C: Student Perception of Instructional Quality Questionnaire

School ……………………………

Date ……………………….

Programme …………………………… Duration: **30minutes**

BIOGRAPHIC DATA (Tick √ as appropriate)

Sex	Male	Female	
Studying E-Maths	YES	NO	
Taught in SHS 1 & 2 by	Same mathematics teacher	Different mathematics teachers	
GES categorisation	A	B	C
Sex categorisation	BOYS	GIRLS	MIXED

This questionnaire seeks to elicit your perception about the quality of instruction your mathematics teacher provides during mathematics word problem teaching. The responses you will provide are for this research only. You are assured of the confidentiality of your responses. Do not write your name on this form.

Please **tick [√]** only one of the following responses – **SD**, **D**, **A**, and **SA** to each statement in the table.

Where;

Strongly Disagree (SD): To a large extent, you do NOT accept the statement as it applies to instructional quality.

Disagree (D): To some extent, you do NOT accept the statement as it applies to instructional quality.

Agree (A): To some extent, you do accept the statement as it applies to instructional quality.

Strongly Agree (SA): To a large extent, you do accept the statement as it applies to instructional quality.

		SD	D	A	SA
	Challenging level of tasks				
1	My mathematics teacher sets word problem tasks where we have to take time to think.				
2	My mathematics teacher gives word problem tasks that can be solved in several different ways.				
3	My mathematics teacher sometimes asks individual students to demonstrate several different ways of solving word problem tasks.				
4	My mathematics teacher presents word problem tasks for which there is obvious method of solution.				
5	My mathematics teacher often sets word problem tasks with hints on the appropriate solution approach.				
	Relevance of tasks				
6	My mathematics teacher provides word problem tasks that relate to our everyday life activities.				
7	My mathematics teacher provides word problem tasks that relate to our interest.				
8	My mathematics teacher provides word problem tasks that address the relevance of the mathematical concept to social activities.				
9	My mathematics teacher gives us sufficient number of word problem tasks as exercises.				
10	My mathematics teacher gives word problem tasks that borders on all sections of the topic taught.				
	Activation of prior knowledge				
11	My mathematics teacher lets us use our own strategies to solve word problem tasks.				
12	My mathematics teacher sometimes lets us go straight forward in working on word problem tasks using previous knowledge.				
13	My mathematics teacher sometimes lets us carry on with our mistakes until we see that something must be wrong.				

14	My mathematics teacher presents a short summary of the previous lesson at the beginning of a lesson on word problems.				
15	My mathematics teacher presents word problem tasks that require us to apply what we have learnt to new contexts.				
	Explanations				
16	My mathematics teacher often involves students in oral questions.				
17	My mathematics teacher asks students to present our thinking about a word problem tasks at some length.				
18	My mathematics teacher asks students to explain how we have solved a word problem tasks.				
	Feedback				
19	My mathematics teacher asks questions to check whether students have understood the approach to solving word problem tasks.				
20	My mathematics teacher tells individual student about how well he/she is doing in solving word problem tasks.				
21	My mathematics teacher gives me feedback on my strengths and weaknesses in word problem tasks.				
22	My mathematics teacher checks whether students have understood the lesson when he/she is teaching word problems				
23	My mathematics teacher checks whether students are completing their word problem tasks correctly				
24	My mathematics teacher gives feedback on the way students arrive at the answers to word problem tasks				
	Adaptive support				
25	My mathematics teacher lets students solve word problem tasks according to our personal preferences.				
26	My mathematics teacher always addresses problems students encounter when solving word problem tasks.				
27	My mathematics teacher always takes time to talk if students want to discuss word problem challenges with him/her.				

28	My mathematics teacher gives students the opportunity to express opinions about a word problem task.					
29	My mathematics teacher helps students to learn from mistakes made in solving word problem tasks.					
30	My mathematics teacher provides extra help on solving word problems when needed.					
	Technology-integrated teaching					
31	My mathematics teacher provides images of real life situations for us to formulate word problems					
32	My mathematics teacher gives word problem tasks that can easily be solved using computers and calculators.					
33	My mathematics teacher encourages students to support the formulation of word problem tasks with sketches/tables.					
34	My mathematics teacher insists that students support the solutions of word problem tasks with sketches/tables.					
35	My mathematics teacher uses technology tools such as graphs, pictures, calculators or computers in class to improve our engagement with the content and class.					
36	My mathematics teacher makes audio/video recordings of supplementary content material accessible.					
37	My mathematics teacher makes it possible for students to be able to access audio/video recordings of lessons on word problems.					
38	My mathematics teacher often uses whole group presentation style such as PowerPoint or other instructional software to demonstrate word problem tasks.					

Appendix D: Reliabilities Internal Consistencies of Factors Extracted from Exploratory factor analysis

Factor ID	Factor name	Item code	Correlations	Alpha (∝)	CR	N
1	Teacher feedback	SS22	0.878	0.885	0.904	5
		SS21	0.832			
		SS23	0.810			
		SS20	0.760			
		SS24	0.760			
2	Challenging level of task	CA4	0.916	0.876	0.904	4
		CA3	0.871			
		CA5_R	0.786			
		CA2	0.772			
3	Adaptive support	SS28	0.793	0.783	0.828	5
		SS27	0.743			
		SS26	0.707			
		SS29	0.696			
		SS30	0.553			
4	Prior knowledge activation	CA15	0.854	0.740	0.864	4
		CA12	0.801			
		CA13	0.754			
		CA14	0.718			
5	Relevance of task	CA8	0.780	0.795	0.821	4
		CA6	0.774			
		CA9	0.730			
		CA7	0.635			
6	Explanations	CA16	0.845	0.800	0.865	3
		CA17	0.820			
		CA18	0.812			

Appendix E: Word Problem Achievement Test

Achievement test

This achievement test is in two sections. Section A relates to word problem tasks which seek to examine your ability to translate and solve mathematics word problems in equations and inequalities. Section B tests your ability to comprehend instructional terms and decode algebraic symbols and vocabulary.

Kindly provide your solutions to the questions in the spaces provided. Your performance in this test would solely be for this research. Note that your identity is not required.

Section A: Word Problem Tests

This section has two parts. Part I has a set of four multiple choice questions. Choose the **most appropriate response** from the alternatives A to D. Part II also has two questions that require you to show workings on how you arrived at your answers (on the extra paper provided).

Part I

1. A stationary shop requires that Kwame spends GH₵ 4.00 or more if he wants to pay using mobile money. A pen costs GH₵ 0.80 each. An exercise book costs GH₵1.20. If d represents the number of pens Kwame needs to buy to pay for 1 exercise book and the pens using mobile money, which of the following inequalities **best** models the situation described above?
   A. $0.8(d + 1.2) > 4$
   B. $0.8(d + 1.2) \geq 4$
   C. $0.8d + 1.2 > 4$
   D. $0.8d + 1.2 \geq 4$
2. Twice a certain number added to thrice the difference between the number and four is at least 1. The possible range of values of the number can be...
   I. $x \geq \frac{13}{5}$
   II. $x < 11$
   III. $x \leq 11$
   IV. $x \geq \frac{-11}{5}$
   A. I and IV only
   B. I and III only
   C. II and III only
   D. II and IV only

3. The length of a rectangle is 4cm more than three times its width. If the perimeter is more than 56 cm, an expression for this situation [take w to be the width and l the length of the rectangle] can be modelled as
   A. $l = 4 + 3w = 56$
   B. $3w + 4 + w > 56$
   C. $2(3w + 4) + 2w > 56$
   D. $2(3w + 4) + 2w \geq 56$
4. Afi's mother, Eno, is six years older than Afi's uncle, Wofa. Wofa will be 60 years old in two years' time. Eno's age, $\boldsymbol{e}$, is:
   A. $e = 60 + 6 - 2$
   B. $e = 60 - 6 - 2$
   C. $e = 60 + 6 + 2$
   D. $e = 60 - 6 + 2$

Part II

5. Odo had GH¢ 500.00 in a saving account at the beginning of the January, 2020. He wants to have at least GH¢ 200.00 in the account by the end of the March, 2020. However, he withdraws GH₵ 25.00 each week for food and stationary.
   A. Write an inequality that represents Odo's situation.
   B. How many weeks can Odo withdraw money from her account. Justify your answer.

6. Dadaa bought some shirts for GH¢720.00. If each shirt was GH¢2.00 cheaper, Dadaa would have received 4 more shirts. Calculate the number of shirts Dadaa bought.

7. George Boateng paid GH¢ 29 for 11 books. Some of the books were geography books, and the rest were history books. If each geography book cost GH¢ 3 and each history book cost GH¢2, write a linear algebraic equation in terms of geography and hence find the number of geography books that George Boateng can buy.

8. An SHS 2 class is planning a picnic. The cost of a permit to use a city park is GH¢ 250. To pay for the permit, there is a fee of GH¢ 0.75 for each SHS 2 student and GH¢ 1.25 for each guest who does not belong to the class. Two hundred SHS 2 students plan to attend. Write and

solve an inequality to find how many guests must attend for the class to pay for the permit.

SECTION B: Mathematics Language Competency Test

Use these instructional terms: **Solving; Simplifying; Factorising; Grouping** and **Expanding** to describe the actions being carried out in the task column. Use each term once only to answer questions 9, 10, 11, and 12.

S/N.	*Task*	*Instructional term*
9.	$x(x+3y)+2y(x+3y)=(x+3y)(x+2y)$	
10.	$2x^2-x+7-(x^2+1-6x)=x^2+5x+6$	
11.	$\frac{1}{x^2+2x+1}=\frac{x+1}{2}$ $\quad\therefore\quad$ $x=1$	
12.	$(x+2)(x+3)=x^2+2x+3x+6$	

Provide the appropriate the meaning of the **bolded texts** in each of the preamble given in the second column.

S/N	*Algebraic vocabulary/phrase*	*Meaning*
13.	Her rent is **no more than** GH₵40.00	
14.	Fosu weighed 145 kg in 2015 and weighs 190 kg in 2018. What was the rate of **change in weight**?	
15.	Adwo gave Yao **9 fewer** mangoes than expected	
16.	Afi and Enyo have GH₵ 20.00 **between them**. How much has Afi in terms of Enyo's money?	
17.	Workers are eligible for long service leave **after 10 years** of service.	

