EFFECT OF SELECTED CLASSROOM INTERACTIONS ON LEARNER'S ACADEMIC ACHIEVEMENT IN CHEMISTRY IN PUBLIC SECONDARY SCHOOLS IN MURANG'A COUNTY, KENYA
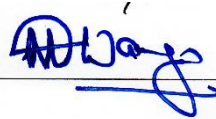
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A Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Doctor of Education in Curriculum Studies

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DECLARATION

This research thesis is my original work and has not been presented for a degree in any other University

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I dedicate this work to my wife: Elizabeth Watiri; our children: Benson Ngura, Solomon Maingi and Daisy Wanjiku; my mother: Miriam Wanjiku; my late father: Solomon Mutitu and my siblings for their love and support.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
ASEI	Activity, Student-Centred, Experiment and Improvisation
CAT	Chemistry Achievement Test
CDE	County Director of Education
CEMASTEA	Centre For Mathematics Science and Technology Education In Africa
CPC	County Planning Committee
CQASO	County Quality Assurance and Standards Officer
KCSE	Kenya Certificate of Secondary Education
KMO	Kaiser-Meyer-Olkin
KNEC	Kenya National Examinations Council
NACOSTI	National Commission for Science, Technology and Innovation
OECD	Organization for Economic Co-Operation and Development
PDSI	Plan, Do, See and Improve

ABSTRACT

The purpose of the study was to investigate the effect of selected classroom interactions on learners' academic achievement in Chemistry in public secondary schools in Murang'a County, Kenya. The specific objectives of the study were to: establish the effect of teacher-learner class talk (oral) on learners' academic achievement in Chemistry, examine the effect of learners' written interaction on learners' academic achievement in Chemistry, determine the effect of learners-teachers' non-verbal interaction on learners' academic achievement in Chemistry and examine effect of gender interaction on learners' academic achievement in Chemistry. This study used descriptive survey design and was guided by Vygotsky Social Development Theory. The target population was, 10,010 Form 3 students taking chemistry and 300 chemistry teachers from 120 public secondary schools with mean scores of 4.0 to 6.0 in Chemistry in Kenya Certificate of Secondary Education National Examination between year 2009 and 2016 which were purposively selected. Using Yamane formulae 32 public secondary schools, 32 chemistry teachers, 384 Form 3 students taking chemistry and County Quality Assurance and Standards Officer from the county were sampled for the study. The study used six research instruments to collect data: student's questionnaire, observation schedules, document analysis guide, an interview guide, a learners' discussion guide and a chemistry achievement test. The computer application SPSS (statistical package for social sciences) was used to analyze the data. Descriptive statistics such as frequencies, means, percentages, and standard deviation were used to discuss the research findings. The study further used inferential statistics: ANOVA, Chi^2, Pearson Moment Correlation Coefficient, Simple and Multiple Regression to test the statistical significance in the four null hypotheses generated for the study. The findings from the regression analysis indicated that, there was positive and significant effect of teacher-learner oral interaction on learners' academic achievement in chemistry. It was further established that, non-verbal interaction had statistical and significant effect on academic achievement in chemistry. The regression model showed that oral and non-verbal interactions explained 33% and 58% of the variation respectively in academic achievement in chemistry. It was also found that there was no statistically significant effect of written interaction and gender interaction on learners' academic achievement in Chemistry. The current study highlights interactive areas where teaching and learning practice may be improved. The study recommended that secondary school teachers training institutions should incorporate oral and non-verbal interaction in their programs, intensive capacity building workshops to Chemistry teachers to improve their pedagogical skills in effective class talk and non-verbal interaction. The researcher suggested a similar study to be conducted in other parts of the country for comparative purposes.

CHAPTER ONE

INTRODUCTION

1.1Background to the study

Classroom-centered research has emerged as an important and productive research which attempts to explore the nature of classroom interaction during teaching and learning (Al-Otaibi, 2004). This is because in formal school situation a significant amount of time is spent in the classrooms where the learners and instructors interact with each other. It involves interpersonal relationship between learners to learners, learners to learning materials and learners to teachers (Van den Bergh, Ros & Beijaard, 2014). Through such interactions, learners share knowledge with teachers and classmates leading to learners' cognitive development whose indicator is academic achievement, usually given in terms of scores.

Although there are various variables determining the 'success' of any specific learning environment, the main determinant is the way students interact with each other and the way they interact with their teachers (Myint & Lourdusamy, 2005). Such interactions are a powerful force that influences learners' cognitive and affective development. Downey (2008) noted that, the amount of relationship between the teacher and the learner determines the degree of teaching in the classroom eventually determining learners' academic achievement. The implication of this, is that, the higher the level of the relationship, the more effective the interactions in the classroom leading to high academic achievement.

Inamullah (2005) stated that, teacher-student interaction in a learning environment involves both parties where each participant has a social influence on the behaviour of the other, that is, teachers influence the behaviour of students and students influence the behaviour of their teachers. Since the social relationship is a critical and essential part of the pedagogical process, both the learner's and teacher's interactive roles enhance the quality of learning which is likely to influence the learner's academic achievement. When the process of teaching and learning involves active interaction, the teacher is motivated and enjoys teaching while the learner is motivated to learn (Hamre, Pianta, Burchinal, Crouch, Downer, Howes, LaParo & Little, 2012). When such an interactive classroom environment motivates both the learner and the teacher, the end result is quality learning and high academic achievement.

Therefore, interactions and active learning are key components necessary for higher academic achievements. For instance, one main element of learners' academic achievement involves their productive interaction in the classroom with teachers, learners and when studying on their own (Dina, 2015). In supporting this argument, some countries have adopted policies that are in favour of small classes to enhance effective classroom interactive environment. For example, in the United States of America (USA), more than thirty states have a policy for Class Size Reduction (CSR) while a policy of a class size of 30 pupils has been adopted in England and Wales (Blatchford, Bassett, & Brown, 2011). Therefore, from a global perspective, educationists are becoming more innovative to create effective interactions with an

objective of raising teaching and learning quality that is likely to improve learners' academic achievements.

Classroom interaction as an effective pedagogical method of curriculum delivery is not a new global phenomenon. For instance, Paulo Freire, in his work in the 1950s and 1960s in Brazil, noted that, students are the subject and not objects in the process of learning since they have their destiny. Both the instructor and the learners participate equally in the learning process which is kept lively by the continuous dialogue between the two parties (Cole, 2009). Learners must therefore be active during teaching and learning if meaningful learning is desired. Therefore, teachers need to involve the learners through interaction, so that they share knowledge and build on what they already have.

Wettasinghe and Lourdusamy (2002) study conducted in Singapore asserted that learners have a positive view of teachers whose classroom leadership style greatly influences the formation of an interactive enabling learning environment. Moreover, whenever a teacher interacts with a student or a group of students during the instructional process then learning is considered to be taking place (Solmaz, Adel &Yusef, 2013). Therefore, interaction is a very critical element during instruction and its role is very crucial for teaching to be efficient. The implication of the two studies is that, the nature and type of interaction that occurs between the instructor and the learner, learner to learner, learner and learning materials is what determines the strengths and weaknesses in a lesson during the learning process.

Bart, Golsteyn, Arjan and Ulf (2017) study that focused on interaction in university students showed that students' academic achievement is causally affected by peer personality. In order to identify the causal impact of peers, the study exploited the random assignment provided to students. The findings indicated that students who were less risk tolerant peers and exposed to more persistent peers scored higher achievement scores. Therefore, classroom interaction enhances quality teaching and learning at high levels of learning. The independent variable for this study was peer personality at university level, while the learners' interaction was the independent variable for the current study and the target group was public secondary school students.

From a global context, classroom interaction is not a new phenomenon to teachers. Insung, Seonghee, Ewha, Cheolil and Junghoon (2002), for instance asserted that, the common familiar and frequent types of interactions used by teachers are: learner-learner interaction which is a type of social interaction that occurs between two or more learners during teaching and learning and which may take place in the presence or absence of a teacher. The second one is between learner-instructor whereby the teacher provides the knowledge and serves as a facilitator and an expert during the instructional process. This suggest that while learning, the teachers' presence is critical because of feedback to learners, clarification of concepts, interpretations of results, motivating and stimulating the learners. The third type of interaction is learner-content. This is the type of interaction characterized by learners seeking knowledge from the learning materials like text

books, handouts and online materials (Insung, Seonghee, Ewha, Cheolil & Junghoon, 2002). Learner-content is considered an effective method of learning because learners participate in learning, hence become creators of own knowledge as well as building on the knowledge they have, making learning interesting and meaningful. Such knowledge can easily be recalled. The three types of interactions can be referred to as the conventional interactions that are familiar to nearly all the teachers. However, verbal, non-verbal and written interaction may sound obvious but relatively little is known about their use during teaching and learning except during the teaching of languages. Their effectiveness need to be explored in other subject areas to establish their effects and influence on quality of learning (Mahmoodi, 2016).

Verbal interaction is one form of interaction where students interact through oral and written interaction. Oral interaction also referred to as class talk means that learners interaction with fellow learners is through speaking, asking and answering questions, discussions and coming up with comments (Goronga, 2013). The results obtained from a study in Iran by Solmaz, Adel and Yusef (2013) showed that 48.4% of interactions taking place in a class are through explanations by teachers and their speeches. The proportion of interaction of learners was 24.6% and this was as a result of talks while responding to questions posed by teachers and the remaining 8.1% was spent in silence. Hence, the study's findings indicate that, teachers have continued to dominate during the learning process. This is against the principles of effective classroom teaching practices because the best teaching practices in the

classroom is learner centered where the learner dominates during learning process. Therefore, the learner must be active in sharing of experiences with other learners and the teacher to make learning meaningful.

On the other hand, written interaction is an interaction style where learners are involved in written thoughts and ideas thus they interact with each other via written words and documents. Without reinforcement provided through daily practice from quizzes and homework, learners often fail to develop a complete comprehension of the concepts learned. This lack of knowledge may remain undiscovered until after the examination (Bullock, LaBella, Clingan, Ding, Stewart & Thibado, 2002). This probably explains why some learners are unable to put down answers in writing because of lack of written practice. This is supported by feedback from Kenya National Examinations Council (KNEC) regarding the weaknesses of candidates in Kenya Certificate of Secondary Examination (KCSE) in chemistry in 2017 (KNEC, 2018). It was noted that, candidates could not balance simple equations and majority did not write the correct state symbols.

Non-verbal is another form of interaction which is a behavioural response style of interaction where students and teachers are engaged with one other through eye contact; nodding of the head; raising hands and gestures (York, 2014). According to Guerrero and Floyd, (2006) non-verbal interaction puts across 60% to 65% of meaning from one person to another. Therefore, a lesson may be improved by using non-verbal interaction during the teaching and learning process. For instance, eye

to eye contact between student and the teacher can enhance the attention of the student towards the lesson (Bambaeeroo & shokrpour, 2017).

According to Audu and Achor (2003) interaction in a learning environment involves participation of the instructor and the learners using verbal, written and non-verbal means. But how often are the three types of interaction used by teachers? One possible answer to the question is that teachers could be using them unconsciously, but if planned and incorporated in the lesson plan, the quality of learning would probably be improved leading to high academic achievement of learners. This argument is supported by a study by Fatemeh and Nasrin (2016) who suggested that if non-verbal interaction was practiced by teachers, it would likely raise the students' desire to learn by motivating them leading to high academic achievement.

Therefore, it appears there is need for chemistry teachers to acquire the skills of non-verbal interaction for effective curriculum implementation. The findings of Fatemeh and Nasrin (2016) are supported by Wahyuni (2017) whose study revealed that, a learning process takes place when both the student and the instructor interact in form of written, verbal and non-verbal interactions during teaching and learning. These interactions are inter-related and at times they happen simultaneously. Therefore, the teacher needs to be skilled enough to know when and where each interaction method should be appropriately used.

The implication is that, effective process of instruction may be enhanced by the teachers' capacity to use the three methods of interaction during the implementation and delivery of curriculum. Although, other variables may influence students and teachers interaction for instance; the style and manner of teachers' verbal and non-verbal interaction, such as the way a teacher smiles, voice modulation and posture, helping to capture and retain the learners' attention in the classroom leading to quality learning (Velez & Cano, 2008). It can be argued from this point of view that, subjects like mathematics and sciences that are perceived as difficult can be made easy by capturing and retaining the learners' attention using effective verbal and non-verbal interaction.

It therefore appears that if teachers frequently use verbal and non-verbal interaction, relationship between the teacher and learners may be improved enhancing quality of learning. This might result in learners' interest and desire toward classroom participation, making learning meaningful. This is supported by Lisa and Calvin (2006) who suggested that, teachers should use more verbal and non-verbal interactions during teaching and learning.

Wenhua (2012), in a study done in China showed that in non-verbal interaction, boys are encouraged, acknowledged, praised and given correct feedback more than girls. However, instructors were found to laugh or smile more regularly with girls than they did with boys. This is probably due to gender bias which at times occurs naturally. For instance, it is natural to find a male teacher smiling and laughing with

girls more than boys, meaning a girls' class taught by such a teacher is likely to enjoy the lesson by raising the desire to learn. Therefore, another form of classroom interaction that can lead to effective teaching and learning is based on gender interaction, because most teachers have stereotypes and discriminate the males' and females' learners potential. This is a view supported by Nana (2012) whose conclusion was that gender biased anticipation and perception leads to unequal treatment and low self-esteem among the girls.

Despite the existing body of knowledge of learner interaction in the instructional environment, there is need to carry out continuous research to fill the gender disparity gaps and the emerging challenges facing teachers and learners in achieving effective interaction in the classroom during the implementation of the curriculum. This view is supported by Scott, (2003); Nwakonobi and Onwuachu, (2009) who noted that, there is need for continuous research within any educational system so as to identify emerging gender disparity gaps with a view to raising the standards and quality of teaching within the set curriculum. This will build on teachers' current knowledge and skills leading to improved pedagogical practices.

From a global point of view, learning of science subjects like Chemistry is critical in secondary schools because of its significant importance in helping learners in tertiary colleges to take technological courses like Agriculture, Engineering and Medicine that are viewed by the modern society as critical in tackling challenges in the ever advancing scientific development (Vilia, Candeias, Neto, Franco & Melo,

2017). This explains why most countries are spending a huge portion of their annual budget to fund science related courses.

One of the resolutions of the United Nations agenda held on 25 - 27 September 2015, in New York on Sustainable Development agenda involved Transforming the world in the 2030 vision Agenda. The resolution stated that between 2015 and 2030, all countries should endeavour to end poverty and hunger and promote gender equality as well as empowerment of women (United Nations, 2015). Poverty and hunger are inter-related and to have adequate food production the world needs experts in the area of food production and technology where knowledge of Chemistry is very critical.

Gender empowerment is critical to ensure girls are given the same opportunities as boys in areas where they are perceived by the society to be weak. For instance, Chemistry and other science subjects are perceived to be masculine subjects. For purposes of equality, teachers should give equal opportunities to both genders during teaching and learning.

Additionally, the Kenya government current development agenda in the next five years (2017-2022) is anchored on four pillars referred to as agenda four which was launched by the president on December 12th, 2017 after his re-election for the second term. The four pillars are: Expansion of Manufacturing Sector: This will focus on the blue economy, agro-processing, leather and textile industries; Affordable Housing: Kenya citizens were promised habitable houses; Food Security: the government promised to encourage large-scale commercial farming

with a view to ensuring diversity of food production by means of irrigation and other technologies. In his address, the president noted that, the country requires relevant skills to be factored in the new curriculum to allow learners compete well among themselves (GoK, 2017). Chemistry as a subject offers the skills required by the professionals to achieve the agenda four. For instance, textile industry requires skills in organic Chemistry while in food production experts in organic chemistry are required for manufacture of high quality fertilizers. One implication of the United Nations agenda held between 25 - 27 September 2015 and Kenya government agenda four was that academic achievement in chemistry is critical to achieve the UN and GoK development agendas.

Furthermore, for learners to understand the concepts in other science subjects like physics, biology, environmental science, and geology, the knowledge of Chemistry is fundamental and this is why Chemistry is generally referred to as the "Mother of all Sciences" or "central science" (Goldsby & Raymond, 2013). Moreover, the knowledge of Chemistry cannot be underrated in our daily lives because it is also linked to our daily routines like the composition of the drugs we take when we are sick; cooking fuel; breathing air; drinking water; soft and alcoholic drinks are examples of substances where chemistry is involved in our daily life (Chua & Mageswary, 2015). It is therefore important for chemistry teachers to be innovative in pedagogical practices like classroom interaction to popularize the subject with a view to attracting learners and enhancing academic performance.

Studies have shown that, a gap exists in the methodology of teaching and learning of Chemistry which influences academic achievement (Ganai & Muhammad, 2013). This probably explains why chemistry is not a popular subject with learners despite its importance to students who take technological courses in tertiary institutions. For instance, a study by Awan, Sarwar, Naz and Noreen (2011) on attitudes towards science among learners of various countries revealed that, Biology is most popular with girls while boys like Physics.

Therefore, Chemistry is not a favourite subject for learners, a factor that might influence the academic achievement in the subject. It is the current researchers' view that a paradigm shift is necessary to change the mindset of learners toward Chemistry. Another study by Khan and Ali (2012) in Pakistan revealed that students were very much satisfied with the Chemistry teacher but worried about the methodology of teaching that led to lack of understanding of some concepts leading to poor academic achievement. The best option would be to adopt an effective methodology to deliver the curriculum effectively.

Findings of a study by Yunus and Ali (2013) that was done in Malaysia revealed that, most learners have a negative perception towards Chemistry as a subject since they have no interest in it which results in poor academic achievement. Lack of interest which is most likely caused by poor teaching methods will certainly result in poor quality teaching and learning. Hordzi's (2015) study in Ghana that targeted academic achievement of science students on distance learning program revealed

that, there is need for Chemistry tutors to use verbal, nonverbal and written interaction methods to encourage students to like Chemistry with a view to improving academic achievement. The current study focused on the four selected interaction patterns: verbal, written, nonverbal and gender interactions due to two reasons: insufficient research on the four selected interaction patterns and the need for further empirical studies to support the previous findings from similar studies.

Through Verbal interaction learners may be encouraged through words like "very good, keep up" while acknowledging the learner's answers through nodding, a friendly face and good comments in learners written work can probably make the teacher attractive to learners. When the teacher is attractive to learners they tend to like the subject. Since learning is an influence of several interaction behaviours, the current study focused on the following selected interactions: verbal, Written, non-verbal and gender interactions and their effects on academic achievement in gas laws in chemistry.

National results in Chemistry in Nigeria have been poor compared to other science subjects (Oluwatosin & Ogbeba, 2017). The West African Examination Council (WAEC) feedback report attributed the poor performance in Chemistry to their inability to handle simple laboratory apparatus, lack of exposure to laboratory techniques, poor observational skills, inability to carry out simple calculations, unit's omission in worked out values, lack of ability to balance chemical equations and indicate the correct charges of the ions. From this feedback report it can be

concluded that, the learners were inadequately exposed to adequate practical activities in Chemistry.

For instance, there was probably little or no interaction of students with apparatus and chemicals that would enhance interest in learning leading to quality learning and higher academic achievement. Chemistry like any other subject can be interesting if the teachers involve the learners to become part of the learning process while the classroom interaction might make the subject interesting, hence improving the academic achievement. Learners can be actively involved to interact with apparatus, manipulation of data, group reporting, and peer teaching which would make learning more meaningful and interesting.

Fatokun and Omenesa (2015) study revealed that, student-teacher interaction is a factor that needs more research to establish its contribution to learners' academic performance in Chemistry. The study recommended further research on the effect of classroom interaction on academic achievement of learners which formed the basis of the current study. A study done in Nigeria by Iroha and Ali (2004) on classroom interactions and learners' achievements in Physics revealed a noteworthy positive relationship between interactions and learners post-instructional attitude and low academic task achievement.

However, although there are generic teaching skills, Iroha (2006) reported that, methods of effective teaching and learning differ by subjects and therefore, what the study obtained in Physics may not be exactly so in other subjects. The effect of

selected interaction patterns on learner's academic achievement and the apparent gap between theoretical knowledge and classroom interaction practices in gas laws in Chemistry in the Kenyan public secondary schools context, was the focus of the current study. Moreover, at the time of this study, similar studies had not or perhaps may not have been carried out in the Kenyan context.

According to Burn (1999), Chemistry teachers can assist learners to enjoy learning Chemistry which is applicable in our daily lives. This can easily be done through creating confidence, assist the learners in problem solving skills as well as solving problems by application of principles of Chemistry. Therefore, a conducive teaching and learning environment interaction enhanced with cognitive framework that is well defined will improve learners' retention of concepts learnt and such ideas can easily be recalled when needed.

Findings of the situational analysis from Centre for Mathematics Science and Technology Education in Africa (CEMASTEA, 2009), established that the practice of Activity, Student-Centered, Experiments and improvisation – Plan, Do, See and Improve (ASEI- PDSI) approach was not adequately practiced in many secondary schools. Most chemistry teachers were noted to be involving less of learner-centered methodologies. A topic like mole concept which is perceived as a difficult topic in Chemistry can easily be taught and concept understood using the principles and techniques advocated by CEMASTEA because learning becomes interesting when learners are actively involved.

This lack of learners' involvement during the learning process is evidenced by the National performance in Chemistry in Kenya, which has consistently remained the worst among the three science subjects in 2009-2016 as shown in Table 1.1.This is a critical matter of national concern that needs intervention to reverse the trend.

Table 1.1: National Mean KCSE performance of Sciences (2009-2016) in percentages

Subject	2009	2010	2011	2012	2013	2014	2015	2016
Physics	31.33	35.13	36.64	36.23	40.10	38.52	39.87	22.34
Biology	27.20	29.23	32.44	24.36	31.63	30.18	31.08	19.67
Chemistry	**19.13**	**24.91**	**23.65**	**25.95**	**24.83**	**24.76**	**24.76**	**15.51**

Source: KNEC (2017)

From Table 1.1 the National mean achievement in Chemistry is generally below 25 percent in the last eight years. Over the same period it was the worst performed among the three sciences except in 2012 when Chemistry KCSE academic performance was better than Biology. This raises the question: "is Chemistry subject difficult than Physics and Biology or is it the teaching methodologies?" The performance of Chemistry in Murang'a County is not exceptional from the national performance. Table 1.2 shows the County's KCSE performance of Chemistry, Physics and   Biology subjects in mean score in the years 2009-2016.

Table1.2: Murang'a County Mean KCSE performance of Sciences (2009-2016)

Subject	2009	2010	2011	2012	2013	2014	2015	2016
Physics	4.621	4.765	4.721	4.794	4.656	4.621	4.593	3.62
Biology	4.683	4.569	4.584	4.408	4.605	4.489	4.603	3.45
Chemistry	**3.972**	**4.038**	**3.897**	**4.591**	**3.890**	**4.135**	**4.242**	**3.12**

Source: County Director of Education (CDE), Murang'a County (2017)

Performance was available in terms of mean score unlike in the national performance which was given in percentage mean. From Table 1.2 out of the three sciences, Chemistry was consistently the worst performed in the last eight years in Murang'a County. According to Kenya National Examinations Council (KNEC) this is a mean grade of D+. According to KNEC (2017) report, one of the areas that teachers need to address is mole concept where 80% of candidates had challenges in answering questions correctly. It is for this reason that, the focus of this study was mole concept and because it is a wide topic the researcher narrowed down to the subtopic of gas laws.

Moreover, Chemistry subject is universal in almost all the science oriented courses at university level. Therefore, poor academic performance in Chemistry limits learners' opportunities to advance in professional courses like Engineering, Human Medicine, Veterinary Medicine, Agriculture, Food Science and technology and

Industrial Chemistry. The country needs experts in these courses if the GoK "Big Four Agenda" and "Vision 2030" are to be achieved. The researcher narrowed down to verbal, written, nonverbal and gender interactions because it was possible to collect data when learners were together in a learning environment where interactions are expected to take place. Thus, this study intended to fill the existing skills and knowledge gaps among Chemistry teachers in the interactive pedagogical practices in the classroom environment.

1.2 Statement of the Problem

Chemistry is a universal subject in over 80% of all the scientific and technological courses offered in post-secondary institutions all over the world. Such scientific and technological courses are critical requirements for achievement of United Nations agendas, the Kenya government current development agenda, like "Big Four Agenda" and "Vision 2030".According to a Chemistry survey conducted by SMASSE County Planning Committee (CPC) in Murang'a County (2015), the area of interaction of learners during teaching and learning of Chemistry is a legitimate concern, because most of the teachers use passive learning approach.

Passive learning is a quick method of covering the syllabus leading to rote learning. This denies the learners an opportunity to interact in the learning process. Topics that are perceived difficult like the mole concept would probably be easy for learners to understand if teachers selected appropriate interaction methods during implementation of the curriculum. Reigeluth (2012) asserted that, subjects are unique and certain teaching methods may not be effective in all situations, hence

must be combined with other methods so that different needs of learners can be taken care of.

This study hypothesized the effect of verbal, nonverbal, written and gender interactions on learners' academic achievement in chemistry with a view to filling the existing skills and knowledge gaps among chemistry teachers. Fawzia, (2002) asserted that, the area of verbal, nonverbal, written and gender interactions has received little attention in pedagogical practices.

1.3 Purpose of the Study

The purpose of the study was to investigate the effect of selected classroom interactions on learners' academic achievement in Chemistry in public secondary schools in Murang'a County, Kenya.

1.4 Objectives of the Study

This study was guided by the following research objectives:

i.   To establish the effect of teacher-learner class talk (oral) interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

ii. To examine the effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

iii. To determine the effect of teacher-learner non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

iv. To examine the effect of gender interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

1.5 Research Hypotheses

To ascertain this study's objectives, the following respective null hypotheses were tested:

Ho_1 There is no statistically significant effect of teacher-learner class talk (oral interaction) on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

Ho_2 There is no statistically significant effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

Ho_3 There is no statistically significant effect of teacher-learner non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

Ho_4 There is no statistically significant effect of gender interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

1.6 Significance of the study

Oso and Onen (2016) define significance of a study as the relevance of a study to the target society. It clearly states the contributions the study is expected to make from the results, conclusions and finally recommendations. A study therefore, should be significant to the researched target population, country and even globally. Kenya Institute of Curriculum Development (KICD) and SMASSE might find the

study useful to guide the chemistry teachers on the best pedagogical practices of teaching the subject related to classroom interaction. This may increase the quality of classroom interactions and in turn, increase student engagement and ultimately learning and cognitive development. Hence teachers may benefit by fostering understanding and equipping themselves with pedagogical skills and knowledge involving learners during the implementation of the curriculum, through classroom interaction that will result in quality learning and consequently high academic achievement.

Learners may benefit through using the new knowledge when they are interacting among themselves and with the teacher during the learning process. Results of the current study may have useful information about present status regarding verbal, nonverbal, written and gender interactions, which in turn will improve the educational training programs. Further, the study could also contribute knowledge in the area of classroom interaction and curriculum implementation.

1.7 Limitation of the Study

According to Kombo and Tromp (2006) limitations are challenges over which the researcher has no control. The presence of an observer inside the classroom caused anxiety to the respondents defeating the logic of a true natural teaching environment. To overcome the anxiety, the researcher provided relevant information about the study and assured the respondents that the data collected was for research purpose only and that their identity will remain confidential.

1.8 Delimitations of the study

Delimitations define the parameters or the scope of the research study (Best & Kahn, 2011). It defines the boundaries of a study such as methodology, geographical area and the theoretical coverage of the study (Oso &Onen, 2016). The current study was done in Murang'a County, it involved public secondary schools while the respondents were Form 3 teachers of chemistry and Form 3 learners who were taking chemistry.

The researcher avoided Form four students because they were candidates, while Form three students were considered more experienced than Form two and one students; hence they were likely to provide more reliable data. Gas laws was chosen because it is within the topic of mole concept which is considered a challenge to most learners. It was found suitable because during teaching it involves lecture method, practical work and manipulation of data, hence requires discussion, teacher-learner and learner-learner interaction.

Murang'a County was the area of study because the county performance in Chemistry was consistent with the national performance. The researcher focused on class talk (oral) interaction, written interaction, non-verbal interaction, and gender interaction which have received little attention from chemistry teachers (Fawzia, 2002), hence excluding other factors that may have affected learners' academic achievement. The researcher focused on gas laws in Chemistry. Therefore the findings of the current study were generalized with caution.

1.9 Assumptions of the Study

Best and Kahn (2011) defines assumptions as unverified information perceived by the researcher as facts. The current study was based on the following assumptions:

i. Learners were of similar intelligence level. The researcher used academically average secondary schools whose previous KCSE mean scores and grades in Chemistry were between 4.00 and 6.00 (D+ to C- respectively).

ii. All the sampled schools were at the same level of syllabus coverage and were covering gas laws normally covered in Form Three, first term. The researcher sought an appointment with chemistry teachers to visit the school when the topic was being taught.

iii. Respondents would be honest in providing accurate information and to overcome the challenge, the respondents were assured that, the data and findings of the current study were purely for purposes of research only.

iv. That the researcher's presence inside the classroom would not influence the teacher's Chemistry lesson presentation. To overcome the challenge the respondents were assured that their identities would not be revealed.

1.10 Definitions of Significant Terms

Academic achievement is the scores in numerical form obtained from a standardized test administered to learners after a period of instruction within a classroom environment.

Class talk is the frequency of talking between learner and the teacher in the classroom within 80 minutes.

Classroom interaction is the ways in which learners in the classrooms interact with one another, through non-verbal interaction, written interaction, teacher and learner talk (oral).

Class size is the number of learners in a class as per the Ministry of Education guidelines.

Collaborative learning is the type of learning involving the engagement of a learner with fellow learners, teacher and instructional materials.

Facial expression is the communication from the teacher's and learner's face and where one's personality traits can be easily learnt from the face.

Gender refers to male and female learners and teachers.

Gesture refers to an expressive action, normally done through use of head, hands, arms and the whole body. Gestures can be used when the teacher or learner is speaking or is silent, meaning that, the body can communicate through gestures.

Interaction refers to exchange of ideas, feelings or thoughts between the teacher and two or more learners during teaching and learning.

Kaiser-Meyer-Olkin refers to a test that determines the suitability of factor analysis for a given data.

Learning is an influence of interactive behaviour whose outcome is acquisition of knowledge and skills that can be tested and measured using scores.

Non-verbal interaction is the physical action of learners like raising hand, body posture, eye contact and nodding.

Selected classroom interactions refer to verbal, non-verbal, written and gender interactions excluding all other forms of interactions.

Social interaction is an organized and planned learning by two or more learners through sharing of knowledge.

Socially interactive learners are learners involved in sharing of knowledge.

Written interaction is the assignments, making of own notes and marking own assignment.

1.11 Organization of the Study

The study comprises of 5 chapters. Chapter 1 is introduction and consists of background to the study, statement of the problem, objectives of the study, research hypotheses, significance, assumptions, limitations, delimitations of the study and definition of significant terms.

Chapter 2 is on related literature review covering introduction, studies on learners' academic achievement in Chemistry, meaning of classroom interaction in a teaching and learning environment, studies on teacher's role in classroom interaction, studies on teacher and learner talk (oral), studies on written interaction, studies on non-verbal interaction, studies related to gender interaction and learners' academic achievement, summary of related literature review and the identified research gaps. Theoretical framework and conceptual framework are also discussed.

Chapter 3 focused on methodology of research which consisted of research design, target population, sample size and sampling procedures, research instruments, data collection procedure, data analysis techniques and ethical considerations. Chapter 4 consist of data analysis, presentation, discussion and interpretation while Chapter 5 consists of summary, conclusions and recommendations for further study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter deals with review of literature on related studies on classroom interactions and how they affect learners' academic achievement. Specifically it consists studies on learners' academic achievement in Chemistry, studies on classroom interaction during the instructional process, studies on the role of teacher in classroom interaction, studies on teacher and learner talk (oral) interaction, written interaction, nonverbal interaction, gender interaction and learners' academic achievement, summary of literature review and the identified research gaps. Theoretical framework and conceptual framework were also discussed.

2.2 Learners' academic achievement in Chemistry

Education has been perceived as a cognitive asset for social, economic progress and development in an increasingly diverse, competitive, complex, and globalized society. In the modern society, learners attend school to prepare themselves for full participation in the activities of the society (Inamullah, 2005). The extent to which learning takes place is measured in grades or scores usually referred to as academic achievement. Akabogu and Ajiwoju (2015) asserted that, the classrooms have become globalized and critical elements of 21st century where learning should be addressed and integrated in the education system so as to be incorporated in the teaching-learning process in order to adequately prepare learners for their expected

roles in society. For global participation and competitiveness one aim of education is to create an independent minded learner who will easily fit in the dynamic society through interaction with others (Juan & Lasaten, 2016). Through the social interaction in the classroom setting, learning process takes place which is quantified through grades or scores referred to as academic achievement.