Appendix F: Item-Total Statistics on WPAT

Mathematics word problem test			Mathematics language competency test		
Item	Corrected item-total correlation	Cronbach's ∝ if Item Deleted	Item	Corrected item-total correlation	Cronbach's ∝ if Item Deleted
Q1	.294	.729	Q9	.347	.633
Q2	.207	.737	Q10	.497	.575
Q5	.521	.676	Q11	.477	.584
Q6	.481	.683	Q12	.495	.582
Q7	.699	.586	Q13	.265	.656
Q8	.655	.607	Q14	.267	.661

Appendix G: Inter-Item Correlation Matrix for Word Problem Test

	Q1	Q2	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	1											
Q2	.203	1										
Q5	.221	.108	1									
Q6	.155	.194	.395	1								
Q7	.261	.167	.484	.381	1							
Q8	.216	.167	.409	.400	.722	1						
Q9							1					
Q10							.376	1				
Q11							.219	.485	1			
Q12							.299	.335	.423	1		
Q13							.107	.101	.174	.246	1	
Q14							.093	.190	.154	.205	.246	1

Appendix H: Mathematics Teacher Interview and Student Interview

Teacher interview

Case number: …………………………………………………

Date of interview: ……………………………………………

Time of interview: ……..……………………………………

Introduction

Thank you for accepting to take part in this phase of the research. Isaac Bengre Taley is my name. I am a post-graduate student in the Mathematics & ICT Education Department of the University of Cape Coast.

This is the interview phase. It is a follow-up to the survey on students' perception of instructional quality in mathematics word problems. In this session, I am tapping into your instructional experiences in the teaching of word problems and students' performance in word problem tasks.

The responses you provide me in this interview discussion will equip me with valuable feedback in understanding the quality of word problem instruction mathematics teachers enacts in word problem lessons. You are assured of the confidentiality of your responses and person. Again, the responses provided are for this research only. After the final report is written and the results published, I will destroy the notes and audiotapes recorded herein.

Working together

Before I continue to the questions, I would want you to note the following rules guiding this discussion.

(i) This is a discussion session where there is no wrong or correct answer. I am to learn from your experience and opinion.

(ii) You are entreated to answer all questions, but you may choose not to answer those you do not feel comfortable with.

(iii) Because I would want to be accurate and quick, I would want to seek your consent to tape-record and take notes on this discussion.

(iv) However, if there is something you wish it is not recorded, feel free to prompt me to pause the recording.

(v) This discussion is likely to span for 30 minutes.

Do you have any questions or comments before we start the interview?

Please indicate your consent for the continuation of his discussion with your signature ……………………………………

Questions and probes

Background

(i) How long have you been teaching core mathematics?

(ii) What is your general impression about the inclusion of word problems in the core mathematics curriculum?

(iii) What is your general impression of your students' ability to answer word problem tasks?

Topic: Classroom instruction in word problems

1. Do you think the quality of your instruction has any influence on students' ability to solve word problem tasks? How?
2. In the light of all your instructional experiences in mathematics, what effective instructional strategies can a teacher employ to increase students' ability to solve mathematics word problems?

3. As a teacher, your paramount role is to provide quality instruction/teaching in mathematics. In your attempt to enacting quality instruction in word problems, what considerations influence the selection of your word problem tasks?
4. Irrespective of the energy and effort you put in to promote instructional quality in word problems, some students still have challenge answering word problem tasks. From your experience as a mathematics teacher, what factors could account for students' difficulty in solving word problems?
5. By integrating technology tools like calculators, computers and models in your lessons, how do you think your students' performance in solving word problem tasks and your instructional quality could be impacted?
6. Can you share with me how students' level of competence in mathematics language (such as the appropriate use of instructional terms, the meaning of operational terms) affect their ability to solve word problem tasks and/or your quality of instruction?
7. Between students' mathematics language competence and integrating technology into your teaching, which of these would have maximum impact on the quality of instruction in mathematics word problems?
8. How does the categorisation of schools have any impact on
   a) your quality of instruction in mathematics word problems?
   b) students' ability to solve mathematics word problems?

Conclusion

I think that should be all the questions I wanted to ask. If you have any final thought about classroom instruction on word problems and student's mathematics language competence, you are at liberty to share with me. Otherwise, we end here.

Student interview

Case number: ………………………………………………………

Date of interview: ………………………………………………

Time of interview: ……..…………………………………………

Introduction

Thank you for accepting to take part in this phase of the research. Isaac Bengre Taley is my name. I am a post-graduate student in the Mathematics & ICT Education Department of the University of Cape Coast.

This is the interview phase. It is a follow-up to the survey on students' perception of instructional quality in mathematics word problems. This session will help me gain an in-depth understanding of the survey results.

You are assured of the confidentiality of your responses and person. Again, the responses you will provide are for this research only. After the final report is written and the results published, I will destroy the notes and audiotapes recorded herein.

Working together

Before I continue to the questions, I would want you to note the following rules guiding this discussion.

(i) This is a discussion session where there is no wrong or correct answer. I am to learn from your experience and opinion.

(ii) You are entreated to answer all questions, but you may choose not to answer those you do not feel comfortable with.

(iii) Because I will want to be accurate and quick, I will want to seek your consent to tape-record and take notes on this discussion.

(iv) However, if there is something you wish it is not recorded, feel free to prompt me to pause the recording.

Questions and probes

(i) You and your colleagues performed well in the test (or gave a high rating of the quality of instruction in word problems).

What is the magic?

Is it because of the category of your school?

(ii) Based on your experience in solving mathematics tasks, do you like mathematics word problem tasks?
Why?

(iii) Why do you and/or your colleagues underperform in solving word problems

1. Do you think the way your teacher teaches can influence your ability to solve word problem tasks?

   How do you explain that?

2. What do you expect your teachers to do so that your ability to perform word problem tasks will improve?

3. Kindly help me understand some activities your teacher takes you through when teaching word problems

4. How do you think your competence/mastery in mathematics language affects your ability to understand your word problem lessons and solve word problems?

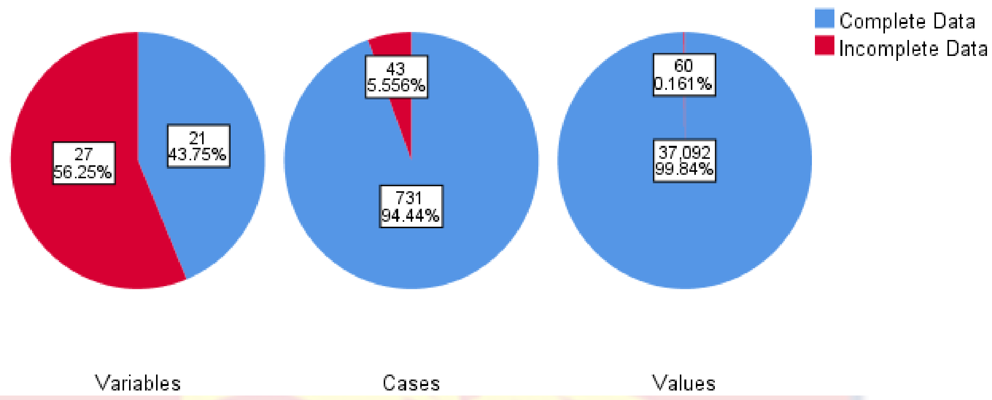
5. Do your teachers integrate technology tools in teaching word problems?
6. How do you think the integration of technology tools in teaching word problems can help you understand your word problem lessons and improve your performance in solving word problems?

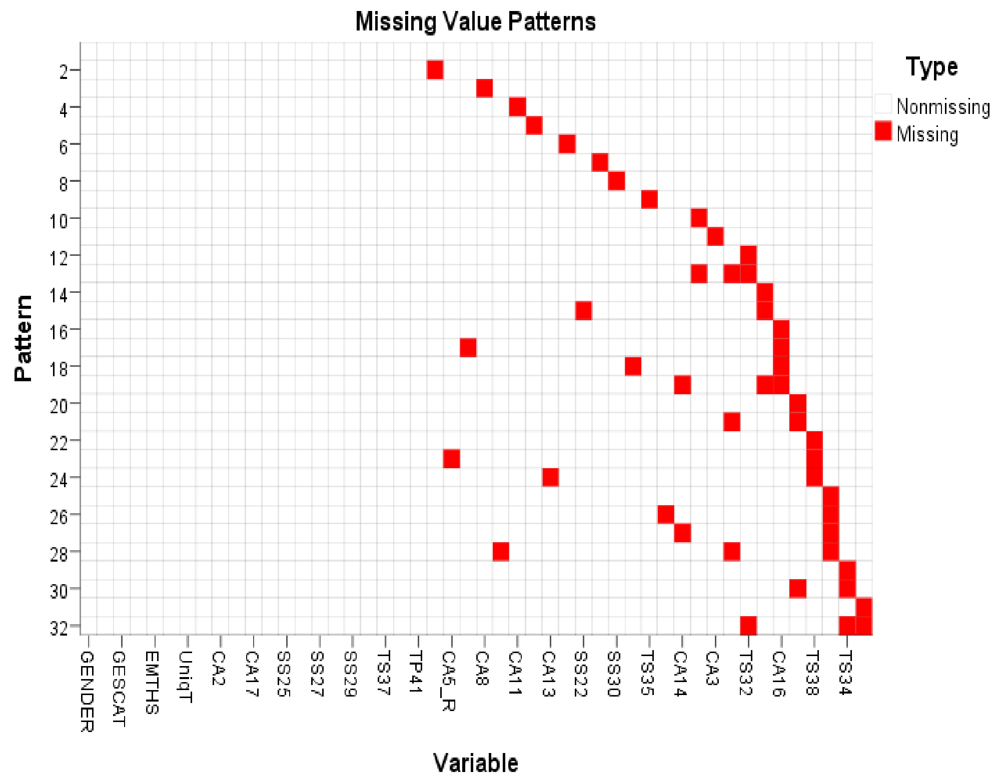
Conclusion

I think that should be all the questions I wanted to ask. If you have any final thought about classroom instruction on word problems and student's mathematics language competence, you are at liberty to share with me. Otherwise, we end here.

Thank you very much for being part of this study.