Therefore, learning is generally an influence of interactive behaviour whose outcome is knowledge acquisition, thinking skills and attitudes (Santrock, 2006). In a formal setting learning takes place in a classroom environment through interactive behaviour while the learning outcome is quantitatively measured by administering a standard test and scores obtained through marking. The academic success of a learner in Kenya is mainly determined by the academic achievement of national examinations administered annually by Kenya National Examinations Council.

Ganai and Muhammad (2013) indicated that academic achievement can be defined as attainment of knowledge which may be measured using tests that are standardized while the level of achievement is expressed as a grade or a unit based on learners' achievement. In a school setting, academic achievement is usually measured through assessment tests administered in the course of learning and examinations which are usually administered after the end of a term, semester, year or end of a course and is affected by several factors like, learner, teacher, environmental, and economic factors (Ganai & Muhammad, 2013). Therefore, a subject like Chemistry that was consistently poorly performed in KCSE in

Murang'a County and the entire country compared to other subjects for eight years may have been affected by some of these factors and therefore, a lot of attention is required to improve the performance. This study narrowed down to interaction of learner-learner, learner-teachers, teaching and learning materials–learner interactions and their effect on academic achievement of learners in gas laws in chemistry in public secondary schools in Murang'a County.

According to Mehdipour and Balaramulu (2013), teaching refers to manipulation of a situation with gaps in an organized manner and is also a process where learning process occurs as a result of a learners' attempt to overcome the challenges at hand. Therefore, effective classroom chemistry teachers can turn a student's life around by manipulating methods of curriculum delivery such as effective interactive methods of teaching leading to high academic achievements. It is therefore the teachers' role to use the most effective pedagogical methods of teaching Chemistry to ensure meaningful learning that will lead to high academic achievement.

Moreover, teaching and learning of Chemistry can be effectively done through various methods of interactions like teacher-learner, learner-learner, learner-teaching resources interactions like asking of questions, group discussions, assignments, experiments which involves manipulation of apparatus and data, accurate observations, recording and revision of examinations (Babelan, 2012). The indicators of quality learning is high learner's academic achievement measured in terms of scores and the higher the score the higher the learner's academic achievement and vice versa. This study therefore, identified the gaps arising from

selected classroom interactions that are probably the causes of the poor academic achievement in Chemistry.

2.3 Studies on classroom interaction during instructional process

Teacher's organized and planned activities which are aimed at creating change in the behaviour of a learner is referred to as teaching (Hurst, Randall & Sarah, 2013) and all this is done through the process of teacher-learner, learner-learner and learner-learning resources interaction. Luu and Nguyen (2010) define interaction as a process that involve exchange of ideas, feelings or thoughts between two or more individuals, where the participants benefit from one another.

The more effective the interaction skills between teacher-learners and learner-learner are, the better the quality of learning. Therefore, before the teaching process starts, the teacher's social relationship with the learners needs to be strengthened to create a friendly, conducive environment necessary to enhance an effective interactive class (Bambaeeroo & Shokrpour, 2017). Therefore, the current study hypothesized that, teacher-learners and learner-learner oral, written, gender and non-verbal interaction have no effects on learners' academic achievement in gas laws in chemistry.

Harvey (2011) noted that, knowledge can be gained by learners through the process of interaction by listening to one another, using dialogical means, and solving tasks in groups. The outcome of an effective interaction is active learners

who contribute to the learning process resulting to meaningful learning (Harvey, 2011). In the process learners acquire new knowledge by building on their current experiences. Therefore learners should always be encouraged to contribute towards new knowledge and never to be assumed to be empty vessels (Duran, 2015). The current study suggest that, teachers should have a new paradigm shift and change their perceptions from the old tradition beliefs that learners attend school as parasites to be fed with new knowledge.

For instance in Form one class when the chemistry teacher is introducing a Bunsen burner, the learners can be asked to name other sources of heating that they know. As the teacher introduces the Bunsen burner, it will not appear very strange because the learners will relate it to their experiences. Such an introduction can be interesting to learners if it is done through some interaction between learner/teacher and learner/learner.

According to Luu and Nguyen (2010) there are two types of classroom interactions. One form of interaction is the teacher-learner interaction where the teacher engages the learners by asking questions while learners respond through answering of questions and vice versa. Such interactions generally occur when the teacher is delivering the content in the classroom or in small groups during discussion groups. This is the recommended methodology of teaching which is in contrast from the traditional method referred to as passive learning, where the instructor is assumed to be the main source of information and knowledge and spends the whole lesson giving lectures while learners listen and take notes

passively. But how effective is the teacher's interaction with the learners? Does the teacher portray verbal and non-verbal behaviour that can be attractive to learners? For instance if a teacher asks learners a question in an angry mood, will the learners be motivated to answer? The current study investigated the effects of such interactions like the way a teacher walks, smiles, and encourages learners verbally or through non-verbal means.

Learner-learner is another form of interaction that occurs between the Learners themselves in which case each learner is a contributor of knowledge. In this form of interaction, the teacher guides and gives direction to learners who, in the process of learning, are the key participants. Interaction of learner-learner takes place in small groups which are referred to as learner-learner interaction, in pairs referred to as peer interaction while a whole class of learners can interact effectively under the guidance and supervision of the teacher (Insung, Seonghee, Ewha, Cheolil & Junghoon, 2002). This is a very effective form of interaction because the learners can interact with one another freely in a social context.

Therefore a classroom lesson followed by peer teaching can be a very effective way of learners understanding what was not clear while the teacher was teaching. This can be done by accomplishing a given task either through oral, written interaction like doing assignment together, or non-verbal, through appreciating one another through facial expressions and gestures (Tuan & Nhu, 2010). However, learner interactions may not be effective unless some issues like gender are addressed. Gender can hinder effective interaction due to the gender

stereotypical perceptions in our society, while unless the written work is marked, learners may not know their strengths and weaknesses. Therefore, teachers must be skilled on how to handle gender issues and check learners' written work when guiding the learner-learner interaction groups.

Therefore, when learners are engaged in class during teaching and learning, the activity of learning becomes interesting and meaningful. For instance, Goss and Sonnemann (2017) asserted that, it is very crucial that teachers be creative when creating conducive classroom environment for teaching and learning by encouraging learners, developing a rapport with learners, challenging learners to participate in class and taking challenging tasks. Such activities influence how much the learners are engaged in the learning process.

Jerry Chih- Yuan Sun and Yu- Ting Yu (2016) study done in Taiwan revealed that, small group discussions offered the learners more chances to clarify questions in an interactive environment than did the self-study in a normal conventional class. The learners consequently enjoyed the learning because they were active participants enhanced by social interactive aspect making the learning process more meaningful. When the teacher groups the learners and assigns them tasks, an interactive environment is necessary if lesson's objectives are to be achieved. This is because meaningful learning is a function of teacher's ability in creating effective interactive lessons.

In a study by Hurst, Randall and Sarah (2013) three literacy teacher preparation courses that took place over the summer were selected based on the nature of the

courses which were highly interactive. The study's objective was to find out if quality of learning in the classroom is affected by learners' perceptions on social interaction that take place in the classroom. It was found that learners' perception were positive, suggesting that, interaction of learners from a social perspective led to their improvement in problem-solving skills, learning through enhancement of their knowledge of literacy and teaching and helped the learners to think critically.

The implication of the study's findings is that, teaching through social interaction can improve the effectiveness of delivery of curriculum leading to quality learning. One shortcoming in this study was that, indicators of quality learning, learners' perception and critical thinking were not clear. The current study focused on learners' academic achievement as the dependent variable whose verifiable indicators were learners' scores from a standardized test.

What is arising from the current study is that, classroom interaction enhances the learners to be more active in the classroom during the process of instruction. It raises learners' desire to learn and increases participation during teaching and learning. Through the structured learner-learner, learner-teacher interactions learners become critical thinkers and develop cognitive competency necessary for quality learning (Kalu, 2013). This can be concluded to mean that, learning becomes interesting when the learners are active and they should not be assumed to be empty vessels. But to what extent is the practice used by teachers in the

classroom and how effective is the practice? The current study focused on the effect of selected interactions on learners' academic achievement.

Additionally, interaction skills are very important to teachers to improve on the effectiveness of pedagogical skills during curriculum implementation. Teachers who embrace classroom interactions become effective classroom teachers and create meaningful learning (Wahyuni, 2017). Flanders who is credited with studies on interaction, conducted many research studies, for instance, concerning learner–teacher interaction in the face-to-face classroom setting and concluded that increased interaction between learner–teacher was positively correlated with student achievement and attitudes towards learning (Firooz, 2016).

Furthermore, there is clear contrast between the philosophy that learning is a social activity and the idea that teachers do all the talking in classrooms (page, 2010). Therefore, for effective pedagogical practices, one way for learners to be responsible for their learning is for them to be actively involved and become thinkers by being actively engaged in interacting socially with others (Wilkinson, Soter, & Murphy, 2010). Hence through interactive learning, passive learning is avoided and learners are able to generate their own knowledge making learning interesting, effective and meaningful and at the same time becomes part of the learning process. Such activities enhance the cognitive development of learners, raising an independent minded individual capable of solving societal challenges. The current study has established that interaction is a familiar area in pedagogical practices but continuous research is necessary due to the ever changing dynamics

of the process of instruction and to establish the extent of usage and the existing challenges. However, all the studies reviewed under this section did not address specific interactions during learning, while the current study addressed verbal, non-verbal, written and gender interactions.

2.4 Studies on the role of teacher in classroom interaction during the teaching and learning process

To articulate our ideas, feelings, emotions and skills during the instructional process, verbal, written, non-verbal and gender interactions are necessary (Page, 2010). Teachers can apply verbal, written and non-verbal skills to assist learner's understanding of concepts that are perceived difficult (Bunglowala & Bunglowala, (2015). Furthermore, if a teacher is conversant on how to use these interactions in an efficient way, there will be improved association between the learner and the teacher, and the learner's efficiency in learning and their cognitive ability will develop. It is important to note that teachers must involve both genders equally so that both are given equal opportunities during the learning process.

Traditional lessons were characterized by a teacher standing or sitting behind a table in front of the class and lecturing or directing students during the entire lesson while the students sit, listen and take notes passively (Tuan, & Kim, 2010). Rather than being the provider of knowledge, the teacher should facilitate and be a role model to create learners who are active during the entire lesson. Learners' preparedness to learn is determined by a teacher's actions such that, if the teacher

prepares a conducive, learning environment, learners are likely to pay more attention during the instructional process (Julia, 2014). A teacher can create either a positive or a negative environment and the learners can sense the mood of the teacher such that if the teacher appears annoyed, the learners may react negatively impairing the teaching and learning process. Therefore the teacher is a fundamental player during the lesson to initiate and maintain interactions during learning.

For effective teaching practices the teacher acts as a mentor through interacting with learners which motivates them to have the desire to perform well (Awofala & Nneji, 2011). This is likely to impact on learners towards learning depending on the teacher's nature. Listening to learners can also be a way of mentoring them because listening requires patience and learners are attracted to teachers who care. The current study focused on interactions that involved listening, appreciating like thumb up, nodding, words like thank you, teachers' way of dressing and facial expression and their effects on learners' academic achievement.

Effective classroom interaction practices are therefore critical during the implementation of the curriculum and teachers should know the factors that hinder such practices. For example, learners can be discouraged if answers they provide are criticized in a demoralizing manner or teachers do not pay attention to them. After all, learning should be a social activity where learners and teachers are engaged in sharing of ideas and appreciating one another. This is supported by the social constructivist theory based on the belief that learners should be trained to

construct relevant knowledge to tackle the challenges facing a person's world which is an active process that engages the mind (Hurst, Randall & Sarah, 2013). This simply means that information should be acted upon mentally so that it can have meaning to the learner. The implication arising from the current study is that, for effective interactive lessons, the teacher needs to create a social environment that will enhance the interactive activity.

Constructivist views shows that learning is a process involving building from learner's experiences to new experiences in the current situation, restructuring it to create new knowledge (Roberts & Billings, 2008). Therefore, sharing of experiences emanating from learners from diverge backgrounds and interests results to effective interactive activities. This is supported by (Page, 2010) whose study established that, for effective learning practices, teachers must create motivating methods of teaching during curriculum implementation. Therefore for meaningful learning to take place, teachers must incorporate social interaction practices among the learners that will help them in solving complex problems.

Sukris (2018) for instance asserted that teachers can use a variety of interactions as curriculum delivery techniques with a view of enhancing the desire to learn amongst the learners which is likely to raise learners' academic achievement. Therefore, an effective teacher should be able to incorporate effective interactive methods in the lesson plan to create learners' readiness and desire to learn. The current study focused on verbal, non-verbal, written and gender interactions.

2.5 Studies on teacher and learner class talk (oral) and learners' academic achievement

Class talk interaction is where learners interact with each other and the teachers during the learning process. Activities such as questions, answers, speaking, comments, seeking clarification and participating in either class or group discussion takes place (Tuan, & Kim, 2010). Firooz (2016) noted that, there is too much teacher talk compared to learners' talk. The study recommended that, teachers should be more indirect, should ask more questions and deliver less lectures and frequently praise, accept and incorporate learners' feelings and ideas during the process of teaching and learning.

If class talk interaction behaviours such as frequent praises like good, keep up, thanks for attempting are likely to raise the learner's desire to share experience and participate in learning environment, the learners' academic achievement is likely to improve as hypothesized by the current study. This is not a new concept to our teachers but are they practicing it in the classroom setting during the implementation of the curriculum?

Apparently, in 1970 Flanders gave a historical background regarding oral interaction and revealed why it is important and why teachers should adopt it as a way of delivering the curriculum (Masitah, 2013). Flanders asserted that, probably before or from the time of Plato and Socrates, teachers have been using questions to stimulate thinking of their learners in the classrooms. But how effective has this

practice been? Effective questioning technique is a strong instrument used to initiate oral learning context and negotiate meaning in a classroom by providing dialogic process aimed at ensuring students gain experience regarding situations of real life (Kamile, 2012).

According to Masitah (2013) effective teacher questioning techniques in mathematics involve high order teacher questions while the teacher need to allow a few seconds to get thoughtful responses from the learners. The questions should be structured in a way to attract wide participation while the teacher should appreciate each answer, whether correct or wrong. Such a questioning technique promotes verbal interaction during learning. While the two studies focused on the importance of verbal or oral method of interaction during the lessons the current was based on effect of oral interaction on learners' academic achievement in gas laws in Chemistry.

Fawzia (2002) study, conducted in Omani, revealed that, the three factors that influence oral interaction during teaching and learning are learner, social and pedagogical factors. Learner aspect includes the way a learner perceives learning, attitudes towards learning, effective language for interaction, and style of learning, learners experience and individual emotional factors. Social aspects include but not limited to learner's gender in the classroom and how learners socially interact among themselves and teachers. This is because learning is a social activity that

involves learning from one another. Pedagogical factors include the classroom teacher, topic and the teaching methodology.

This study was on factors (independent variable) that affect learners' verbal participation (Dependent variable) in university level academic classes, but the focus of the current study was on the effects of non-verbal (Independent variable) interaction on learners' academic achievement (Dependent variable) in gas laws in chemistry at secondary school level. Furthermore, the dependent variable in the current study was measured in scores which is more measurable compared to oral interaction whose indicators were not clear.

Moreover, a similar study by Tatar (2005), revealed several factors that influence oral interaction during teaching and learning and consequently impacting on classroom participation of learners. These factors included; lack of self-confidence, learners fearing to make mistakes during the lesson, hence avoiding embarrassing situations, learners' challenges in language skills and lack of adequate content knowledge. Beside oral interaction being the dependent variable, this study was on classroom participation experiences among English speaking students. Learners' academic achievement in Chemistry formed the dependent variable in the current study.

An investigation by Usendia, Udo and Effiong (2015) on oral interaction patterns on students' academic achievement in junior secondary, in basic science and technology in Nigeria established that, learners in integrative classroom had

significantly higher academic achievement than those in teacher dominative classes. The study analyzed data by comparing two means using t-test and Analysis of Variance (ANOVA) while the current study analyzed data using simple regression to predict dependent variable and compared multiple means using one way ANOVA. Further, the current study was on gas laws in Chemistry. Moreover, Kalu (2013) study done in River State, Nigeria established a positive and significant correlation between oral interaction behaviour and physics learners' post instructional attitude and academic performance. This study utilized students' attitude and achievement in physics as data collection instruments.

The focus of the study was on physics and a correlation design study while the current study focused on predicting learner's academic achievement in gas laws. According to Lisa (2011), oral interaction draws the attention of the teacher and the learner almost immediately. Research suggests that oral interaction in small groups improve basic thinking and motivate learners towards a profound learning approach (Hmelo-Silver, 2004). The dependent variable was basic thinking and motivation of learners. One major shortcoming about this study is that, basic thinking and motivation are not easily quantifiable' and this was a review study. The current study was an empirical study while the dependent variable was derived from learners' test scores.

Findings from Elaine and Henk's (2007) study on investigation of verbal collaborations in problem based learning, showed that many learners' associated with oral interaction concentrated on expressing or reviewing actualities with a

much lower rate including valuable articulations, contentions, assessment, proposition and basic inquiries. The study revealed a positive relationship between verbal interactions and quality learning. The study used one problem-based learning group of five students. The study recommended a similar research with a bigger sample size utilizing multiple linear regressions that will investigate the effect between teachers'/students' oral interaction, individual learners' study, teachers' role and the learners' academic achievement. This study was a correlation study while the current study was based on descriptive survey design.

In addition, the current study was based on the recommendation of this study, hence focused on learners' academic achievement and used a larger sample size of 384 learners. The current study further analyzed the data using simple and multiple regression analysis.

Solmaz, Adel and Yusef (2013) in their research on learner-teacher oral interactions during the teaching process and the association with students' achievements in academics for middle school students in Ardabil, Iran used the following data collection tools: recording documents to record the score of students, rank table for factor analysis, and French and Galway non-verbal communication scoring system. At the end of 2001/02 academic year, the mean score obtained was taken as the achievement score. From the findings, positive correlation between oral interaction and student's academic achievement was found.

The current study used the following data collection tools: a students' questionnaire, observation guide, students' discussion guide, CQUASO interview guide and a Chemistry achievement test that was set and marked by the researcher. All the instruments focused on one sub-topic only: Gas laws while Form three secondary school students were used. Additionally, this study was on association which tested correlation coefficient, but the current study was on effect which therefore tested the prediction of dependent variable.

An empirical study by Sukri (2018) investigated the effects of verbal interaction on learners' academic performance in English language in Magelang, Central Java Indonesia. The study revealed that, the two variables were significantly and positively related. This study collected data through questionnaires and score of final English test while analysis of regression was used to analyze the data. One shortcoming of the study is the collection of data using one instrument which was a questionnaire. This is because responses provided in a questionnaire are likely to be subjective. Another shortcoming is the score of final English test.

The current study used observational checklist as the main instrument of data collection which was more objective than a questionnaire because the researcher recorded the exact behaviours of the respondents. The score for the current study emanated from a topic that was taught and observed within 80 minutes while the study was on gas laws in Chemistry.

An investigation by Lisa and Calvin (2006) in Taiwan on the relationship between teachers' oral behaviour and willingness of learners to speak in English in central Taiwanese college classrooms revealed that teachers' oral behaviour had a positive correlation with learners' willingness to speak in English language during English instructional lessons. This study was in English, teachers' oral behaviour as the independent variable and willingness of students to speak as the dependent variable and used correlation design while the current study was on oral interaction as the independent variable, while learners' academic achievement was the dependent variable and focused on gas laws in Chemistry and used descriptive survey design.

Dina (2015) study on the analysis of teacher oral behaviour and the nature of learner's interaction during the teaching of English as a foreign language revealed that teacher oral behaviour in the learner's interaction is indirectly influenced based on Flanders' Interaction Analysis Categories System (FIACS). Moreover, the study focused on teacher oral behaviour and recommended future research whose objective would be to investigate teachers' correlation oral behaviour with the learners' performance. The current study used FIACS on the observational schedule and sought to investigate the effect of oral (Class talk) interaction on learners' academic achievement in gas laws in Chemistry. Furthermore, the nature of interaction in an English class is different from a chemistry class because the teaching methodologies of the two subjects are different.

Results from a study by Firooz (2016) done in Tabriz high schools using one-way ANOVA established that praises or encouragements during the teaching of Mathematics and humanities have a statistical significant difference. The finding revealed that teachers of humanity were encouraging learners more compared with those of Mathematics. Additionally, direct teaching revealed a negative correlation with learners' achievement. This study was a descriptive and correlation one. Analysis was done using t-test and one-way ANOVA to compare the teaching of Mathematics and humanities. The current study focused on Gas laws in Chemistry while data was additionally analyzed using simple regression to predict the effect of the two variables under study.

Nurzali and Khairu's (2009) study on the effects of classroom oral interaction on learners' academic achievement at the international Islamic University Malaysia (IIUM), observed two lecturers in a classroom oral interaction lessons and its effect on academic achievement of learners. The outcome of the study revealed that lecturers were good in their practice of classroom interaction. The results further revealed insignificant impact of classroom oral interaction and learners' academic achievement in the two lessons. While the study used a very small sample of two lecturers at University level, the current study involved 30 teachers in public secondary schools whose data was more reliable compared to a sample size of two lecturers.

Hafiz, Nasiraldin and Eshtiagh, 2008 (as cited in Solmaz, Adel & Yusef, 2013) carried out a research study involving middle school students in Ardabil and found that three quarter of the talks in a classroom were by the teacher and the remaining quarter were by the learners while a study by Solmaz, Adel and Yusef (2013) revealed that out of all interactions that take place in a classroom, 48.4% were speeches and explanations by teachers. Interaction of learners was 24.6% and this was as a result of talks while responding to questions posed by teachers and the remaining 8.1% was spent in silence. Hence, the conclusions of this study revealed that, classroom teachers continue to dominate during the learning process.

Additionally, the talk time for students in this study, when they are responding to teachers questions and when having free and initiative talks, was high compared to a study findings of Solberg, 2008 (as cited in Solmaz, Adel & Yusef, 2013), which indicated that participation of students was high than other studies and also the talk time of teachers was higher. The two studies focused on English language and analyzed the data quantitatively, presenting the findings in frequency tables while the current study analyzed data through one way ANOVA and simple regression and was based on gas laws in chemistry.

Cheruiyot (2015) carried out a study in Baringo Sub-County, Kenya on the relationship between classroom verbal interactions and learner's academic performance in Physics. The study revealed a relationship between verbal interaction patterns in the classroom and learners' participation and performance in

Physics. The study further revealed that, learners were more active in classes where teacher's teaching methods were dominated by indirect verbal interaction compared to those dominated by direct verbal interaction. Data was analyzed using frequency tables and t-test was used for comparison of the means in learners' achievement, while the relationship between verbal interactions and learner's academic achievement in Physics was done through Pearson Product-Moment Correlation Coefficient. Therefore, this study was a correlation design while the current study tested the prediction of dependent variable by the independent variable using simple regression and tested the hypothesis using a one-way ANOVA and was based on gas laws in chemistry.

Irfan , Rabia and Muhammad (2018) study in Biology subject involved a quasi-experimental study where the control group was taught in the normal tradition method and the experimental one exposed to peer teaching among the students. Both groups were involved in a pre-test to determine their levels and a post test. Results of a post-test revealed significantly higher academic achievement in the experimental group compared to control group.

The findings suggest meaningful learning in the experimental group due to interaction of learners, unlike the control group which was characterized by passive learning. The findings of this study further revealed that, peer teaching encourage oral interaction through social context. The study used male students hence recommending further studies using both male and female to take care of gender

balance. An independent *t*-test was used to analyze the data collected from pre-test and post-test.

While the study used quasi-experimental research design and focused on Biology, the current study used descriptive survey design and focused on gas laws in Chemistry. Quasi-experimental research design has its own shortcoming due to human nature. This is because when human beings are aware that, they are being experimented on, they tend to modify their behaviour resulting to unreliable data. Additionally, the current study used both gender to avoid gender bias that might result in unreliable results.

2.6 Studies on written interaction and learners' academic achievement

Written interaction is the method of learning which is characterized by learners writing out the knowledge or ideas they have in mind. It means they interact with others through writing and sharing their own written documents. Through written interaction, learners perfect the skills of writing and answering of questions which will then be tested during assessments (Mallozzi, 2013). The aim of written interaction is to allow learners to know how much knowledge they have retrieved from a concept taught in a given topic (Lisa, 2011). Written interaction therefore trains the learners to develop the interest of looking for knowledge away from teachers, making them independent in knowledge seeking, a factor that is likely to improve their academic achievement.

Peer feedback, also referred to as peer interaction is a useful cognitive social activity that is useful in improving the learning of English writing where learners derive social benefits of peer feedback (Maryam, Seyyed & Maryam, 2013). In academia, learners are generally assessed through writing and hence, writing is a fundamental factor in measuring academic success. This is because one way of a learner expressing what is in the mind is through writing.

Traditionally, teachers were believed to be the only people to provide feedback to students' writing because they were perceived to have all the required knowledge and skills. Educationists have however, realized that peer feedback is a critical technique for improving students' writing all around the world (Luu & nguyen, 2010). Learners can therefore learn from one another through peer feedback. Therefore, peer feedback on writing provides learners an opportunity to perceive concepts and issues critically, and to improve their autonomy and knowledge.

One can therefore argue that, when a learner is teaching others or guiding them in chemistry, some writing is necessary. For instance, in the balancing of chemical equations the peer teacher interacts with other learners and writings. However, Luu and nguyen (2010) study did not address the effect of writing on student's academic achievement which is the focus of the current study. Munyaradzi (2013) asserted that, knowledge generated by the learners is easily recalled compared to what learners receive from the teacher.

Learners are encouraged to be knowledge seekers instead of the teacher dominating the search for knowledge on behalf of the learners. From this study Munyaradzi

(2013) was not clear how recalling of knowledge as a variable was measured while the current study addressed writing as an activity and independent variable and its effect on academic achievement which was the dependent variable.

Yusuf (2014) did an investigation targeting secondary schools in Nigeria on the effects of assignments on learners' achievement in Chemistry and level of anxiety in stoichiometry topic involving the balancing of chemical equations. Results revealed that, learners who received instruction through assignments had higher academic achievements and lower anxiety levels when compared with learners who received instruction using lecture method. This was a quasi-experimental design study while the current study was descriptive survey design and focused on gas laws in chemistry. Lindsay and Rosa (2000) study in Los Angeles revealed that feedback from teachers improve the writing skills of learners. However, the study did not address the effect of writing skills on learners' academic achievement.

Mallozzi (2013) investigated whether certain written comments from teachers, provided as feedback to learners in the Interactive Student Notebook (ISN), improved the use of ISNs to benefit the learners' science process skills. The study revealed that experimental group had higher scores compared to learners in the control group. Additionally, the findings of the study revealed that the nature of feedback received by learners (process-specific, task-specific, or metacognitively-specific) has no effect on learners' science process post-test scores. Further, qualitative analyses showed that learners perceived learning to be enhanced by use of ISN and receiving specific written teacher feedback.

In contrast (Mallozzi, 2013) noted that, from the teachers' perception, the ISN may be helpful in some conditions but a combination of feedback, especially oral feedback, was more effective compared to written feedback. The dependent variable in this study was science process skills. Among the recommendations suggested by the study was more research to explore the effect and type of feedback that learners receive (process-specific, task-specific, or metacognitively-specific) on academic achievement and the teachers' belief that verbal feedback is likely to be more effective than written feedback needs to be explored further. The study used quasi-experimental design which may be influenced by human shortcomings.

Matsumura, Patthey-Chavez, Valdes, and Garnier (2002) in their study on writing assignment in English language revealed that corrections of grammar and punctuation reduced the writing convention errors. The conclusion of the study indicated that, quality of learning was predicted by the quality of writing. The study focused on 29 urban third-grade classrooms in 8 schools and targeted Whites, Asians and Latino learners. The findings further indicated a small significant difference between the Whites, Asians and Latino learners on the quality of writing. In this study, quality of learning was predicted by the quality of writing, while the current study investigated if written interaction predicted learners' academic achievement.

Furthermore, academic achievement is easily measurable by scores compared to quality learning. If such interactions happen during the teaching process in

Chemistry, topics that appear difficult like balancing of chemical equations would arguably be made easy and probably improve the learners' academic achievement. However, written interaction takes more of the teacher's time because for it to be effective the teacher must take time to mark the learner's work. Nonetheless, this is another criterion to determine if the learners have achieved the academic expectations. Moreover, written interaction allows the teacher an opportunity to correct responses like state symbols, chemical formulae and chemical symbols as in the example of balancing of chemical equations in Chemistry (Matsumura et al., 2002).

The implication is that, when teachers give assignments to learners and take time to mark, learners are likely to achieve more through corrections and teachers remarks. Mistakes made during the assignments are unlikely to be repeated during examinations, resulting to higher learner's academic achievements. This study focused on quality of writing and quality of learning in English language while the current study addressed academic achievement and written interactions and was based on gas laws in chemistry subject.

Findings from a study by Lisa (2011) in USA involving fifth grade students revealed that, instructors are no longer using written interactions effectively because of the time limits that different partners in training have put in place. In the process, written teacher interaction is given very little time. One of the study's conclusions was that learners require written feedback from the teacher for effective

academic achievement. This is the same scenario in Kenya secondary schools where the teachers rush over to complete the syllabus so as to create adequate time for revision denying the learners the opportunity to interact through writing to enhance understanding of scientific concepts. Moreover revision can be effective if the concepts learnt in class were understood and where writing interaction is used as one way of understanding concepts in chemistry.

In Murang'a County for instance, the Chemistry County mean score in year 2017 was 3.11 which by all standards is very low. According to KNEC (2018), the examination demanded mastery of content than summarized points and candidates who relied on revision books instead of the primary course books lacked enough content. Candidates did not demonstrate mastery of content and lacked application skills especially in questions that involved explanation and discussion. Additionally, questions that required critical thinking were very unpopular with candidates. Therefore, students seemed not to have understood simple Chemistry concepts which probably were the reason why they gave sketchy answers where they were required to provide elaborate answers.

This is most likely due to inadequate written interaction in which teachers would have discovered the weakness early enough. When learners are continuously given difficult assignments that require interaction with text books and discussion in the classroom, they are likely to gain the skills to tackle questions that require critical thinking and application (KNEC, 2018). The implication of this report is that,

teachers should avoid relying on revision books which drill the learners in memorization rather than making them creators of knowledge. Moreover, from the reviewed studies it is apparent that, there is insufficient research regarding the field of written interaction and academic achievement. Therefore, more attention and research is required because most of the reviewed studies were on writing skills in English.

2.7 Studies on Nonverbal interaction and learners' academic achievement

According to Fabri, Moore and Hobbs (2015) non-verbal refers to human interaction events that surpasses the impact of the spoken or written words, while Fatemeh, Samaneh and Ali (2014) refer to non-verbal interaction as a means of stimulating meaning in another person's mind through use of non-verbal signs such as nodding and facial expression. Non-verbal interaction may be in form of change of tone, dressing, body movement, facial expression, gazing, types of gestures and body posture (Samaneh & Ali, 2014). This suggests that, non-verbal interaction may have a better impact compared to oral interaction depending on how it is applied in a classroom environment.

Okon (2011) noted that, the common types of nonverbal interaction in both humans and other primates are emotional expressions derived from facial expressions. Apparently, findings from several studies show similar physiological reactions on facial expressions, emanating from different cultural background across the world (Manusov and Patterson, as cited in, Okon, 2011). For instance, a smile is perceived as an indicator of happiness while tightening and hardening the facial muscles is

perceived as an indicator of one being annoyed. An effective teacher is conscious to what is happening to students during the instructional process, is a good listener, attend the students with interest in learning and those not interested in learning. The teacher has the ability to create learning interest by use of non-verbal cues with a view of creating motivation to learn. Learners' desire to learn may be raised by teacher's appearance like dressing, smiling face, humbleness, caring and patience. In contrast learners' desire to learn may be lowered when the teacher seems unhappy, possess an intimidating face, and is arrogant and proud.

This is supported by Buja (2009) who opined that, a smile may create a conducive scenario where learners' motivation to learn can be raised during the instructional process. This seems to suggest that, an intimidating facial expression of a teacher may become a barrier towards effective learning. Okon (2011) and Buja (2009) studies did not focus on the effect of non-verbal interactions on learner's academic achievement which was addressed by the current study.

Findings from a study by Julia (2014) on the effect of teacher non-verbal behaviour on ratings of effectiveness of the teacher and student learning revealed a high correlation between the two variables while the teacher's effectiveness was correlated with teacher's zealousness. The study adopted a correlational design. Noureen, Chaudhry and Manzoor (2012) did a study on teachers' non-verbal behaviour and its effect on learners' academic performance whose objective was to assess teachers' non-verbal behaviour of both gender working in English medium

Federal Government Cantt Garrison schools, Army Public schools and Private schools. The outcome of the study was that, non-verbal behaviour of the teachers reinforced their verbal conduct which influenced learners' academic achievement. The focus of the study was Physics, Biology and Chemistry while observation schedule and video recording were used as the instruments to collect data. This study targeted both Army public schools and private schools while the current study focused on public secondary schools to ensure the needs of learners are the same because learners in private schools are of higher economic status compared to learners in public schools.