Appendix I: Distribution of Missing Data in the SPIQQ Survey-



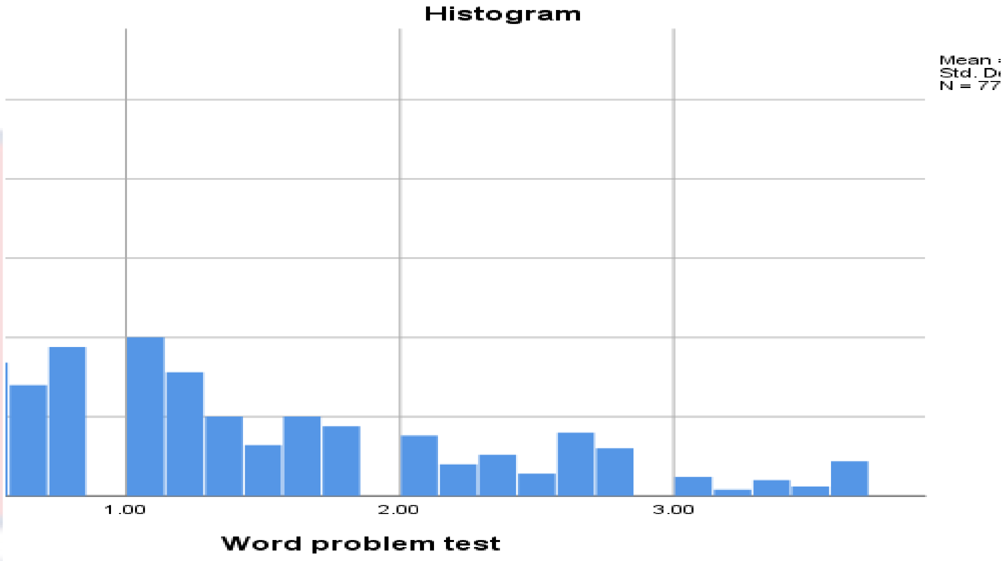


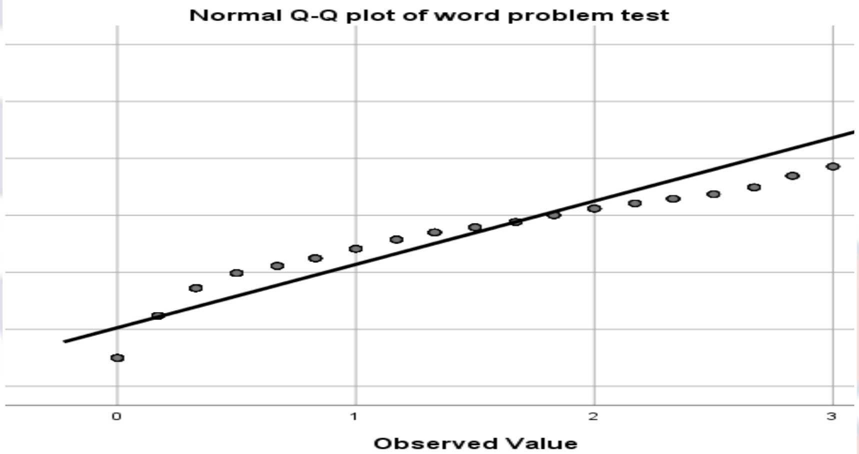
Appendix J: Item Difficulty and Discrimination Analysis of the Word Problem Achievement Test Items – main study

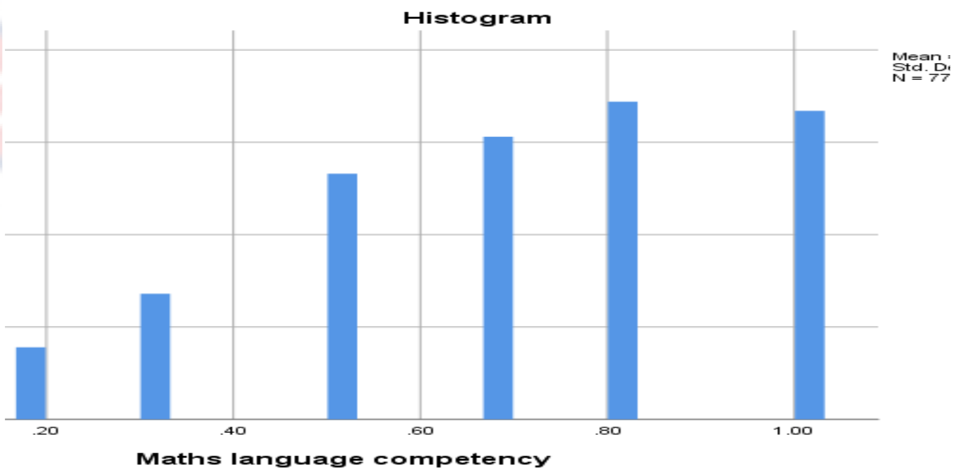
Item	UAG	LAG		Difficulty (IDI) %		Discrimination (DI)		Decision
				Value	Interpretation	Value	Interpretation	
Word problem test score								
1	204	26		55.0	Excellent	0.43	Excellent	Retained
2	182	21		48.6	Excellent	0.39	Excellent	Retained
3	205	147		84.2	Good	0.14	Poor	Retained
4	186	48		56.0	Excellent	0.33	Good	Retained
	$\bar{X}_U$	$\bar{X}_L$	MS	$\bar{X}_P$				
5	2.2679	0.3206	5	49.1	Excellent	0.42	Excellent	Retained
6	0.3206	0.0622	5	7.7	Too difficult	0.05	Poor	Removed
7	1.4641	0.0574	5	30.4	Good	0.28	Good	Retained
8	1.3589	0.0957	5	29.1	Good	0.25	Good	Retained
Mathematics language competence score								
9	181	63		58.4	Excellent	0.28	Good	Retained
10	190	23		51.0	Excellent	0.40	Excellent	Retained
11	198	51		59.6	Excellent	0.35	Excellent	Retained
12	205	69		65.6	Good	0.33	Good	Retained
13	193	114		73.4	Good	0.19	Marginal	Retained
14	194	60		60.8	Good	0.32	Good	Retained
15	157	72		54.8	Excellent	0.20	Marginal	Retained
16	68	13		19.4	Too difficult	0.13	Poor	Removed
17	98	25		29.4	Good	0.17	Marginal	Retained

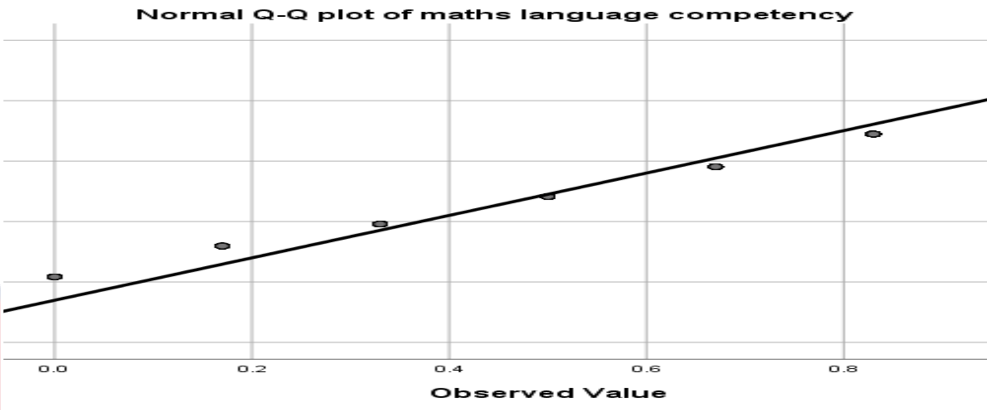
(UAG/LAG: Upper/Lower adjusted groups, $\bar{X}_U$: mean score of the upper group, $\bar{X}_L$: mean score of the lower group, MS: item maximum score, $\bar{X}_P$: mean proportion of mark scored by all students who attempted the question).

Appendix K: Univariate Normal Test Plots for Word Problem Test and Mathematics Language Competence Test

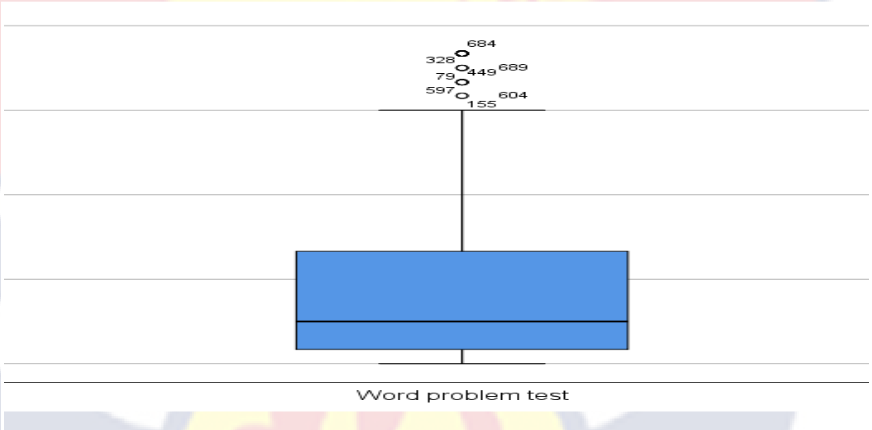




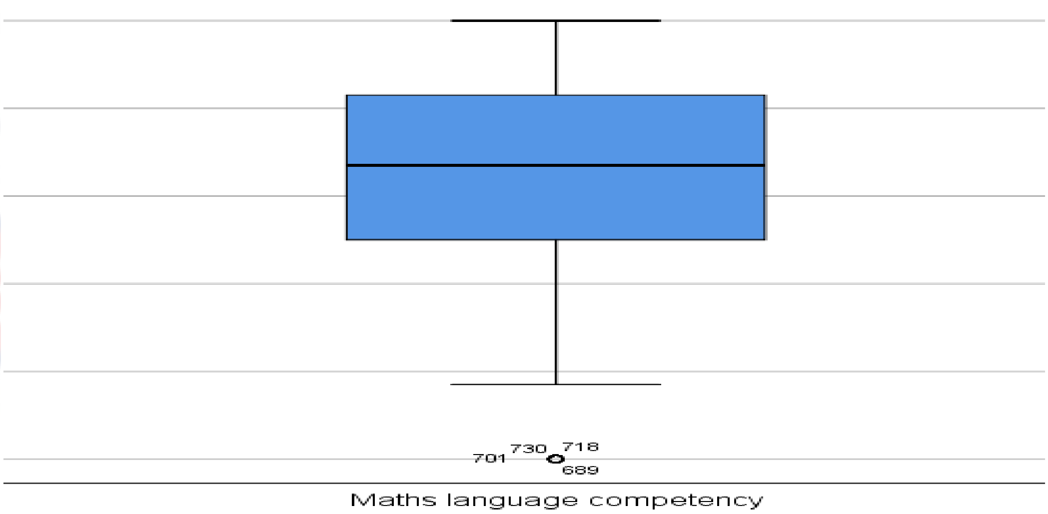




Normal Q-Q plot of maths language competency
0.0
0.2
0.4
0.6
0.8
Observed Value



684
328
689
449
79
597
604
155
Word problem test



730
718
701
689
Maths language competency

Appendix L: Kaiser-Meyer-Olkin (KMO) Value for each item of Instructional Quality (N = 30 items)