Further, the current study narrowed down to Chemistry and specifically to gas laws, while data collection was enriched through students' questionnaire, students' discussion guide and interview schedule. The researcher in the current study did not use video recording because of human shortcomings. Video recording can cause anxiety to respondents, hence distorting the data.

Sukris (2018) study done in central Java-Indonesia revealed that non-verbal interaction significantly and positively influence learners' English academic performance. The main data collection instrument was a questionnaire while the English examination at the end of the year provided the scores for the dependent variable. Data for this study was analyzed through regression analysis. The main data collection tool for the current study was lesson observation checklist and besides using simple regression, descriptive analysis, Pearson Moment Correlation

Coefficient and ANOVA were used to increase the reliability of the findings while the focus was gas laws in Chemistry.

In a study on the impact of perceived teachers' non-verbal behaviour on learners' motivation during learning of English in Taiwan, Lisa (2006) noted that, instructor's non-verbal behaviour improves learners' morale in the learning of English. Target group for this study was from a technology institution in central Taiwan. The study's focus was on motivation of learners in English as the dependent variable and used multiple regression and correlation design.

A review study by Bambaeeroo and Shokrpour (2017) on the impact of the teachers' non-verbal interaction on successful teaching revealed that, amount, quality and technique of utilization of non-verbal interaction by teachers during instructions was strongly and positively related with academic achievement. This was a review study that involved searching similar articles in the same field using key words like quality teaching, verbal interaction and non-verbal interaction while the current study was a research study and a descriptive survey design and analyzed data through descriptive and inferential statistics.

Bambaeeroo and Shokrpour (2017) suggested that teachers should make efforts in attracting and guiding the learners using both verbal and non-verbal interactions. The study suggested that stakeholders in education to plan and hold educational programs to familiarize educators and learners with skills of non-verbal interaction to make the teaching and learning process more effective.

York (2015) study conducted in a midsized Midwestern university United States of America, regarding non-verbal immediacy on student learning revealed that, the effect of non-verbal interaction during the learning process on the impact of learner's academic achievements was inconsistent. The study's objective was to determine the relationship between teachers' non-verbal interaction and learners' academic performance. Among the findings was an association between non-verbal interaction and academic performance of learners. This study used correlation design and utilized introductory speech in English language in post-secondary learners while the current study employed descriptive survey design and targeted gas laws in chemistry whose teaching methodology is different from English language.

Findings from a study by Fatemeh, Samaneh and Ali (2014), conducted in Shariyar, Iran, revealed that teachers' facial expressions and eye contact influenced students' learning of language. This seems to suggest that, learner's attention and concentration can be improved significantly. The end result is an active learning environment which enhances learner's retention and understanding of concepts.

The major data collection instrument in Fatemeh, Samaneh and Ali (2014) study was a questionnaire which can be subjective while the target group was Iranian students at Shahriyar Islamic Azad University. The current study used lesson observation checklist as the main instrument and the target group was secondary school Form three learners.

Lisa and Calvin (2006) study revealed a positive relationship between teachers' non-verbal immediacy behaviours and learners' willingness to speak in English. This study adopted a correlational design while the current study used a descriptive survey design.

Mehdipour and Balaramulu (2013) study revealed that teacher's friendliness and attitude toward the learners had a positive significant impact on motivation towards learning and improved discipline of learners. The participants of this study were university students in India. Research data for this study was analyzed through frequency tables, chi-square and Pearson's Product Moment Coefficient of Correlation (r). The current study used the same method of data analysis and improved by using simple regression and a one way ANOVA. From the literature review it seems the focus was more on languages while other subjects appears unexplored.

2.8 Studies on gender interaction and learners' academic achievement

The term gender refers to a wide range of biological, behavioural, physical and mental characteristics with regard to and differentiating the female and the male population (Adigun, Onihunwa, Irunokhai, Sada, Adesina, 2015). Gender and sex are not interchangeable; the term sex refers to the biological distinction between the two genders and cannot change. Therefore gender is an aspect concerning the responsibilities, roles, opportunities, constraints, and needs of males and females in all aspects of social context (Filgona & Sababa, 2017). Therefore, gender, is a

critical issue, which has attracted the attention of teachers especially due to the fact that gender equality is a focus in all sectors of life.

As noted by Palt (2018), the proportion of male scientists in Africa remains high compared to female; the proportion of female in the research field is 29% for the whole of sub-Saharan Africa while it exceeds 45% in Tunisia and Egypt. In Kenya, out of a population of 48 million people, 300 people get a PhD every year, and only 75 of them are female. This shows how serious females are disadvantaged especially in Africa due to their assigned gender roles.

This orientation is a critical issue faced by students in schools. For instance, many studies have noted that teachers do not give equal attention to male and female learners. If learners are regularly exposed to these stereotypes it may send negative messages about how they are expected to behave according to their gender (Lindsey, 2013). Moreover, potential growth and development of learners is limited when they are faced with gender stereotypes (Firooz, 2016).

Therefore, the gender of a student is a fundamental variable in explaining academic performance of learners. One of the intriguing explanations of variation in gender in student's academic achievement relates to the dynamics of gender interaction between the student and the teacher, especially to gender combination of students and teachers. Therefore the current study investigated the effect of gender interaction on learners' academic achievement. Recently, the findings of research related to gender interaction between students and teachers have influenced many

changes in educational policy globally (UNESCO, 2000). For instance, many countries have campaigned for equal opportunities for both genders in all sectors of the economy with a view to eliminating the perceived gender stereotype by many societies.

Filgona1i and Sababa (2017) noted that, male and female students should be treated equally during teaching and learning and all students should be provided with equal opportunities and same encouragement level and engagement irrespective of gender. Lauren (2012) asserted that within the learning environment, gender is a critical phenomenon, since teachers have different responses to boys and girls within the same classroom. Therefore, teachers tend to confirm the traditional gender roles taught by the society. Boys for instance are often praised for their knowledge while girls are praised due to their perceived obedience. One of the conclusions arising from Lauren (2012) study was that teachers should focus on reducing the gender stereotyping that learners may have arising from the different cultural background.

Another study by Berk (2006) revealed that in a mixed class, teachers who tend to interact more with boys than girls have high chances of interrupting girls more often than boys during discussions. Moreover, such gender bias makes boys more active than girls in the classroom during the teaching and learning process (Christine, 2015). However, Lauren (2012), Berk (2006) and (Christine, 2015) studies failed to address the effect of gender stereotype on learner's academic achievement.

An investigation by Nana (2012) in Georgia revealed that, instructors mostly treat students of various genders differently and have stereotyped the potential of boys and of girls. Conclusion arising from this study established that, regardless of better academic outcomes among girls, their potentials are underestimated leading to low morale and their conduct is confined to stereotypical female roles. This is likely to promote gender-bias perception resulting in unequal treatment and low self-esteem among girls. Would this result to low academic achievement in girls? An attitude questionnaire was the main data collection instrument in Nana (2012) study while all subjects in the curriculum were involved. Observational schedule was the main instrument for data collection for the current study and narrowed down to gas laws in chemistry.

Oluwatosin and Ogbeba (2017) study on impact of gender on senior secondary Chemistry learners' academic performance in stoichiometry using hands-on activities revealed insignificant difference in average performance score between both genders. Additionally there was significant correlation between the techniques and gender on average achievement score of learners in stoichiometry. To enhance learners' academic achievement in stoichiometry, the study recommended that, because the activity of hands-on is not sensitive to gender, students of both genders should be made to participate in the hands-on activities. While this study was on impact of gender, used quasi-experimental research design and stoichiometry as the subtopic, the current study was on gender interaction effect, used a descriptive survey design and gas laws as the subtopic while the main instrument of data

collection was an observational schedule. Quasi-experimental has the human behaviour shortcoming. When human beings are aware they are part of an experiment, they tend to behave differently.

In their study Nematullah, Mohammad and Saeed (2008) noted that classroom interactions are gender-related. One of their recommendations was that self-regard and social values found in both boys and girls need to be investigated to establish why boys speak more than girls in classes dominated by girls. However, an in-depth interview schedule was recommended to be used to complement the findings of this study. In addition to other instruments, the current study used in-depth interviews with CQUASO and students' discussion guide as recommended by the study. This study did not address the effect of gender on academic achievement.

Durán (2015) did a case study whose purpose was to investigate the perception of teacher and learner on gender in an EFL class and its manifestation in their discourse patterns. Results showed differences in the manner boys and girls interacted during the lessons. Further findings from this study was that, girls had low self-esteem. The study revealed that, part of teachers' and learners' perception of gender was stereotypical.

In regard to gender, the attitude of teachers tended to be in the favour of the boys. The female learners seemed aware of the conscious or unconscious indifference of the teachers towards them, which in turn affected their self-esteem and confidence in learning English. This study compared self-esteem, stereotype factors and confidence among boys and girls and was in English while the current study

compared the academic achievement of boys and girls in relation to gender interaction and was based on gas laws in chemistry.

A study by Onyegegbu (2004) noted that boys were more active in interactions than girls while Fatokun and Odagboyi (2010) reported gender as a major factor that determine learners' academic achievement in Chemistry as a result of interaction. Both studies used correlational research design and were done in Nigeria while the current study used descriptive research design.

However, findings from a study by O'Connor, Dearing, and Collins (2011) had contradicting results that revealed high chances of girls interacting more among themselves compared to boys. Girls were found to work well in small group settings and discussing a problem or task ideas while boys often "argued over who will lead when working in a group and preferred to work alone". This study compared interactions of boys and girls when learning separately. One weakness in this study is that; to establish gender effect on learning or academic achievement, the two genders need to be in the same class. The current study addressed the weakness by sampling more mixed secondary schools compared to one-gender schools.

Fatokun and Omenesa (2015) study done in Nigeria to establish the effect of prior knowledge on classroom interaction on learners' academic achievement in Chemistry used Quasi-experimental design and two schools were purposively sampled. The study revealed a positive significant effect of treatment on learners' academic achievement in Chemistry. However, insignificant effect was found on

learners' academic achievement in Chemistry regarding gender. The study further revealed insignificant mean variation in prior knowledge between the control and experimental groups. One of the recommendations of the study was that teachers should be sensitive to gender and make sure that teaching of Chemistry is done in an interactive classroom style to improve quality learning that is likely to yield high academic achievement in Chemistry. This study investigated prior knowledge and learners' academic achievement, sampled two schools and used quasi-experimental design. The current study sampled 32 schools for reliable results while a descriptive survey design was adopted.

According to Nana (2012), there are few researches related to gender interaction on comparison of classroom interaction of male and female students and the few studies that have been conducted show that there is a clear cut line in differences that relate to gender. A study entitled Gendered EFL Classroom Interaction; case of Chinas senior middle school, Wenhua (2012) established that researches reflect the classroom cooperation of girls and boys are generally rare, yet a couple of the researches report obvious gender bias. The current study was based on the conclusions from Nana (2012) and Wenhua (2012) studies.

Results of a study by Nnamani and Oyibe (2016) regarding effect of gender on academic performance of secondary school Students in social studies in Nigeria revealed that, the mean academic performance of boys' learners was lower than the mean academic performance scores of girls' learners. Further results indicated that: when both genders were taught by male teachers, they had higher mean scores

compared to when they were taught by female teachers. Further findings revealed that, when girl learners were taught by male teacher, they achieved higher mean scores than boy learners taught by male teachers and vice versa.

The study further revealed significant difference in academic achievement of post primary school learners in Social Studies in relation to gender. The study under review focused on social sciences, and utilized means, standard deviations and analysis of co-variance (ANCOVA) to test the null hypotheses.

Beside mean and standard deviation the current study analyzed objectives using frequency tables and pie chart while one way ANOVA was used to analyze the null hypotheses and prediction of dependent variable was done through simple regression analysis. Furthermore, this study was based on Social Studies and involved 3,479 students while the current study involved 384 students and focused on gas laws in chemistry.

Similar results are exhibited by a study by Burusic, Babarovic and Seric (2011) that was conducted in Croatia whose objective was to investigate the teacher–learner gender interaction impact on learners' academic performance in elementary schools. The study used standardized knowledge tests and school marks in all the subjects within the curriculum to measure the pupils' school achievement. The study revealed that results of the standardized tests were the same irrespective of gender. Standardized knowledge tests and school marks for almost all subjects in the school curriculum were used while the current study narrowed down to subtopic of gas laws in mole concept in chemistry while the researcher set a CAT in gas

laws. This study used a target population of 844 Croatian elementary schools and 48,232 pupils aged 10 and 46,196 pupils aged 14 while the current study used a target population of 10,020 students aged between 16 years and 21 years who were considered more mature.

This study further revealed that during elementary and early post primary education, girls tend to perform better than boys, even in subjects like Mathematics and sciences which are always perceived as "masculine subjects." This implies that, if teachers avoid gender bias, then both genders have the same intellectual capacity to perform equally. Among the weaknesses of this study was using almost all subjects in the school curriculum which might make researcher lose focus. The current study focused on a gas law subtopic within mole concept in chemistry.

A study in physical science on students' gender differences in motivation by Almut (2017), done in secondary school had one major research question: are teachers' implicit cognitions another piece of the puzzle? Almut (2017) observed that learners are motivated better by teachers who are of the same gender because they could act as their role models. In addition, the study noted that educators preferred presenting tasks in contexts that favours same-sex students which are associated with their own gender.

Further, Almut (2017) revealed that the stereotype of educators that science-is-male has a positive relationship with self-concept of male but has a negative relationship with the motivational belief of females. The results of the study agreed that teachers' stereotypes contribute varying motivational beliefs between the genders

which could also be as a result of gendered educational choices. Girls are likely to select humanity based courses while boys are likely to select science oriented courses. The study was a correlation design and did not address effect of gender on academic achievement of learners which was addressed by the current study that was a descriptive survey design and analyzed data using simple regression and a one -way ANOVA.

Akabogu and Ajiwoju (2015) study on impact of gender and learners' academic performance in English vocabulary in Nigeria junior secondary schools in Akoka South Education Zone Ondo State revealed that gender positively and significantly affects the achievements of secondary school learners in English. Female learners had higher scores compared to male learners in English achievement test. One of the recommendations of the study was that teachers, school administrators and stakeholders need to change and provide equal learning opportunities to boy and girl learners. The study was based on achievement of English and therefore not justified to generalize the results.

Ajai and Imoko (2015) did an investigatory study in Nigeria to determine gender differences in Mathematics academic achievement by utilizing Problem-Based Learning (PBL). Findings of the study showed insignificant variation between students of both genders when taught algebra with the use of PBL establishing that students of both genders have the ability to compete and collaborate in Mathematics. The study was in mathematics, meaning there is a possibility of

different results from different subjects, hence no justification to generalize the findings based on one subject.

In a study carried out by Makila (2015) in Sweden, girls and boys were observed when doing science practical in single and mixed-sex classes. This study purposed to establish the dominance of male learners in physical sciences and assist teachers develop teaching methodologies favourable to both sexes. The findings revealed that: in the control group, girls in mixed-sex groups spent most of their time listening and observing rather than in actively taking part in the assigned task. The hands-on task-time in the experimental groups was reported to be almost similar. Nevertheless, even in the experimental group girls were found to watch and listen more compared to boys.

One behaviour that emerged from Makila (2015) findings was that boys in the mixed-sex small groups, happened to be the first ones to use the science equipment that were required to complete the assigned task without sharing them with the girls. Each group received a set of equipment, but girls had to wait until the boys were through with the equipment, which gave the girls a disadvantage of not finishing within the lesson. Results of this study showed that girls still perceive themselves as inferior to boys during science lessons. Teachers have continued encouraging girls but the girl child still wants to retain the traditional back seat when working in the same environment with the boy child.

More studies need to be carried out to find out the reasons why the girl child remains inactive in the presence of the boy child. The study used quasi-experimental design

and was mainly an observational study. The current study used descriptive survey design due to human shortcomings on quasi-experimental design; in that human beings may behave differently when aware they are being experimented on. Another shortcoming was that, the study did not reveal the effect of male dominance on learners' academic achievement.

Other studies have confirmed that boys are more interactive than girls. For instance, Marcus and Joakim (2016) who researched on gender variation regarding perception of boys and girls during the process of teaching and learning Mathematics found that boys use group work discussion more compared to girls and are more active during the lesson than girls. Boys received more attention because it is believed that they are very disruptive, and therefore, receiving more attention was a precautionary measure to prevent them going off the task. Because of that belief, girls received less attention and their involvement in class was low as compared to boys. This study addressed gender perception of teaching and learning Mathematics.

A study by Sheeba and Imran (2015) whose aim was to establish the effect of self-esteem, stress and gender on academic performance of learners in private universities in Pakistan, indicated that stress and self-esteem were positively and strongly correlated. However, gender and GPA of the learners were insignificantly correlated. The study further revealed that, effects of analysis of self-esteem and stress impact on GPA established that both effects insignificantly correlated with students' academic achievement. The study concluded that academic performance

of students is not significantly influenced by stress level and self-esteem in private institutions of higher learning which is in agreement with already existing literature. This study employed correlation design, focused on self-esteem and stress as the independent variables, while target group was university students. The current study employed descriptive survey design, focused on gender interaction as the predictor variable while Form three students in public secondary schools were the target group.

A study by Hoque, Razak, Mosa and Reazul (2013) attempted to establish the impact of teacher-gender interaction on pre-secondary school learners' academic achievement in Malaysia. Classes taught by women had higher test scores than classes that were taught by men. Therefore, the general results of the study were that female teachers were better than men in teaching of primary school pupils. The implication of the study was that women spent more time with children than men did and women had better interaction skills. This gives female teachers an advantage of being better teachers in terms of social interaction in class making learning interesting and meaningful. Primary school pupils who were the target population for this study may behave differently from secondary school learners due to age and cognitive level. Primary school pupils may not be conscious of gender stereotypes as compared to secondary school students.

Several studies have shown similar results. For instance a study by UNESCO found that learners instructed by female teachers are likely to achieve better scores than

learners instructed by male teachers (UNESCO 2000, 2005). Female teachers are patient, gentle, compassionate, and friendlier. This could explain the findings of a study by Myhill and Jones (2006) which revealed that, worldwide statistics have shown that majority of teachers are female while the predominant perception of learners is that boys are treated negatively by teachers compared to girls, while this perception increases with age. The objective of this study was to investigate learner's responses using an interview question. This study relied on one instrument which has a high rate of subjectivity and addressed the perception of pupils on academic achievement. The current study used six research instruments to collect data; students' questionnaire, observational checklist, students' discussion guide, CQASO interview guide and a CAT to allow triangulation of the findings.

A similar study done in Tunisia by Natasha (2016), indicated that female teachers improve the learner's academic achievement depending on the economic level of the location of the school; in low economic areas, girls significantly benefited from female teachers more than boys. However, in high economic areas female teachers are beneficial to all learners irrespective of the learner's gender. Is it that female teachers are better than males in terms interaction? The implication of this study is that, female teachers are better in the delivery of curriculum than male teachers. This is an interesting area of research that needs more investigation.

Torberg and Linn (2011) explored the schemes used in educational evaluation and learner's academic achievement gender gaps in Norway. The study revealed that,

in Norwegian schools, girls performed better academically when taught by a male teacher, while in Mathematics girls performed better academically when assessed by teachers who had little experience. One implication of the findings was that teachers favoured girl learners, either deliberately or not. The study concluded that, the gender grading gap was related to teacher's characteristics. The study targeted girl learners only but the current study investigated interaction of chemistry teachers with both boys and girls with a view to exploring interaction gender disparity among teachers of both genders and learners of both genders and effect on learners' academic achievement in gas laws in chemistry.

Perkins, Kleiner, Roey and Brown, (2004) established that, female learners attain high academic performance in humanities, sciences and Mathematics in all the levels. A study by Gallagher and Kaufman (2005) revealed that many assessments concerning knowledge administered internationally shows that male learners had high achievement in standardized Mathematics tests while female learners had higher achievement results in reading and language tests. The two studies investigated gender and academic achievement but the current study narrowed down to gender interaction and academic achievement. Moreover, several studies reveal that, gender and age contribute to learners' academic achievement. For instance, findings from a study by Toni, Julija and Gordana (2018) revealed that, female learners have higher academic achievement from kindergarten level to university level.

The implications of the contradicting findings in the reviewed literature is that, gender issues are not yet resolved, hence need for further research. Interestingly some studies reveal evidence of boy child threats in education compared to girl child. For instance, Camille (2016) observed that, boys are increasingly performing poorly than girls at school and this has increased the boy's risk of dropping out of school, low college/university attendance, and/or un-employability. Camille (2016) further noted that in Organization for Economic Co-operation and Development (OECD) countries, 66% of females entered post-secondary institutions in the year 2009 while 52% were male and the gap is continuously increasing.

In Europe, in the year 2015, 43% of females aged 30–34 completed their tertiary education while only 34% of males of the same age completed (Camille, 2016). The gap had increased by 4.4% over the past decade and therefore there is need to identify the reason behind the ever widening gap. Camille (2016) study focused on school completion by gender. From the related reviewed literature there are many findings related to gender, but how the gender of a learner affects academic achievement remains unclear. Therefore, there is a need for further empirical studies to support the previous findings.

2.9 Summary of literature review and research gaps

Summary of literature review with the identified research gaps that were addressed by this study are as presented in figure 2.1.

Table 2.1 Summary of literature review and research gaps

Identified research gaps in Verbal (Oral) interactions

Author	Topic	Methodology	Key findings	Research gaps	Focus of the current study
Kalu (2013)	Classroom interaction patterns on learners' learning outcomes in physics.	Correlation design.	A positive significant correlation existed between students' oral interaction pattern and students' achievement in post instructional attitude.	1. Research design. 2. Data collection procedure-a questionnaire and a Physics Achievement Test were used.	Focused on descriptive design while triangulation of data collection was employed.
Hmelo-Silver, 2004	Problem-based learning: what and how do students learn?	A review study	Oral interaction in small groups improve basic thinking and motivate learners	Research design-A review study	An empirical research study
Firooz (2016)	The effect of teacher oral behaviour on academic achievement of learners.	t-test and one-way ANOVA were used to analyze data.	1. Existence of significance difference in praises during the teaching of Mathematics and humanities. 2. Humanity teachers were encouraging	1. Analysis of data. 2. Subject matter-mathematics and humanities were compared.	Focused on chemistry, one-way ANOVA, chi^2 and simple regression. Based on gas laws in chemistry.

			learners more than those of Mathematics. 3.Direct teaching was negatively correlated with students' achievement		
Nurzali and Khairu (2009)	Classroom oral interaction effects on academic achievement of learners.	Observed two university lecturers in a classroom oral interaction lesson.	Insignificant impact of classroom oral interaction and learners' academic achievement in two lessons.	Sample population while the respondents were university students from the international Islamic University at Malaysia (IIUM)	30 teachers in 30 Public secondary schools were involved in Kenya
Solmaz, Adel and Yusef (2013)	Relationship between teacher-student oral interactions and students' academic achievement	A correlational design that used Pearson Product Correlation Coefficient to analyze the data	Positive correlation between oral interaction and academic achievement of students was found.	One method of analysis was used which may lower the reliability of the findings.	Different methods of analysis were used; Pearson Product Correlation Coefficient, regression, one way ANOVA and chi^2
Cheruiyot (2015)	Classroom verbal interaction patterns in relation to learners achievement in Physics.	Mainly a correlational study	There was a positive relationship between verbal interaction patterns in the classroom and learners' participation and performance in Physics.	The study tested the relationship and was on Physics subject.	The study tested the prediction of dependent variable by the independent variable and was based in chemistry.

Identified research gaps in written interactions

Author	Topic	Methodology	Key findings	Knowledge gaps	Focus of current study
Yusuf (2014)	Effects of assignments on achievement of learners' in Chemistry in post-primary schools in Nigeria.	A quasi-experimental research design	Learners who received instruction through assignments had higher academic achievements.	Research design-used quasi-experimental design.	Descriptive design-observational schedule was the main instrument for data collection.
Mallozzi (2013)	Investigated whether certain teacher written remarks, benefited the learners' science process skills.	Research design quasi-experimental	1. Experimental group had significantly higher scores than learners in the control group. 2 .Nature of feedback received by learners (process-specific, task-specific, or metacognitively-specific) does not predict learners' science process posttest scores.	Research design	Descriptive design

Matsumura, Patthey-Chavez,Valdes, and Garnier (2002)	Quality of teacher feedback on learner's written homework and grade three learners' revision.	Targeted Whites, Asians and Latino learners.	1. Corrections of grammar and punctuation reduced the writing convention errors. 2. Quality of learning was predicted by the quality of writing. 3. Small significant difference between the three races on the quality of writing.	The focus was quality writing of learners'.	Focus was on learners' academic achievement. Target group-learners from the same race.

Identified research gaps in non-verbal interactions

Author	Purpose	Methodology	Key findings	Research gaps	Focus of the current study
Julia (2014)	Teacher oral expressiveness effect on teacher effectiveness ratings of learners' learning	Correlation design	A strong positive relationship between the two variables	Research design and dependent variable.	Descriptive survey designs while test scores formed the dependent variable.
Bambaeeroo and Shokrpour (2017)	Teachers' impact on non-verbal interaction on a successful lesson.	This was a review study	Teaching was strongly and positively related with academic achievement.	A review study	An empirical research study
York (2015)	Correlation between teachers' nonverbal interaction and learners' achievement in English.	Correlation design while respondents were post-secondary learners	There was a positive relationship between the two variables.	1. Research design. 2. Level of target group. 3. Subject.	Employed descriptive survey design and targeted chemistry in secondary school.

Identified research gaps in Gender

Author	Topic	Methodology	Key findings	Knowledge gaps	Focus of the current study
Oluwatosin and Ogbeba (2017)	Impact of gender on senior secondary Chemistry students' academic achievement in stoichiometry using hands-on activities	quasi-experimental research design	1. Insignificant difference in average achievement score between males and female students. 2. Significant relationship between the techniques and gender of average achievement score of learners.	Research design	Descriptive survey design.
Torberg and Linn (2011	Educational evaluation schemes and gender gaps in student achievement in Norway.	Focused on girl's students only	Girls performed better academically when assessed by a male teacher.	Target group-the study focused on girl's learners only.	Focused on both gender.
Myhill and Jones (2006)	Learner's perceptions on treatment of boys and girls by teachers.	One research instrument: Interview schedule.	Girls are treated better than boys.	Instruments of data collection	Six instruments were used-triangulation

In conclusion the studies under review showed varying results which do not provide

a clear interpretation regarding the effect of oral, written, non-verbal and gender

interactions on learners' academic achievement. The current study focused on gas laws in Chemistry subject, targeted Form three learners and in the Kenyan context with a view to identifying the existing gaps.

2.10 Theoretical Framework

This study was guided by Vygotsky's Social Development Theory (1896-1934)' which refers to social interaction as a critical fundamental requirement for an individual's full cognitive development. The theory focused on the impact of social interaction, individual's interaction with society, the language and the learning culture. The source of cognitive function is a product of social interaction resulting from social dialogue. "Learning of humans implies a process of social nature that is specific and whereby children have a gradual entry to intellectual life of individuals that surround them" (Topciu & Myftiu, 2015).

According to the theory, cognitive development of a child arises from social interaction with the people within the environment. In contrast Vygotsky was of the opinion that social learning precedes development (Crawford, 1996) as opposed to Jean Piaget's theory regarding the development of a child where development precedes learning. Vygotsky (1896-1934), asserted that: "Each function concerning a child's cultural development occurs twice: on the individual level, and social level."

1. **Social level.** Social learning takes place at this level. The child relates and socially interacts with the family members, neighbours and the school mates.

2. **Individual level.** Once the child undergoes the social level, the next level is the individual cognitive development where the independence of mind sets in. The child can now solve problems, handle tasks within himself and the society.

According to Vygotsky (1980), man is a social being in the sense that he is unable to live in isolation and he needs others in order to survive through interaction and developing of relationships. As a result of his nature man must explore and seek his rightful place in the society through social interaction (Vygotsky, 1980). According to Aristotle, "Man is by nature a social animal," and "society is something that precedes the individual." This implies that man should have the qualities to socialize with others in the society and anyone lacking such qualities is not human. Therefore, this can be summarized to mean that, humanity can be equated to the need to interact and connect with others in a social setting.

It is natural that every individual wants to know the meaning of every aspect within the environmental set up. Children develop curiosity right from childhood and as one's mind develops the person wants to know more about the surrounding and therefore ask questions related to the society and environment (Syomwene, 2016). The child starts looking around, wondering and developing interest in what is

observed, asking questions with a view to making meaning of the surrounding environment. For the child to find or make that meaning, the child must be involved and play an active part through socializing with people within the child's surrounding.

Therefore, it can be argued that a child's cognitive development can only occur when the child interacts with the surrounding environment and the society. In fact, a child living in isolation will develop fear of other people and is unlikely to develop mentally. This is supported by Vygotsky (1980) who argued that human and cognitive development of an individual arises from "dynamic" interaction between the individual and the society. The dynamic relationship indicates a mutual relationship between the two in that an individual has an impact on the societal environment while the society has an impact on the individual. It is from this point of view that it can be argued that, if a child is removed from the society the child will be forbidden to interact with it and consequently unable to learn and develop.

A very good example is the stages of development of a child: the parent is the first teacher of a child, who interacted with the child since birth and this is why a child feels secure in the hands of the mother. Later the child learns to play with brothers, sisters and age mates building strong bonds with the closest friends. From the interactions the child learns to talk, share food and many other things that happen within their environment. On the first day of school, the child meets the first teacher and strange class mates and interacts with them making new friends. In the

subsequent years the child interacts with others, shares ideas leading to further mental and cognitive development and consequently learning, (Topçiu & Myftiu, 2015).

Through social learning experiences, the child gradually develops leading to cognitive and mental development. Therefore, the implication of this theory to this study is that: it provides an insight of how learning takes place through social contexts and also helps teachers to construct active learning classrooms. From Vygotsky's (1980) view learning takes place as learners and teachers share experiences through interaction.

According to Vygotsky (1980) social environments have an influence on the learning process. He asserted that when peers, teachers, and other experts share experiences through interactions, meaningful learning takes place. To maximize the learner's ability to interact, teachers need skills to establish an environment of learning that engages learners with activities like discussion, collaborative learning and feedback from learners themselves.

2.10.1 Application of Vygotsky's Social Development Theory to the current study.

Many teachers have continued using the old model of instruction where the teacher remains the main transmitter of knowledge to learners. Contrary to, Vygotsky's theory, learning takes place effectively through interaction where learners take an active role during learning contexts. According to this theory, the teacher facilitates

learning by providing a conducive environment for teacher-learner and learner-learner interaction making learning meaningful (Santrock, 2006). Therefore, the learner becomes a contributor of knowledge.

The learner will consequently build on what they have or rather through learners sharing experiences and thus a meaningful learning takes place. Learning can therefore be concluded as a reciprocal experience between the learners and the instructors (Vygotsky, 1980). Therefore, Vygotsky concluded that cognitive development of a learner takes place when the learner is first exposed to social interaction learning.

The relevance of this theory was based on the fact that, teacher-learner and learner-learner interaction help learners to explore and discover new knowledge, hence improving the teaching and learning process. Oral interaction enhances cognitive growth of the learners through talk. For instance what a teacher says, like; very good or keep it up, has a significant impact on a learner. Both teacher and learner are involved which is a way of learning through social interaction.

Written interaction enhances cognitive growth and encourages learners to seek knowledge from books and from peers through group discussions. Through group discussions, reporting and peer teaching, the learners are able to socialize through interaction leading to meaningful learning. When learners are empowered to seek knowledge they feel part and parcel of the learning process and as such they get adequately prepared for higher learning. Non-verbal interaction provides

communication such as encouragement through facial expression and gestures which can only happen between two individuals with a common objective like a teacher and a learner in a classroom setting. This can only be practiced in a social and deliberate setting.

Gender can be a factor that may affect the social interaction in the classroom. Some teachers may be biased against a particular gender while some students may be shy to participate in the presence of the opposite gender. For instance, Nana (2012) noted that, instructors mostly treat students of various genders differently and have stereotyped the potential of boys and girls while Berk (2006) revealed that in a mixed class, a teachers interacting more with boys is likely to hinder the potential of girls during discussions. Therefore, for effective curriculum implementation and pedagogical practices, teachers act as facilitators towards social interaction in the classroom so that learners generate knowledge leading to meaningful learning. Several studies have been guided by the same theoretical framework.