Item	KMO	Item	KMO	Item	KMO
CA1	.941[a]	CA11	.821[a]	SS21	.811[a]
CA2	.910[a]	CA12	.744[a]	SS22	.787[a]
CA3	.807[a]	CA13	.783[a]	SS23	.875[a]
CA4	.758[a]	CA14	.760[a]	SS24	.868[a]
CA5_R	.844[a]	CA15	.691[a]	SS25	.855[a]
CA6	.815[a]	CA16	.759[a]	SS26	.876[a]
CA7	.891[a]	CA17	.792[a]	SS27	.888[a]
CA8	.824[a]	CA18	.808[a]	SS28	.877[a]
CA9	.860[a]	SS19	.726[a]	SS29	.889[a]
CA10	.852[a]	SS20	.900[a]	SS30	.943[a]

a. Measures of Sampling Adequacy (MSA)

Appendix M: Exploratory Factor Analysis Tables and Figures

Communalities

Item	Initial	Extraction	Item	Initial	Extraction
CA1	1.000	0.342	SS20	1.000	0.635
CA2	1.000	0.609	SS21	1.000	0.721
CA3	1.000	0.807	SS22	1.000	0.779
CA4	1.000	0.884	SS23	1.000	0.730
CA5_R	1.000	0.656	SS24	1.000	0.649
CA6	1.000	0.581	SS25	1.000	0.464
CA7	1.000	0.418	SS26	1.000	0.564
CA8	1.000	0.591	SS27	1.000	0.572
CA9	1.000	0.585	SS28	1.000	0.644
CA10	1.000	0.324	SS29	1.000	0.528
CA11	1.000	0.448	SS30	1.000	0.420
CA12	1.000	0.660	TS31	1.000	0.347
CA13	1.000	0.622	TS32	1.000	0.541
CA14	1.000	0.530	TS33	1.000	0.691
CA15	1.000	0.723	TS34	1.000	0.714
CA16	1.000	0.738	TS35	1.000	0.585
CA17	1.000	0.722	TS36	1.000	0.657
CA18	1.000	0.681	TS37	1.000	0.686
SS19	1.000	0.630	TS38	1.000	0.573

Extraction Method: Principal Component Analysis.

Component correlation matrix

Component	1	2	3	4	5	6	7	8	9
1	1								
2	.089	1							
3	-.330	-.085	1						
4	-.003	.119	-.076	1					
5	-.203	-.005	.196	-.051	1				
6	.209	.043	-.169	.072	-.191	1			
7	-.253	-.074	.160	-.141	.276	-.177	1		
8	.150	.141	-.117	.090	-.111	.087	-.149	1	
9	.016	.242	-.019	-.011	-.036	.024	-.019	.018	1

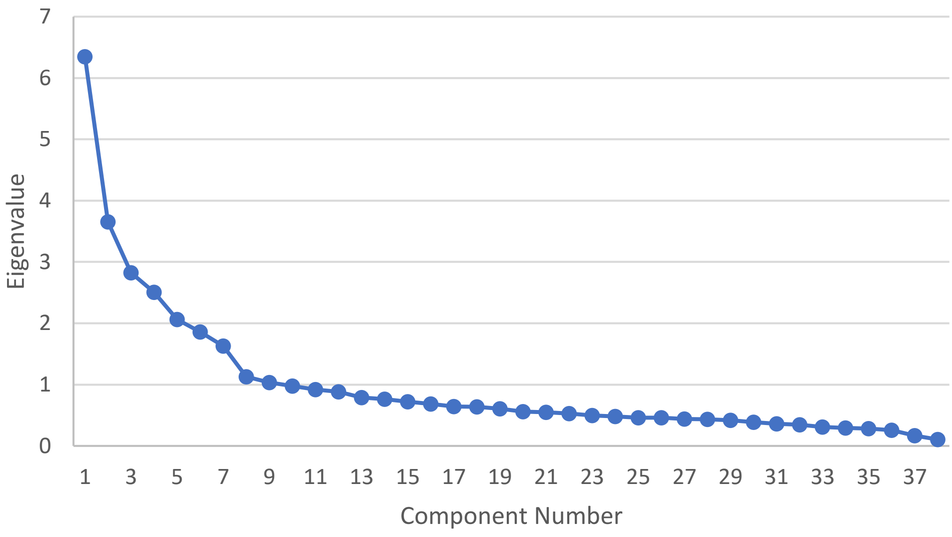
Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Total variance explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.083	20.276	20.276	3.461	11.537	11.537
2	2.822	9.407	29.683	3.106	10.355	21.892
3	2.548	8.493	38.176	2.855	9.518	31.410
4	2.033	6.778	44.954	2.689	8.962	40.372
5	1.856	6.187	51.141	2.546	8.486	48.858
6	1.627	5.423	56.564	2.155	7.185	56.043
7	1.130	3.767	60.331	1.286	4.288	60.331
8	.921	3.069	63.400			
9	.875	2.915	66.315			
10	.785	2.617	68.932			
11	.771	2.571	71.502			
12	.706	2.352	73.854			
13	.669	2.230	76.084			
14	.649	2.164	78.249			
15	.632	2.107	80.355			
16	.572	1.907	82.262			
17	.548	1.826	84.088			
18	.539	1.796	85.885			
19	.505	1.685	87.569			
20	.477	1.589	89.158			
21	.461	1.538	90.696			
22	.444	1.479	92.175			
23	.429	1.430	93.605			
24	.388	1.293	94.898			
25	.365	1.218	96.116			
26	.318	1.059	97.175			
27	.299	.997	98.171			
28	.270	.900	99.071			
29	.173	.576	99.647			
30	.106	.353	100.000			

Extraction Method: Principal Component Analysis.

Scree plot


7
6
5
4
3
2
1
0
Eigenvalue
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37
Component Number

Rotated component matrix[a]

	Component						
	1	2	3	4	5	6	7
SS22	0.878						
SS21	0.827						
SS23	0.810						
SS24	0.762						
SS20	0.754						
CA4		0.908					
CA3		0.868					
CA5_R		0.780					
CA2		0.774					
SS28			0.787				
SS27			0.726				
SS26			0.700				
SS29			0.687				
SS30			0.545				
CA8				0.752			
CA6				0.752			
CA9				0.743			
CA7				0.613			
CA10				0.531			
CA1		0.366		0.369			
CA15					0.846		
CA12					0.792		
CA13					0.753		
CA14					0.718		
CA16						0.842	
CA17						0.820	
CA18						0.806	
SS19							0.730
CA11							0.586
SS25			0.389				0.532

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Appendix N: Monte Carlo PCA for Parallel Analysis Version

Number of variables: 30

Number of subjects: 774

Number of replications: 30

Eigenvalue Number	Random Eigenvalues	Standard Dev
1	1.3922	0.0286
2	1.3343	0.0214
3	1.2983	0.0209
4	1.2574	0.0163
5	1.2267	0.0144
6	1.2018	0.0135
7	1.1763	0.0151
8	1.1505	0.0126
9	1.1289	0.0164
10	1.1057	0.0139
11	1.0802	0.0127
12	1.0584	0.0118
13	1.039	0.0116
14	1.0188	0.0107
15	0.9988	0.0115
16	0.9791	0.0102
17	0.9591	0.0111
18	0.94	0.0114
19	0.9192	0.012
20	0.898	0.0118
21	0.8772	0.0116
22	0.8574	0.0108
23	0.839	0.0136
24	0.8232	0.0132
25	0.7997	0.0133
26	0.7764	0.0114
27	0.7564	0.0122
28	0.731	0.0175
29	0.7053	0.0139
30	0.6718	0.0173

5/22/2021 8:30:41 AM

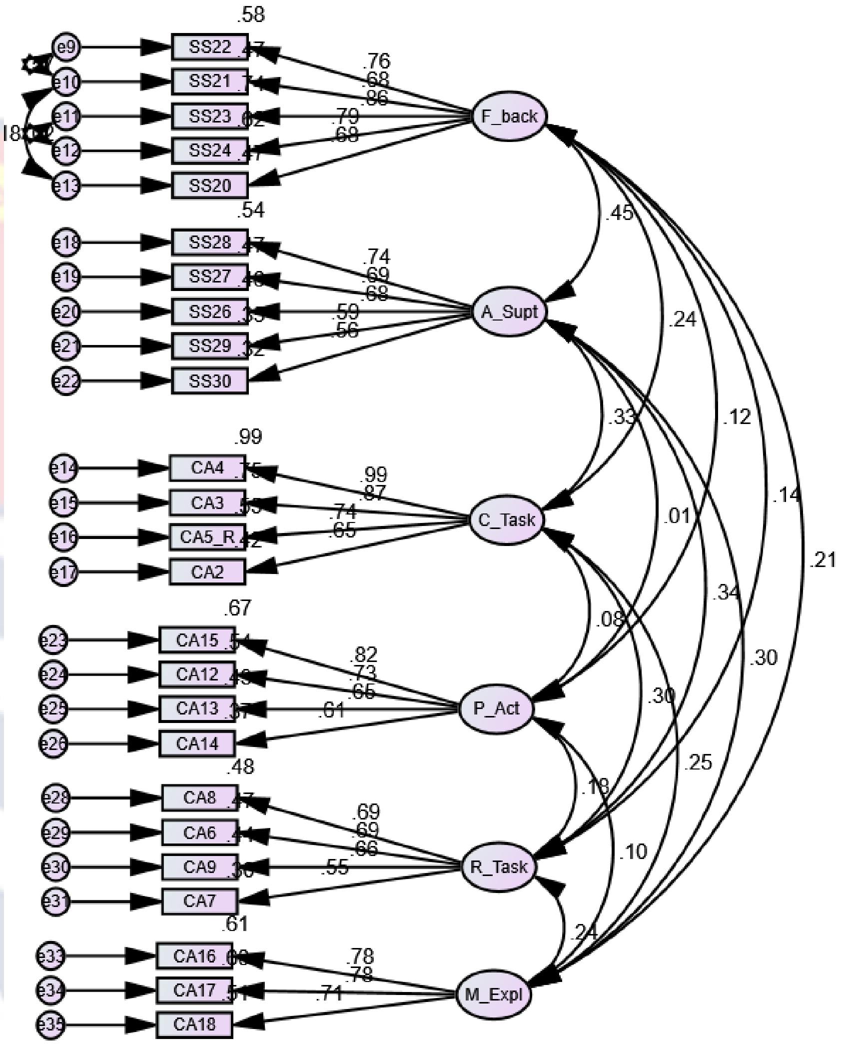
Monte Carlo PCA for Parallel Analysis ©2000 by Marley W. Watkins.

Appendix O: Index Category and the Level of Acceptance for every Index

Name of category	Index full name	Name of index	Level of acceptance	Comments
1. Absolute fit	Discrepancy Chi Square	Chisq	> 0.05	Sensitive to sample size >200
	Root Mean Square of Error Approximation	RMSEA	< 0.08	Range 0.05 to 0.1 is acceptable
	Goodness of Fit Index	GFI	> 0.90	GFI = 0.95 is a good fit
2. Incremental fit	Adjusted Goodness of Fit	AGFI	> 0.90	AGFI = 0.95 is a good fit
	Comparative Fit Index	CFI	> 0.90	CFI = 0.95 is a good fit
	Tucker-Lewis Index	TLI	> 0.90	TLI = 0.95 is a good fit
	Normed Fit Index	NFI	> 0.90	NFI = 0.95 is a good fit
3. Parsimonious fit	Chi Square/Degrees of Freedom	Chisq/df	< 5.0	The value should be less than 5.0.

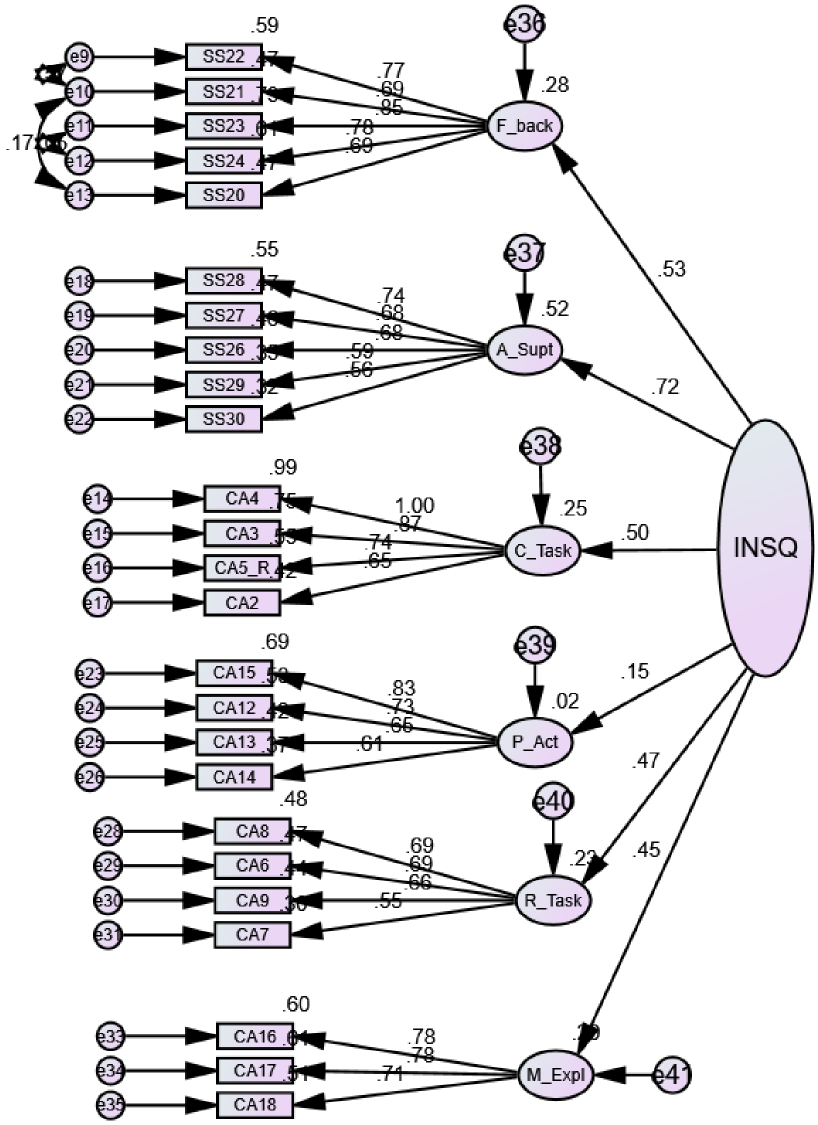
Source: Zainudin (2012, pp. 64–65)

Appendix P: First-order CFA Covariances of the Dimensions of Instructional Quality (Model 1)



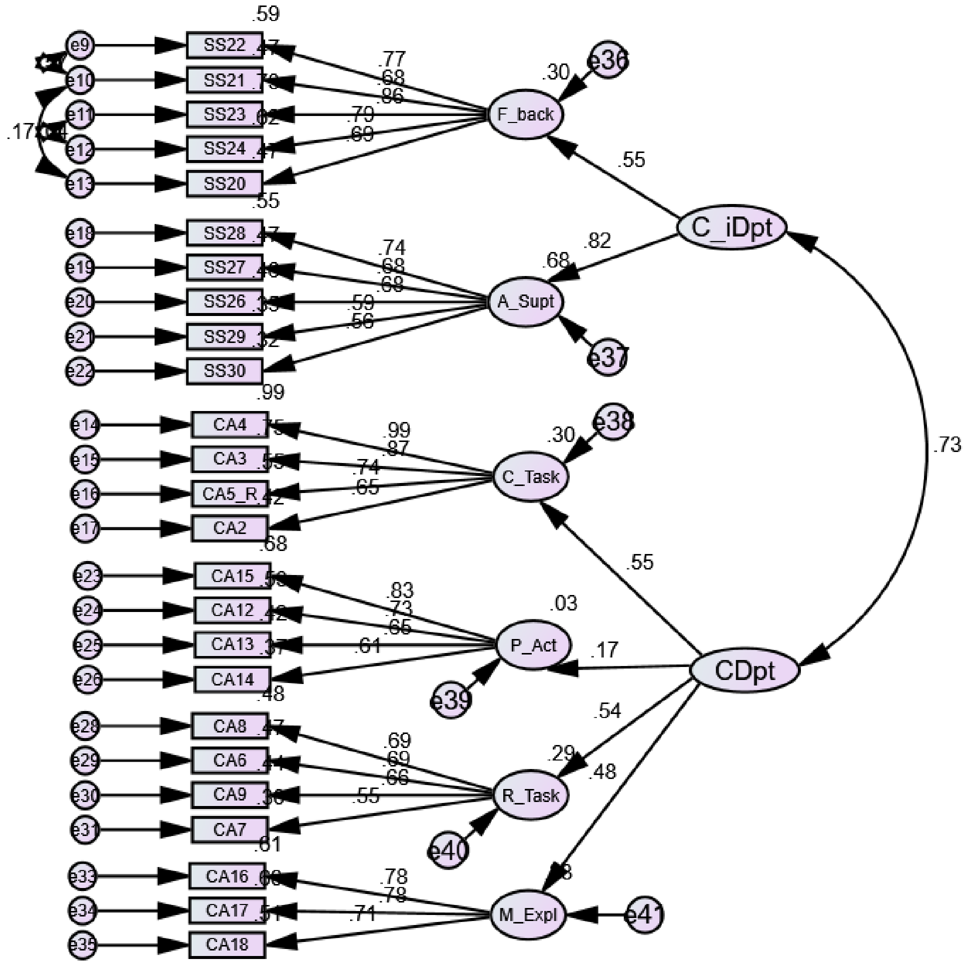
F_back = Teacher feedback; C_Task = Challenging level of tasks; A_supt = Adaptive support; T_instr = Technology-integrated teaching; P_Act = Activation of prior knowledge; and M_Expl = Explanations.

Appendix Q: Second-order CFA Standard Regression Weights of the Dimensions of Instructional Quality (Model 2)



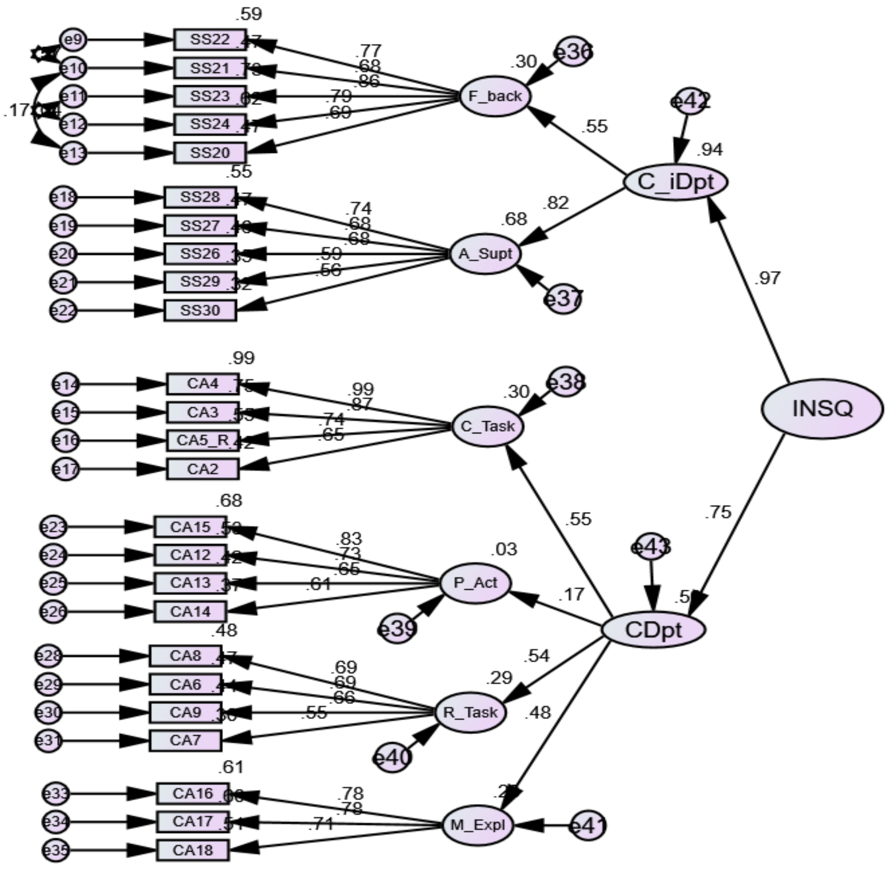
INSQ = Instructional quality

Appendix R: Third-order CFA of the Content-dependent and Content-independent Constructs underlying Instructional Quality (Model 3)



Con_Indept = Content-independent construct; Con_Dept = Content-dependent construct