For instance, a socio-cultural theory based study by Harvey (2011) on the impact of mediation during post-observation conferences on language teacher learning, used the same theory to internalize the study. This study investigated discourse nature and association between mediational discourse and teachers' learning of language. Guided by the same theoretical framework, Syomwene (2016) study established that, for effective pedagogical practices, the learner needs to be involved in interactive social settings. The study recommended that, for meaningful

learner's interaction and the use of knowledge in real situations, there is need to reorganize the English curriculum in the Kenyan schools.

2.11 Conceptual Framework

Conceptual framework is a diagrammatic presentation which shows how the dependent and independent variables are related. Figure 2.1 shows how the dependent variable which was learners' academic achievement is related to the independent variables which were; oral, written, non-verbal and gender interactions.

Figure 2.1: Conceptual Framework

Independent Variables

| Teacher and Learner Class Talk |
| Frequency of: |
| • Teachers' talk |
| • Learners' talk |
| • Group reporting |

Written Interaction
Evidence and frequency of:
- Group work assignments
- Individual assignment
- Marked assignments

Non Verbal Interaction
Frequency of:
- Eye to eye contact
- Nodding
- Gestures
- Varying of voice
- Body language
- Facial expression

Gender interaction
Frequency of:
- Girls' participation
- Boys' participation
- Teachers' gender preference
- Learners' teacher preference

Teaching and learning process

Dependent variable

Test scores

Intervening variables
- Teachers' characteristics
- Learners' characteristics
- Teaching and learning resources
- Physical facilities e.g. science laboratories

Source: Researcher (2021)

From the conceptual framework, the independent variables which are teacher-learner class talk, non-verbal interaction, written interaction and gender interaction impact on the process of teaching and learning thus affecting learners' academic achievement which is given in terms of test scores. However, other factors (Intervening variables) like teachers' characteristics, teaching and learning resources and physical facilities like science laboratories may affect the desired outcome which is the dependent variables which were not part of the study investigation.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents and discusses the research design, target population, sample size and sampling procedures and methods of collecting data. The chapter further presents pilot study, validity and reliability of the research instruments and data analysis technique. Finally, the ethical considerations relevant to this study are discussed.

3.2 Research Design

A research design refers to a planned structure for the purpose of conducting a research study (Kombo & Tromp, 2006). This research study adopted a descriptive survey design. Coopers and Schindler (2008) states that, descriptive studies are more formalized and ordinarily organized with unmistakably expressed hypothesis or investigative inquiries. It serves an assortment of research targets, for example, depictions of marvel or qualities related with a subject populace.

This design tries to acquire data that portrays existing spectacle by getting some information about their values, attitudes and behaviours. Although quasi-experimental design was suitable for this study, the researcher did not use it due to its human shortcomings. When a human being is involved in an experiment, the data might not be reliable because the person may behave in a manner to impress the researcher, hence giving the wrong data.

This study used both qualitative and quantitative methodologies. According to (Leedy and Ormrod (2005) and De Vaus (2001), as cited in Mutea, 2015), quantitative research involves data measured in numerical form. For the purpose of this study, data in dependent variable was reported in terms of scores. The bigger the scores the more the dependent variable while the smaller the scores the less the variable present. The scores from the administered achievement test formed the quantitative measure and their level of academic achievement.

Qualitative research do not produce discreet numerical data (Kothari, 2012) while Mugenda and Mugenda (2008) states that qualitative data is normally in the form of words and is normally collected through observation and interviews. Qualitative research is concerned with description, interpretation, verification and evaluation (Hilttlem and Simon (2002), as cited in Mutea, 2015). Therefore, by use of qualitative techniques, researchers have the ability of collecting data and explaining phenomenon thoroughly (Mugenda & Mugenda, 2008; Hilttlem & Simon, 2002).

3.3 Target Population

Population refers to a group of subjects having common observable characteristics that can be measured (Best and Kahn, 2011). A researcher first defines the target population which will be used to generalize the results of the study (Mugenda & Mugenda, 2008). Murang'a County was selected for the study because the county KCSE Chemistry performance from year 2009 to 2016 was the lowest compared to

performance in Biology and Physics and consistent with the national low performance.

This study targeted public secondary schools whose academic performance were taken as average with mean scores between 4.0 and 6.0 in chemistry in K.C.S.E between 2009 and 2016. This is because learners in secondary schools with mean scores above 6.0 may not show a significant difference since they can even perform well by studying on their own while learners who score less than 4.0 may also not show a significant difference because they were considered weak academically.

According to CDE, Murang'a County (2017), the number of secondary schools in Murang'a County which consistently scored 4.0 to 6.0 mean grades in 2009-2016 KCSE was 120 and the form 3 enrolment in 2017 was 10,020 learners. Therefore, the 120 public secondary schools were purposefully selected. The target population of chemistry teachers teaching Form three classes in the 120 selected public secondary schools was 300 trained teachers with either a Diploma or Bachelor's degree in Education and whose one teaching subject was Chemistry. This was the target population for this study.

Through purposive sampling, the researcher is able to select respondents who will provide detailed information and possess the characteristics that are of interest to the researcher (Best & Kahn, 2011). Subject cases are thus handpicked because they have characteristics of interest and are informative (Kothari, 2014). Therefore, the 120 secondary schools were suitable because they provided the learners with

average mean scores of 4.00-6.00 in Chemistry in KCSE in the years under focus (2009-2016) which was considered rich information for the study. Table 3.1 provides the target population of schools by category, chemistry teachers and Form 3 students by gender in each sub-county that was used in this study.

Table 3.1: Target population of the respondents in each sub-county by gender in Murang'a County

		Category of Schools				Chemistry teachers			Form 3 Students		
	Sub-County	Boys	Girls	Mixed	Total	Males	Females	Total	Boys	Girls	Total
1	Mathioya	5	4	6	15	28	18	46	796	608	1,404
2	Kangema	4	3	9	16	25	17	42	647	619	1,266
3	Kahuro	2	3	8	13	23	13	36	712	506	1,218
4	Murang'a East	4	3	5	12	14	18	32	442	567	1009
5	Murang'a South	3	4	7	14	21	14	35	588	653	1,241
6	Kigumo	4	5	6	15	20	14	34	617	579	1,196
7	Kandara	6	7	11	24	32	18	50	875	823	1,698
8	Gatanga	2	3	6	11	10	15	25	477	511	988
	Total	**30**	**32**	**58**	**120**	**173**	**127**	**300**	**5154**	**4866**	**10,020**

Source: CDE, Murang'a County (2018)

Murang'a County has two national schools which were not part of the study, because their mean scores were above 6.0. From table 3.1, the 120 purposively selected schools, 58 were mixed which were all sub-county schools, 30 were boys'

comprising of 10 extra-county and 20 county schools and 32 girls' public secondary schools comprising of 17 extra-county and 15 county schools. Further, 173 male teachers, 127 female teachers, 5154 boys and 4866 girls in the 120 public secondary schools in Murang'a County formed the target population of the current study.

3.4 Sample Size and Sampling Procedures

A sample refers to a subset of the target population which is selected for analysis (Best & Kahn, 2011). Sampling refers to taking a representative of a population (Kothari, 2012). A big sample can be taken when the researcher has time and resources that are needed. When a larger sample is used, the researcher can be confident that the information obtained is highly reliable (Bryman, 2008).The sampling of the public secondary schools in this study was done from eight sub-counties in Murang'a County. These were; Mathioya, Kangema, Kahuro, Murang'a East, Murang'a South, Kigumo, Kandara and Gatanga Sub-Counties.

The sample size for a study must be chosen by some logical process (Kothari, 2014). This study used Yamane formulae:

$n = N / (1 + Ne^2)$,

Where n= sample size

N = population size

e = error at 95% confidence level that is 0.05 (Yamane, 1967).

After substitution, the calculations using the Yamane formula yielded 32 out of 120 public secondary schools 384/10,020 Form 3 Chemistry learners, 32/120 chemistry teachers from 32 public secondary schools and the County Quality Assurance and Standards Officer from Murang'a county. All the 32 selected schools had more than one stream making the researcher to select one stream from each school using random sampling. The researcher divided the 384 sampled learners by the 32 sampled schools, which yielded 12 learners per school. This was done equally because all the sampled schools had classes of between 40-45 learners as recommended by the Ministry of Education.

From the 40-45 learners, 12 learners were selected from schools with one gender using simple random sampling procedure while stratified random sampling procedure was used in mixed schools to select the 12 learners to take care of gender. The 12 learners in each school took part in student's discussion guide and did the CAT while the whole class was involved during the observation by the researcher.

According to Best and Kahn (2011) simple random sampling allows the subjects in the target population to have similar chances of being selected to form the sample. To ensure gender and school category balance, the researcher used stratified random sampling thus selecting 9 boys' public secondary schools, 6 girls' public secondary schools and 17 mixed public secondary schools. The 9 boys' public secondary schools comprised of 3 extra-county schools, 5 county schools and 1 sub-county school. The 6 girls' public secondary schools comprised of 2 extra-

county public secondary schools, 3 county public secondary schools and 1 sub-county public secondary school. The 17 mixed public secondary schools comprising of 2 county schools and 15 sub-county schools. Mixed secondary schools were more than single gender secondary schools because of their population in the target population. If the population under consideration is not homogeneous, then stratified sampling method can be used in obtaining a sample that is representative (Kothari, 2012). For stratified sampling, the population is grouped into subgroups which are referred to as strata and are individually more homogeneous than the entire population and then items are selected from each of the sub-groups to form a sample.

The main aim of stratified random sampling procedure is to ensure that all the sub-groups are represented fairly. In stratified random sampling, selection of the elements is done to ensure all the sub-groups are represented in the sample (Mugenda & Mugenda, 2003). Murang'a County consists of eight sub-counties and each sub-county provided a different number of secondary schools depending on population of the schools in the sub-county which were also selected through stratified sampling technique.

Selection of teachers was done through simple random, stratified and convenient sampling. To take care of gender 16 male and 16 female teachers were used for the study. Since all the schools had more than one stream and only one class was required, convenient sampling was used to select the class and the teacher. The

researcher started by assigning the gender of teachers to be used in each sampled school. This was done using random sampling. Many schools with more than one stream prefer vertical teaching. This is where a form with more than one stream and both streams are taking the same subject assigns more than one teacher to the forms to enhance competition. The researcher used convenient sampling to pick the class taught by the gender of interest. Where gender was the same, simple sampling procedure was used. Table 3.2 shows the sample size that was used in the current study in each sub-county in Murang'a County.

Table 3.2: Sample size in each sub-county in Murang'a County.

		Sample Size of Schools				Sample Size of Students			Sample Size of Teachers		
	Sub-County	Boys	Girls	Mixed	Total	Boys	Girls	Total	Males	Females	Total
1	Mathioya	1	1	2	4	24	24	48	2	2	4
2	Kangema	1	1	2	4	24	24	48	3	1	4
3	Kahuro	1	0	3	4	24	24	48	3	1	4
4	Murang'a East	1	1	1	3	18	18	36	2	1	3
5	Murang'a South	1	1	2	4	24	24	48	2	2	4
6	Kigumo	0	2	2	4	24	24	48	1	3	4
7	Kandara	1	1	4	6	36	36	72	2	4	6
8	Gatanga	1	1	1	3	18	18	36	1	2	3
	Total	**7**	**8**	**17**	**32**	**198**	**186**	**384**	**16**	**16**	**32**

Source: CDE, Murang'a County (2018)

From the list of target boys' secondary schools from each sub-county, paper pieces bearing the names of the schools were folded and put in a basket. A person with no interest in this study was requested to pick papers equivalent to the assigned number of schools in the sub county as indicated in table 3.2. The same procedure was repeated in girls and mixed schools categories. To select the 12 students to be administered with the CAT, from each school, simple and stratified sampling was also used.

In same gender schools, pieces of papers bearing the names of the students in each class were put in a basket and a person with no interest in this study told to pick 12 papers at random. Separation of boys and girls in mixed schools was done followed by simple sampling to select six boys and six girls. The schools selected for this study had two or more streams in form three. The researcher used simple sampling to select the class to be used for this study.

3.5 Research Instruments

Six research instruments were used for data collection: Students' Questionnaire, Lesson Observational Checklist, Document Analysis Guide, an Interview Guide for the County Quality Assurance and Standards Officer (CQASO), a Student Discussion Guide and a Chemistry Achievement Test (CAT). The six research instruments were used for the purpose of triangulation of the findings.

3.5.1 Students' Questionnaire

In cases where factual information is needed, questionnaires are used (Mugenda & Mugenda, 2008). According to Best and Kahn (2011), a questionnaire is suitable when accurate data is desired and are used whenever important information regarding a population is needed. Development of the items in the questionnaire was done to address the study's objectives, and the study's hypotheses. Section one consisted of student's demographic information, gender and age.

Section two was designed in Likert scale of 1-5. The rating scale involved qualitative description of a limited number of aspects of a thing or traits of a person (Best & Kahn, 2011). For the purpose of this study, 5 meant strongly agree, 4-agree, 3-not sure, 2-disagree, 1-strongly disagree. Students were required to fill the table using the extent to which one agreed with the statement in the table. Section two consisted of 15 items which captured the four objectives of the study.

3.5.2 Lesson Observation Checklist

According to Best and Kahn (2011), a checklist is a prepared list of behaviours or items. According to Bryman (2012) structured observation schedule is used to study specific issues in individuals conduct while Mugenda and Mugenda (2008) indicated that researchers use observation checklist when collecting data, to record whatever they observe or see. The researcher has to first define what is being observed and then develop the list detailing the behaviours.

The advantage of doing this is to enable the researcher to focus on the events occurring during the observation period and therefore ensuring that the study obtain accurate data. Under the observation method, the researcher sought to collect data through direct observation without having to talk to the respondents or the participants. The advantage of this technique if done accurately is that, it eliminates subjective bias while data collected using this method is the reality on the ground. Another advantage is that it does not depend on the willingness of the respondents to participate and therefore it is less demanding (Kothari, 2012).The main research tool was observation checklist and was suitable because data collected was the reality on the ground since it involved the researcher observing the actual behaviour during the chemistry lessons.

For the purpose of this study, gas laws was the target subtopic and was taught in a double lesson in each school. This subtopic was chosen because it is taught in term one, Form three Chemistry. It is among the first subtopics in mole concept which is considered a challenge to most learners while according to the syllabus it is normally covered between January and February.

The observation schedule was designed in Likert scale form in which the observer indicated the extent of usage of particular patterns. The observer recorded the target behaviour and its observable antecedents. Many educational researchers believe that there is need to examine the teaching and learning process through observational techniques because this is the best approach to gather data concerning

the behaviour of teachers and learners during the learning and teaching process (Firooz, 2018).

In this study, the observation checklist was designed in four sections. Section one consisted of demographic information: the category of the school (mixed, boys' or girls' school) and the enrolment in terms of gender. Section two and three consisted of items in Likert scale of 1-5 capturing the four objectives of this study. Section four involved putting a tally when a boy or girl answered or asked a question, demonstrated an activity or did some reading while others were listening. Section two was on class talk items which were modified from FIACS, while section three was on Non-verbal Interaction items adapted and modified from a study by Noureen, Chaudhry and Manzoor (2012).

3.5.3 Document Analysis Guide

Mugenda (2013) define documents as written materials that a researcher can read with a view to seeking useful information to achieve a particular objective. According to Best and Kahn (2011), the purpose of document analysis is to provide information helpful in explaining social or educational practices while the validity of the content is very important and so is its authenticity. Therefore, the researcher must determine how trustworthy the data collected from the documents are. This study used a document analysis guide that was designed with one demographic item, followed by five items that were on a 5-point likert scale.

The researcher was required to form an opinion and rate each item using 1 to mean very poor, 2-poor, 3-good, 4-very good and 5-excellent. The ratings were done on assignments regarding gas laws. For the purpose of this study, assignment books and note books for the 12 selected students from each school were used in document analysis. The researcher focused on qualitative data and the extent to which learners interacted with written activities.

Additionally, the researcher checked assignments and questions given during the instruction period of the study. Assignments given to learners during the lessons were found in the learners' Chemistry notes while assignments to be done outside the class were found in the assignment exercise books and in some cases in the note books. This varied from one school to another.

3.5.4 County Quality and Assurance Standard Officer Interview Guide

Interview refers to orally administering a questionnaire and it involves meeting with the respondent face to face (Mugenda & Mugenda, 2003). For accuracy of data, it is important for the researcher to ensure that the respondent fully cooperates. This can be possible if the researcher ensures that a friendly relationship with the respondent is established before carrying out the interview. The advantage of an interview is that the researcher is able to obtain in-depth information which could not be otherwise obtained using a questionnaire.