Appendix S: Path Diagram of the Conceptual Frame of Instructional Quality



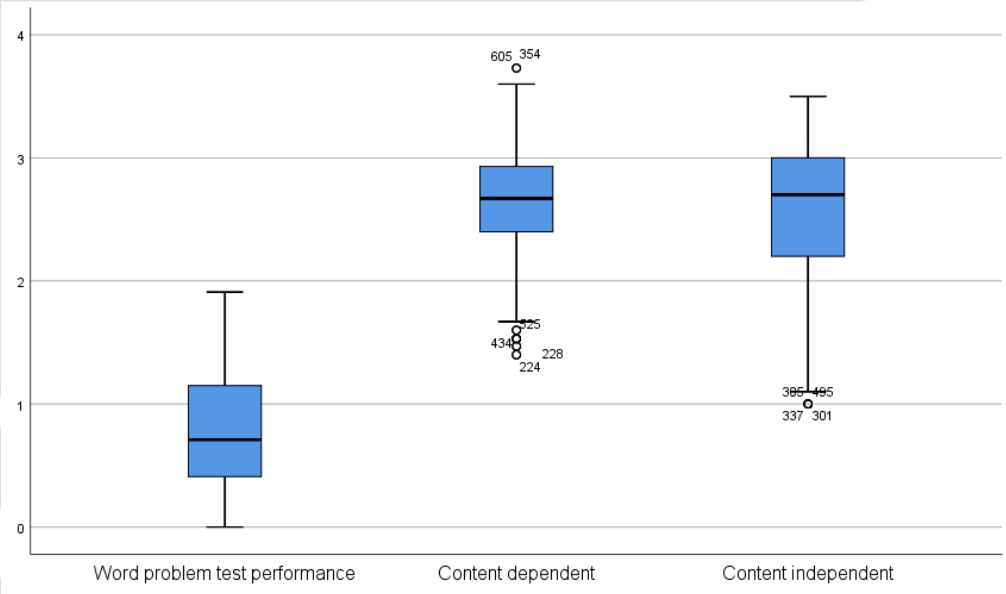
Appendix T: Summary of Instructional Activities defining Instructional Quality

Themes	Files	References	Description	Evidence – student	Evidence – teacher
Defining instructional quality	28	190			
Content-dependent	28	112			
Activation of previous knowledge	16	19	Potential of instruction to draw on and activate students' prior knowledge	"sometimes he does not just introduce the topic class, but in fact, you like you give us certain clues, asks us certain questions, for us we students also to make inferences" DST 1	"Besides, whenever, you are about to teach, the first thing to do is maybe to try to review what they already know" ATR 3
Challenging level of tasks	23	41	Appropriate tasks concerning students' ability and curriculum standard	"The teacher sometimes solves past questions with us. I like the past questions because they are challenging" DST 3	"I need to consider each group. I cannot pick a complex question for the whole period. If I do that, I will be doing injustice to that other group of students. so, I'll pick two complex questions, and two less complex questions so that every student in the class will be taken care of" CTR 2
Mathematical explanations	12	18	Opportunities created to elicit students' thinking through explanation	"He also allows us to explain how we got our equations. After we solve the question, he gives us the marker for us to present our solution on the board and explain" FST 2	"the students explain the statement and try to use variables to represent the statement they have written" DTR 1

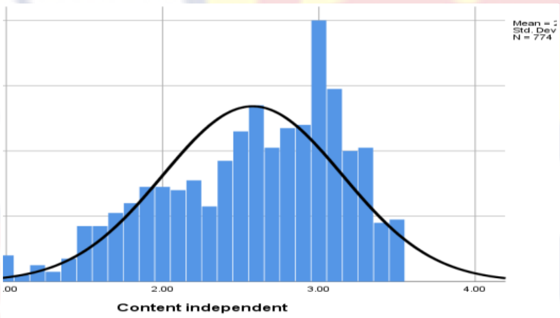
Relevance of tasks	14	23	Relevance of word problem tasks to students' context	"he links the word problem questions to real life problems like buying and selling rice, sugar and books" AST 3	"make it the reality for them, that is bring in their situation level like going to buy something using money" FTR 2
Content-independent	25	78			
Adaptive support	25	52	Teachers' monitoring and attending to the learning needs of students	"involves not only the teaching of a particular academic skills but as importantly, the fostering of students' self-esteem, reinforcing self-esteem in the classroom is associated with increased motivation and learning of word problems" AST 1	"I attend to students individually. I try to solve their problems for he/she to understand. Once you get the concept, that is it" FTR 1
Feedback	10	14	Teachers' feedback to students	"When he marks our exercises, he will call us to show us our mistake" DST 4	"Some of the students do come to me to show me how they have solve a problem related to what I have taught them" DTR 3
Relevant instructional resources	9	12	Teacher's use of instructional resources to advance students' learning	"He uses materials to make us feel the physical means of solving the word problem questions" AST 3	"Using more instructional materials to make the make lessons practical is good to engage students in solving word problems" CTR 2

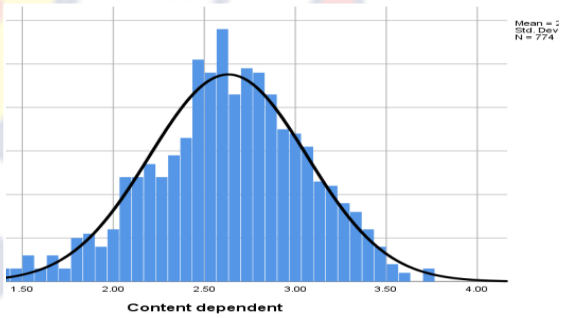
Appendix U: Diagrams and Tables for Multiple Regression Assumptions on Word Problem Test Scores, Content-dependent and Content-independent Dimensions

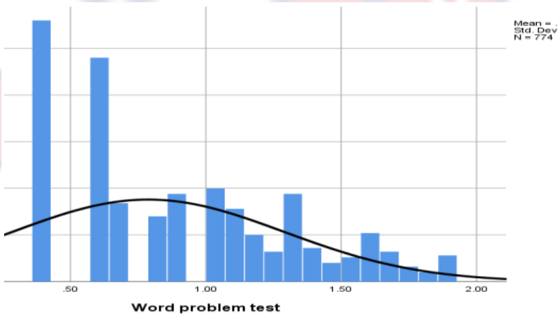
Box plots (Normality)



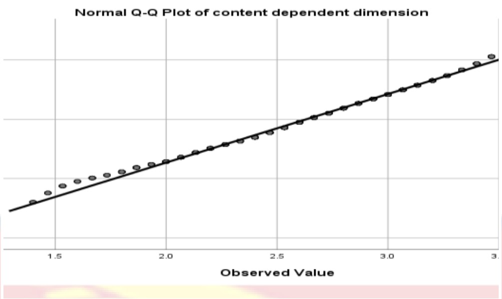
Histograms (Normality)

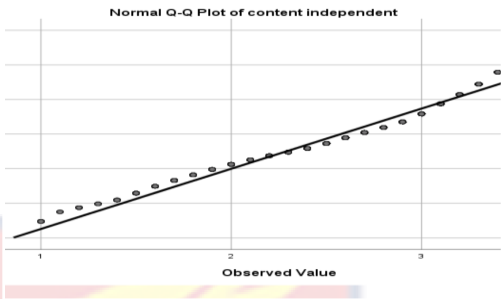


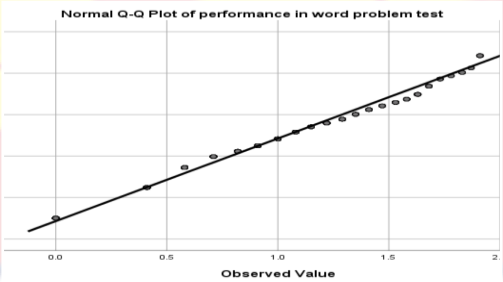




Q-Q plots (Normality)



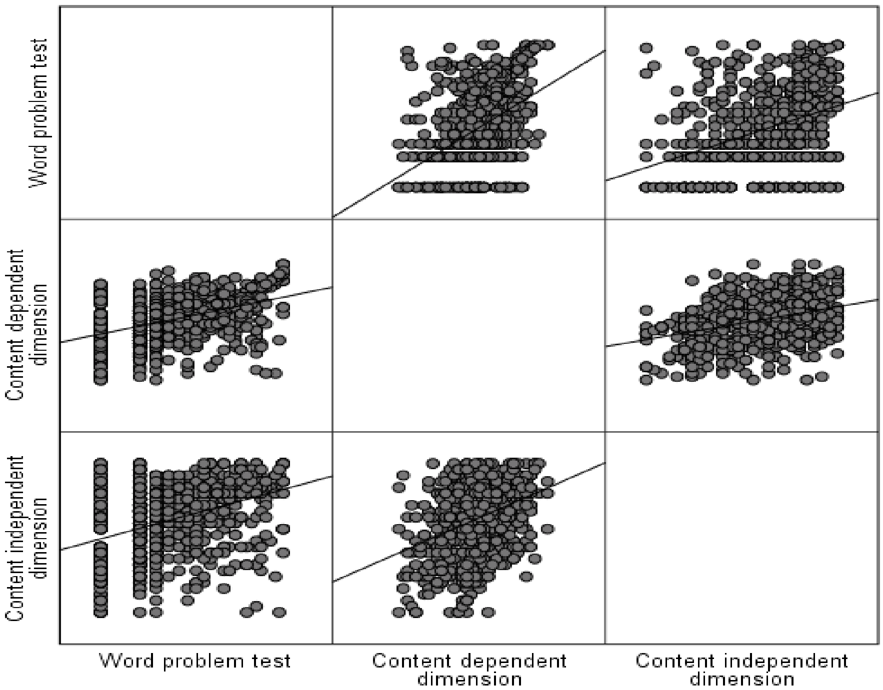




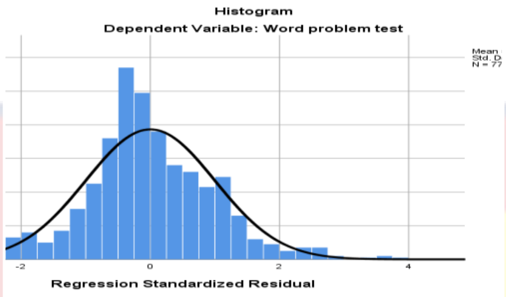
Skewness and Kurtosis

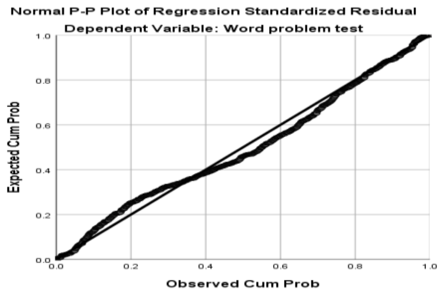
Variables	Skewness	SE	z scores	Kurtosis	SE	z scores
Word problem test	.241	.088	2.744	-.681	.176	-3.880
Content dependent	-.254	.088	-2.886	-.056	.176	-0.318
Content independent	-.571	.088	-6.496	-.435	.176	-2.476

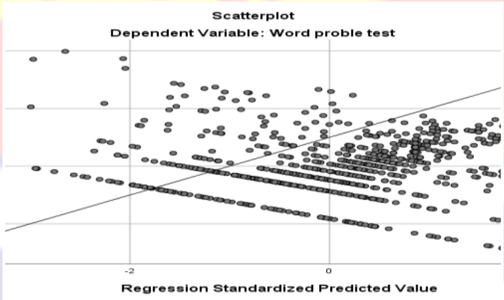
Scatter plots (Linearity test)



Heteroscedasticity (Independence of residuals)





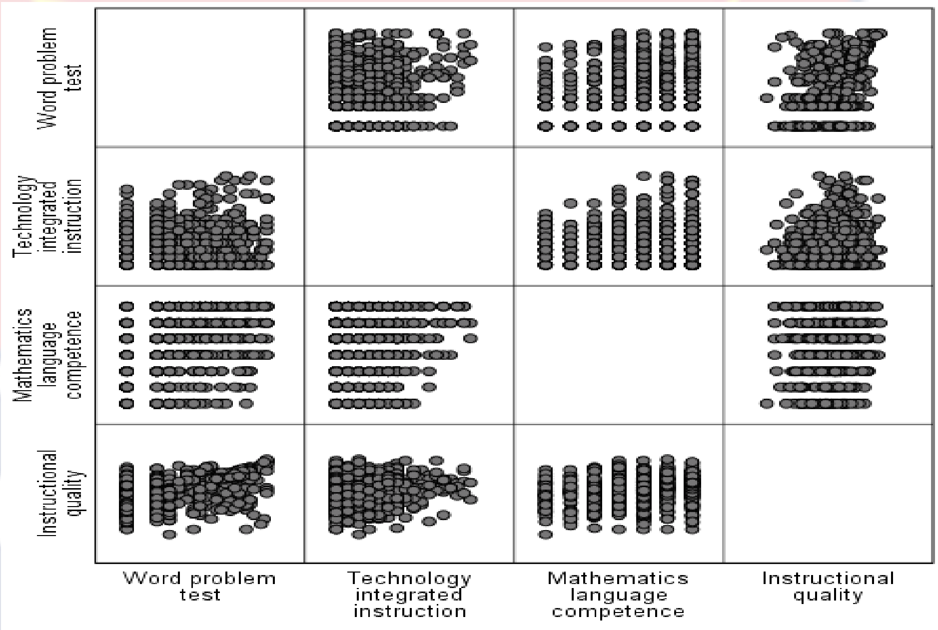


Collinearity statistics

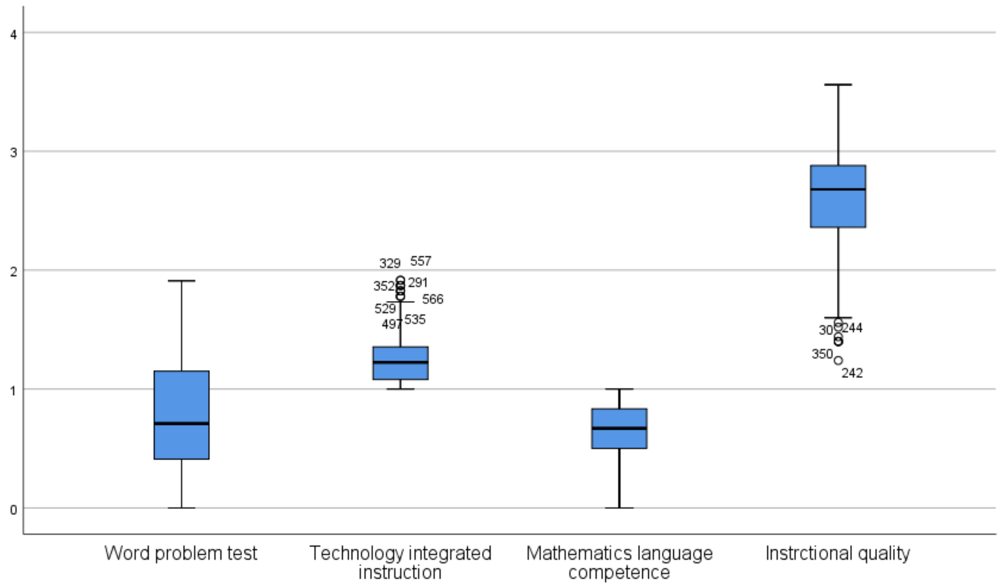
	Collinearity Statistics		Durbin-Watson
	Tolerance	VIF	
Model			1.624
Content dependent dimension	.877	1.141	
Content independent dimension	.877	1.141	

Appendix V: Diagrams and Tables for Multiple Regression Assumptions on Word Problem Test Scores, Mathematics Language Competence, Technology-integrated Teaching and Word Problem Test Scores

Scatter plot (Linearity)



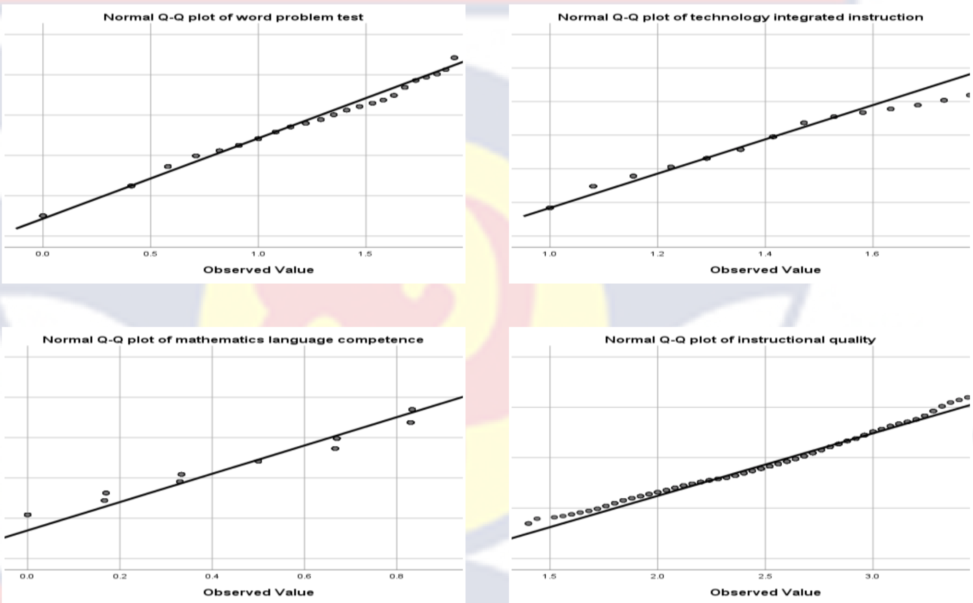
Box plots (Normality)



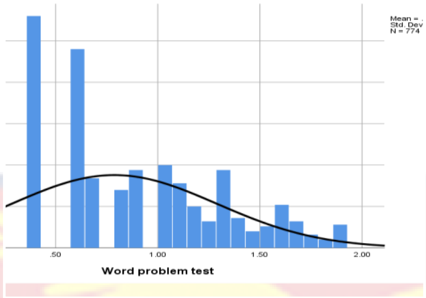
Skewness and Kurtosis

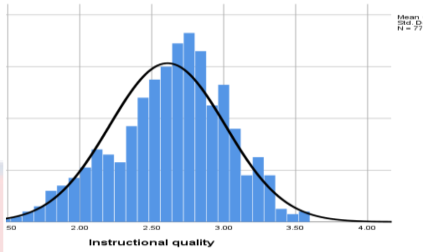
	Skewness			Kurtosis		
	Value	SE	z	Value	SE	z
Word problem test	.241	.088	2.744	-.681	.176	-3.880
Instructional quality	-.458	.088	-5.211	.065	.176	.370
Maths language competence	-.646	.088	-7.347	-.380	.176	-2.164
technology-integ. teaching	.735	.088	8.361	.306	.176	1.743

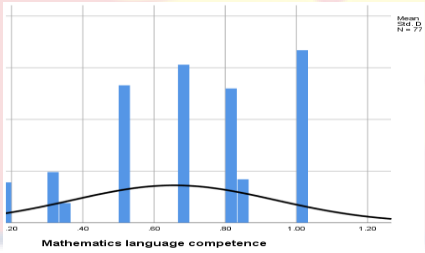
Q-Q plots (Normality)

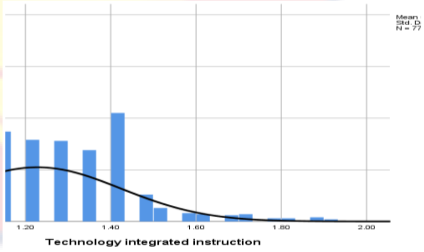


Histogram (normality)





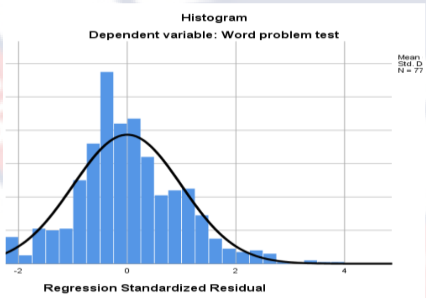


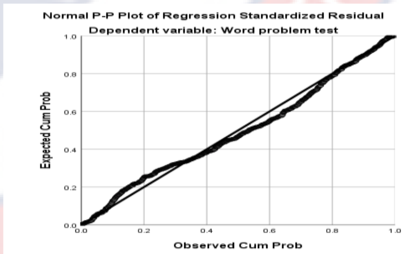


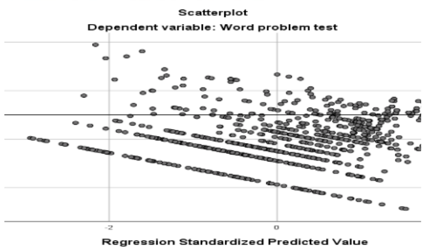
Collinearity statistics

	Collinearity Statistics		Durbin-Watson
	Tolerance	VIF	
Model			1.541
Technology-integrated instruction	.985	1.016	
Mathematics language competence	.938	1.066	
Instructional quality in mathematics	.936	1.068	

Heteroscedasticity (Independence of residuals)







Appendix W: Johnson-Neyman Output of Conditional Effect of Focal Predictor at Values of the Moderator

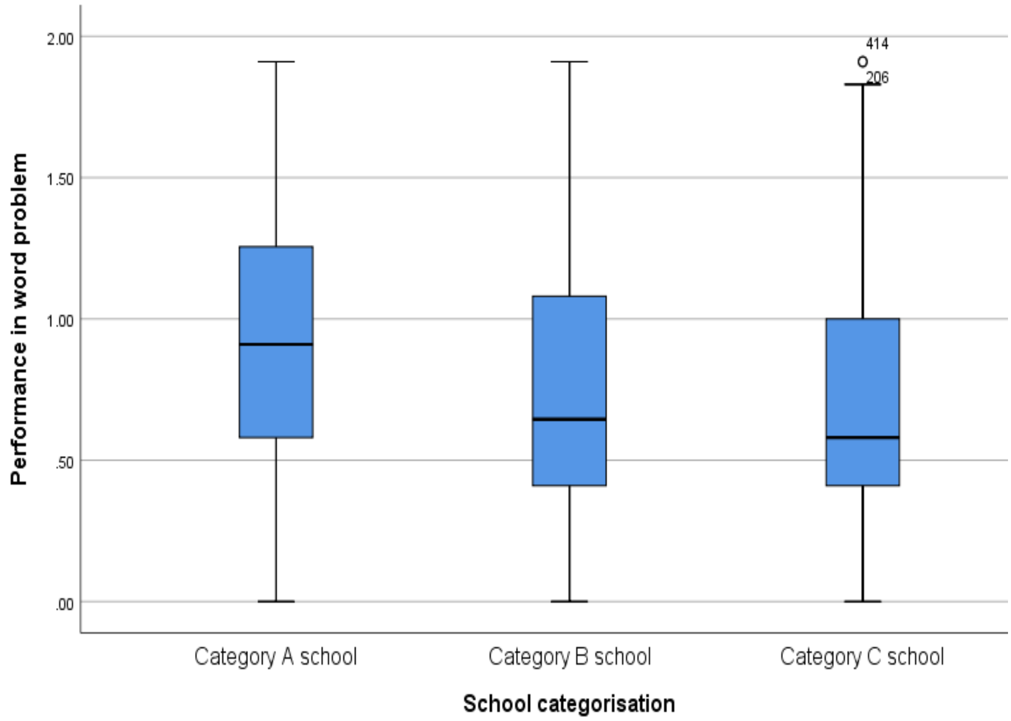
Tech integrated teaching	Effect	SE	t	p	LLCI	ULCI
-0.228	0.714	0.057	12.587	0	0.603	0.825
-0.182	0.695	0.05	13.828	0	0.596	0.793
-0.136	0.675	0.045	15.069	0	0.587	0.763
-0.091	0.656	0.041	16.042	0	0.576	0.736
-0.045	0.637	0.039	16.358	0	0.56	0.713
0.001	0.617	0.039	15.749	0	0.54	0.694
0.047	0.598	0.042	14.348	0	0.516	0.68
0.092	0.579	0.046	12.577	0	0.488	0.669
0.138	0.559	0.052	10.814	0	0.458	0.661
0.184	0.54	0.058	9.243	0	0.425	0.654
0.23	0.52	0.066	7.912	0	0.391	0.65
0.275	0.501	0.074	6.806	0	0.357	0.646
0.321	0.482	0.082	5.888	0	0.321	0.642
0.367	0.462	0.09	5.123	0	0.285	0.64
0.413	0.443	0.099	4.48	0	0.249	0.637
0.458	0.424	0.108	3.936	0	0.212	0.635
0.504	0.404	0.117	3.47	0.001	0.176	0.633
0.55	0.385	0.125	3.068	0.002	0.139	0.631
0.596	0.366	0.135	2.718	0.007	0.102	0.63
0.641	0.346	0.144	2.412	0.016	0.064	0.628
0.687	0.327	0.153	2.141	0.033	0.027	0.627

Appendix X: Pictorial and Tabular Evidence for MANOVA Assumptions

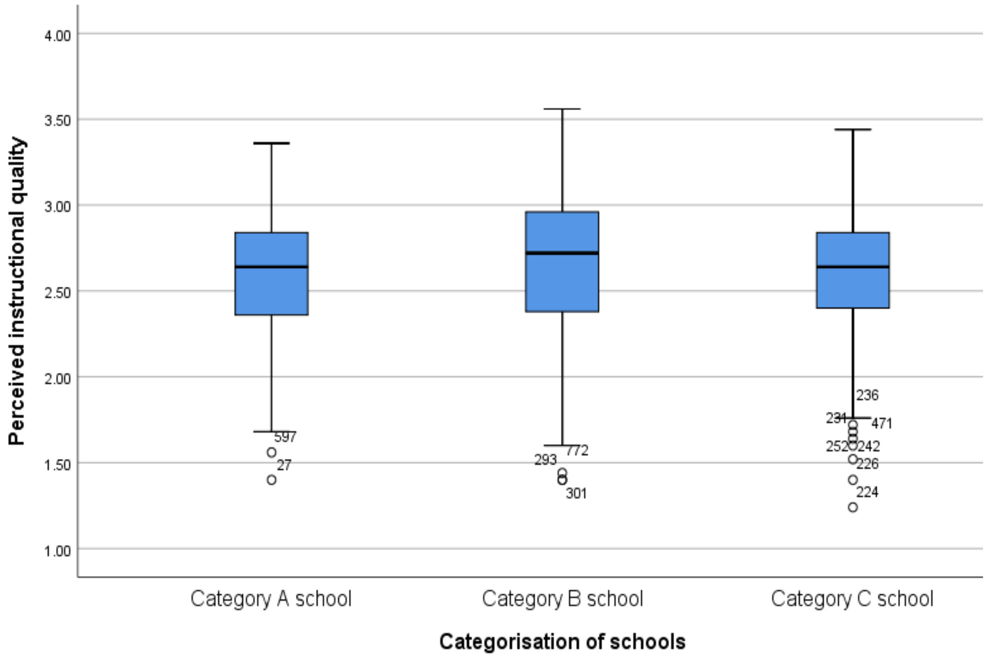
Normality – Skewness, Kurtosis, mean and 5% Trimmed mean

	Word problem performance			Instructional quality		
	Cat A	Cat B	Cat C	Cat A	Cat B	Cat C
Mean	0.909	0.745	0.706	2.582	2.659	2.588
5% Trimmed Mean	0.904	0.726	0.687	2.590	2.672	2.603
Skewness	0.190	0.319	0.404	-0.465	-0.479	-0.617
SE	0.151	0.151	0.153	0.151	0.151	0.153
z-scores	1.254	2.109	2.651	-3.070	-3.168	-4.043
Kurtosis	-0.678	-0.679	-0.602	0.123	-0.300	0.378
SE	0.302	0.301	0.304	0.302	0.301	0.304
z-scores	-2.248	-2.256	-1.981	0.408	-0.998	1.242

Normality – Box plots (Word problem test scores)



Normality – Box plots (Instructional quality in word problem)

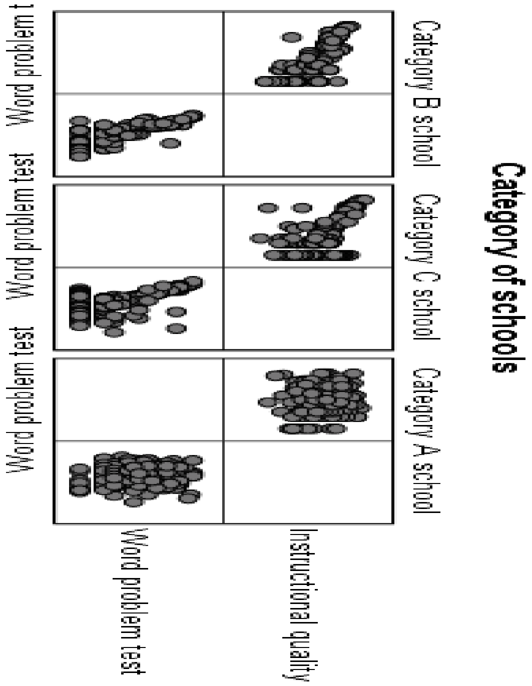


Multivariate normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Word problem performance	.129	774	.000	.956	774	.000
Instructional quality	.073	774	.000	.984	774	.000

a. Lilliefors Significance Correction

Linearity of predictor variables– Scatter graph



Box's Test of Equality of Covariance Matrices[a]

Description	Statistic
Box's M	144.844
F	24.050
df1	6
df2	14788247.178
Sig.	.000

a. Design: Intercept + GESCAT

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
Word problem performance	Based on Mean	3.806	2	771	.023
Instructional quality	Based on Mean	10.104	2	771	.000

a. Design: Intercept + GESCAT

Appendix Y: MANOVA Tables

Tests of Between-Subjects Effects

Source	Outcome Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Corrected Model	Word problem test	6.005[a]	2	3.002	12.270	.000	.031	24.540	.996
	Instructional quality	.952[b]	2	.476	2.950	.053	.008	5.899	.575
Intercept	Word problem test	479.043	1	479.043	1957.644	.000	.717	1957.644	1.000
	Instructional quality	5270.333	1	5270.333	32644.429	.000	.977	32644.429	1.000
GESCAT	Word problem test	6.005	2	3.002	12.270	.000	.031	24.540	.996
	Instructional quality	.952	2	.476	2.950	.053	.008	5.899	.575
Error	Word problem test	188.667	771	.245					
	Instructional quality	124.475	771	.161					
Total	Word problem test	674.192	774						
	Instructional quality	5396.845	774						
Corrected Total	Word problem test	194.672	773						
	Instructional quality	125.428	773						

a. R Squared = .031 (Adjusted R Squared = .028); b. R Squared = .008 (Adjusted R Squared = .005)
c. Computed using alpha = .05

Tukey HSD Multiple Comparisons

Outcome Variable	(I) GESCat	(J) GESCat	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Word problem performance	Category A school	Category B	.1640*	.04343	.001	.0621	.2660
		Category C	.2034*	.04364	.000	.1009	.3059
	Category B school	Category A	-.1640*	.04343	.001	-.2660	-.0621
		Category C	.0394	.04360	.638	-.0630	.1418
	Category C school	Category A	-.2034*	.04364	.000	-.3059	-.1009
		Category B	-.0394	.04360	.638	-.1418	.0630
Instructional quality	Category A school	Category B	-.0770	.03527	.075	-.1598	.0058
		Category C	-.0058	.03545	.985	-.0891	.0774
	Category B school	Category A	.0770	.03527	.075	-.0058	.1598
		Category C	.0712	.03541	.111	-.0120	.1543
	Category C school	Category A	.0058	.03545	.985	-.0774	.0891
		Category B	-.0712	.03541	.111	-.1543	.0120

Based on observed means.

The error term is Mean Square (Error) = .161.

**. The mean difference is significant at the .05 level.*