Interview guides are applied in collecting information on experience of people and their understanding; attitude, opinion and feeling (Best & Kahn, 2011). It is usually

necessary to ask probing questions to get accurate information. Probing questions should be neutral and the interviewer should avoid being biased or subjective. The interview guide used in this study consisted two sections. Section one was on demographic information concerning the CQASO, while section two consisted questions related to verbal, nonverbal, written and gender interactions as per the objectives of this study. The interview for the CQUASO was found necessary because the department of quality assurance and standard is in charge of quality learning in the county and the officer must therefore be familiar with interaction as an effective practice during teaching and learning process.

3.5.5 Students' Discussion Guide

According to Mugenda (2013) a discussion group refers to a research technique used to collect qualitative data through views from subjects having similar characteristics. Freitas, Oliveira, Jenkins, and Popjoy (1998) define discussion guide as a form of in-depth interviews done in a group whereby the meetings provide characteristics which can be explained in terms of size, interview procedures, proposal and composition. Interaction in the group was the focus or object of analysis.

Through their responses to ideas and their contribution to the topic under discussion, participants influence each other. The role of the moderator is to stimulate the discussion using comments or subjects. This process produces data in form of transcripts from the discussion and the reflection and annotations of the

moderator. In this study, the researcher used six questions covering all the four objectives which were meant to provide vital information to enrich the already captured data.

3.5.6 Achievement Test

Achievement tests try to provide measures of what an individual has learnt or the current level of performance of a student. Most learning institutions use achievement tests to assess the level of academic performance of an individual or a group (Best & Kahn, 2012). The scores obtained from the achievement test are used to place, advance or retain a student at a certain grade; they can also be used to diagnose strengths and weaknesses and criteria to award prizes, diplomas, degrees or scholarships. Many of the achievement tests used in schools are non-standardized, teacher-designed tests which may not be reliable to measure accurately the level of the learners' ability. According to Mugenda and Mugenda (2003), a standardized test is one that has consistency and uniform procedures for administering, scoring and reliable in interpreting the behaviour of learners.

In this study, the researcher used three chemistry teachers with teaching experience of more than ten years to set a standard CAT. The teachers were also selected from the best performing schools in Chemistry in Murang'a County. To ensure a standard CAT, nine short answer type questions were carefully drawn from KCSE past question papers that involved gas laws taught during the lesson observation. A marking scheme was also made by the three chemistry teachers with a maximum

score of 100. The CAT was administered to 12 students from all the sampled schools to get the academic achievement of Chemistry during the research period. The mean score for each school and the mean scores per gender were calculated which formed the academic achievement of learners in that school.

3.6 Pilot study

Mugenda and Mugenda (2008) indicated that piloting the research instruments ensures that the items in the research instrument are not ambiguous and possess similar meaning among all the participants. The researcher is able to assess ease of use and clarity of the research instrument during the pilot test. From the information obtained during the pilot test, the instruments were revised. To be more precise, the pilot study purposed to establish if the instruments could provide the expected data and to establish if the questions are relevant to research objectives.

Piloting of research instruments therefore, helps to enhance their validity and reliability. This study used two public secondary schools in different Sub Counties in Murang'a County for the pilot study which were not part of the main study. The instruments were then modified and improved to collect data so as to achieve the objectives of this study. Two chemistry teachers and eighty four learners in Form three were involved in the pilot study.

3.7 Validity of Instruments

Validity refers to the level at which collected data gives a true measure or description of social reality (Kothari, 2012). Validity examines whether an indicator(s) that is made to test an idea truly measures that idea (Bryman, 2012). Therefore validity refers to quality of the instrument used to collect data enabling it to provide measures of what they are intended to measure (Best &Kahn, 2011). Validity, deals with accuracy of the data collected in providing a representation of the variable under investigation. If the data provides an accurate reflection of the variable, then the data can provide accurate and meaningful information to be used in making inference (Mugenda & Mugenda, 2008).

Pilot test for the current study was conducted in two secondary schools in Murang'a County, which were excluded from the main study. Items found to be ambiguous were improved, discarded or replaced. The instrument was modified on areas that appeared ambiguous to students during its administration. Content validity of the CAT was achieved by picking questions from past KCSE Chemistry papers on gas laws since they had been moderated and considered valid. Content validity provide measures of the extent to which collected data using certain instruments provide representation of a domain of indicators or contents of a certain concept (Kothari, 2014). Three chemistry teachers with more than ten years of teaching Chemistry and have participated in the marking of Chemistry during the national KCSE marking exercise for at least four years were engaged to set the Form three CAT.

A marking scheme was also made. Content validity of other instruments were achieved through consultation with supervisors and again through comments made during the proposal defense.

3.8 Reliability of the Instruments

An instrument is reliable if it measures what it is intended to measure (Kombo & Tromp, 2006). According to Best and Kahn (2011) reliability refers to consistency level of an instrument: what is being measured the instrument yield consistent results. Test-retest technique was used to test the reliability of the instruments. This involved giving similar instruments twice to the two schools of the pilot study at the same condition after a lapse of two weeks. Manual scoring was performed on the two scores for the two sets of each instrument.

The two results were then analyzed using Pearson's Product-Moment Coefficient of Correlation (r) to test their reliability. Instruments whose $r \geq 0.8$ were retained while those whose $r \leq 0.8$ were modified or discarded. For instance, the students' questionnaire had $r=0.788$. The instrument was retained with a few amendments. Table 3.3 shows the reliability coefficient of the instruments of this study that emanated from the pilot study.

Table 3.3: Reliability coefficient of the instruments

Instrument	Reliability coefficient	Comment
Students' Questionnaire	0.788	Retained with a few amendments
Lesson Observation Checklist	0.872	Retained
Document Analysis Guide	0.815	Retained
Students' Discussion Guide	-	-
CQASO Interview Guide	-	-
Achievement Test	0.876	Retained

Source: Researcher (2021)

The Achievement Test, Lesson Observation Checklist and Document Analysis Guide Instruments were retained while the Students' Questionnaire Instrument was modified with a few amendments made in areas which seemed ambiguous to learners. For example questions 11 and 15 were not clear to learners before they were modified.

The Students' Discussion Guide, Document Analysis Guide and CQASO interview guide were modified during the actual data collection and therefore not subjected to Pearson Product-Moment Correlation Coefficient. This is because the Students Discussion Guide and CQASO interview guide involved face to face encounter

with the respondents and any ambiguous question was corrected through clarification during the period of data collection. Another reason is that, the two instruments involved discussion depending on the information researcher wanted from the respondents.

The review of the instruments was done with assistance from researchers with experience in construction of research instruments. Document Analysis instruments was also not subjected to Pearson Product-Moment Correlation Coefficient because the instrument was used by the researcher to examine the relevant documents related to this data while the information obtained could not be quantified because it involved recording what was available as per the objective of this study.

3.9 Data Collection Procedures

Mugenda and Mugenda (2003), asserts that, it is often impossible for one person to collect all the data required in a research study and therefore relies on research assistants. The quality data depends a great deal on the ability of research assistants to collect accurate data. It is therefore important to identify research assistants and train them on how to use the instruments.

The study used four research assistants who were graduates of masters' level and experienced in educational research related areas. They were taken through the background of the study, purpose and objectives of the study, the population under study and the methodology of data collection. To ensure effective training, the

researcher gave them time to practice administering the instruments to each other while alternating the roles of respondents and interviewers.

The researcher sought a research permit to conduct research in Murang'a County from the NACOSTI. Through the TSC County Director, the researcher made appointments with the CQASO and the target schools to administer the instruments. The researcher, accompanied by the research assistants made a familiarization visit to the sampled schools and interacted with the respondents in order to create a rapport and inform them the purpose of the visit. Introductory letters from the TSC County Director were delivered to the principals. The chemistry teachers and the research assistants set convenient dates for administering the students' questionnaire, lesson observation, document analysis, students' discussion and date for administering the CAT.

The research assistants visited the sampled schools on the agreed dates and attended Chemistry lessons in one Form three classes in each school. The learners were informed in advance of the researcher's intention to be part of the class. The research assistants sat at the back of the class and completed the lesson observation checklist by physically attending the 32 Chemistry classes in all the 32 public secondary schools in Murang'a County. After gathering data in each class the research assistants discussed the results with a view of improving the accuracy of data in the next school. The four research assistants calculated the average scores from each part. For instance "accept feelings" the scores were 4, 3,3,2,4. Then,

(4+3+3+2+4)/5= 16/5=3.2, which was rounded to 3.0, resulting to moderate behaviour. To avoid interfering with learning in other subjects, questionnaires for 12 students selected at random were also administered after the lessons on the same day. The learners filled the questionnaires as the researcher waited. The research assistants agreed with the chemistry teacher to be informed when the gas law topic was to be covered. Therefore, the CAT was administered to the 12 selected students immediately after the end of the sub-topic and marks awarded in percentage, and the mean score for each class and gender was calculated. To avoid interfering with the school timetable the CAT was administered between 4.00pm and 5.00pm after the lessons.

After the CAT, the research assistants collected qualitative data from the 12 selected students through student discussion. The research assistants went to the chemistry laboratory, sat together at a round table and created a rapport with the 12 students. After reading a question the research assistants explained and clarified to the learners and through probing questions, the research assistants got adequate data that was useful to this study. The research assistants, sought permission from the chemistry teacher to be allowed to go through the learners' chemistry notes and assignment books to examine assignments and questions given to learners that are related to gas laws.

The researcher then went to the CDE office, Murang'a and sought an appointment with the CQUASO for the purpose of conducting an interview. The researcher

clarified the objectives of the study to CQUASO who agreed to be interviewed on the same day in the CDE boardroom. The interview took about 30 minutes.

Therefore this study used the mixed methods approach to collect qualitative and quantitative data from different areas. This method is suitable when a diversity of data is required from many sources (Greene, Benjamin & Goodyear, 2001). Through application of triangulation, the study findings acquired high reliability. Triangulation is a method applied in multiple collection of data and allows qualitative data to be verified and validated (Best & Kahn, 2011).

3.10 Data Analysis Techniques

Kothari (2012) indicates that data analysis is a method for reducing and arranging data to generate findings that need a researchers' interpretation. The researcher describes how the collected data is reduced to a usable size that can be used to draw conclusions (Oso & Onen, 2016). Data was coded appropriately based on the objectives of the study, arranged and grouped by use of SPSS Version 20 into sub-samples for common features and reactions coded to give basic statistical analysis.

Simple regression analysis, multiple regression analysis and one-way analysis of variance (ANOVA) were used to analyze data from the lesson observation checklist. According to Mugenda and Mugenda (2012), simple regression analysis is suitable when a researcher is interested with one independent variable and one dependent variable. ANOVA was suitable to this study because the researcher sought to find out if each independent variable (Oral, written, non-verbal and

gender) predicted the dependent variable which was learners' academic achievement in gas laws in Chemistry.

The simple regression model for the current study was: $Y = B_o + B_1 X_1 + e$

Where:

B_o- is the constant

B_1-is the slope

Y-is the dependent variable

X_1-independent variable

e-is the error

Simple regression analysis provides a statistic referred to as a coefficient (R^2) which provides the amount of variation that can be accounted for by either dependent or independent variables. For instance if $R^2=0.0X$, then X% of variation in the dependent variable is accounted for or predicted by the independent variable. Therefore, variables in the equation cannot account for the remaining (100-X) %. In addition, the independent variable is a significant predictor of the dependent variable when the coefficient of regression associated with the independent variable has a higher value compared to absolute critical t-value.

F-statistic is also generated by regression analysis which establishes if the independent variables significantly predict the dependent variable at the level of

probability of the study. However, according to Mugenda and Mugenda (2003), the levels of probability of each independent variable need to be examined in order to establish significant predictors of the dependent variable among the independent variables of the study.

Multiple regression technique was used to analyze the effect of the combined independent variables; oral, written, non-verbal and gender interactions on the dependent variable. Multiple regression techniques concurrently analyze more than two variables on a sample of observations (Kothari, 2012) while Mugenda and Mugenda (2012) define multiple regression as a statistical technique that establish if a given number of combined variables can predict the dependent variable being investigated.

These techniques are mainly empirical and cope with the reality and have the capability of analyzing complex data for realistic results. This method of analysis was suitable for this study because the main instrument of data collection was observation checklist which provided reality of the phenomenon being investigated and also multiple regression analysis allows studies of several predictor variables for a given criterion.

Another reason for using multiple regression model was to forecast the effect of the four independent variables on the dependent variable. Multiple regression models can be used to predict the level of the dependent phenomenon given the levels of

independent variables (Kothari, 2012). The multiple regression model for the current study was; $Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + \ldots B_nX_{n} + e$, where

Y is achievement in chemistry

B_0 is the constant.

X_1 is teacher & learner class talk.

X_2 is written interaction.

X_3 is non-verbal interaction.

X_4 is gender interaction.

B_1, B_2, B_3 and B_4 are coefficients.

e is the error term.

Therefore, multiple regression model was found suitable since the combined independent variables (Oral, written, nonverbal and gender) predicted the dependent variable which was learners' academic achievement in gas laws in chemistry. ANOVA was used to test the null hypotheses and compare the dependent variable with the independent variable. The independent variables were compared at a p-value of 0.05.

According to Kothari (2012), ANOVA technique examines any number of factors hypothesized to be influencing the dependent variable. In the current study the independent variables; teacher-learner talk (oral), written interaction, non-verbal interaction, gender interactions were hypothesized to have effect on learners' academic achievement in gas laws in chemistry.

Simple regression analysis was combined with one-way analysis of variance (ANOVA). According to Oso and Onen (2016) one-way analysis of variance refers to a situation where two or more different groups are compared on one variable whose levels are different. This technique was suitable to this study so as to establish any significant effect between the means of learners and teachers in each independent variable from the 32 sampled public secondary schools in Murang'a County at a certain probability level.

Two-way analysis of variance (ANOVA) was used to test the null hypotheses of the four variables combined; oral, written, non-verbal and gender on the dependent variable which was the learners' academic achievement in gas laws in chemistry provided from the marked CAT. Mugenda (2013) noted that two way analysis of variance is used when the researcher intends to compare two or more samples. This technique was suitable to the study because the researcher intended to establish the significant difference between the means of learners and teachers in all the four combined independent variables from the 32 sampled public secondary schools in Murang'a County.

During the analysis of variance F-statistic is generated and the researcher is required to decide the desired level of probability to establish if the generated F-statistic value is significant or not significant. The desired level of significance of this study was 0.005. This means that if the calculated f-value was greater than the desired level of significance, the null hypotheses was rejected and vice visa.

Pearson's Product Moment Correlation Coefficient was used to analyze the relationship between variables while Chi^2 was used in the analysis of student's responses on the gender interaction in class. Pearson's Product Moment Correlation Coefficient is used when the dependent and independent variables are measured at a ratio or interval scales and is continuous (Mugenda and Mugenda, 2003). The variables for this study such as scores for the CAT and the independent variable are continuous, making Pearson's Product Moment Correlation Coefficient suitable to measure the relationship between response and predictor variables.

Chi square is a statistical method aiming at establishing the association between two variables categorical in nature (Kothari, 2012). According to Best & Kahn (2011) X^2 test is used only on data that is discrete or values that can be measured. It is an independence test, the concept that the variable is not influenced by other variables. It is not a measure of the level of association but rather the estimation that other factors other than chance account for the apparent association. The technique was found suitable to test the hypotheses regarding the association between gender interaction and academic achievement because gender is categorized as either male or female.

Therefore, gender provides categorical data justifying the use of Chi-square. This technique compared the proportion that was observed in each gender in the observation schedule with the expected observation assuming that the two variables were independent.

To increase the reliability of the study, data was further presented in form of bar chart, pie chart, frequency tables, percentages, mean and standard deviation as per the objective and findings were reported verbatim. According to Mugenda & Mugenda (2003) the main concern of content analysis is explaining the state of a phenomenon at a certain time or its development over a span of time. It adds knowledge in the area of concern and provides an in-depth explanation of a social event.

To establish the most important variables that influence classroom interaction, the researcher carried out factor analysis on classroom interaction. In behavioural and social sciences, the most widely used multivariate technique of research studies is factor analysis (Kothari, 2012). According to Best and Kahn (2011), this is a statistical method used to reduce variables into the most important ones while Mugenda and Mugenda (2008) define factor analysis as a powerful statistical method normally used in research for purposes of validation of hypothetical constructs.

Factor analysis is useful when a researcher wants to cluster factors that appear to highly correlate with one another. The technique is used when the variables under investigation are interdependent and the researcher wants to reduce the variables to some factors that summarize the commonality of the variables under investigation. Factor analysis was found suitable for this study because the four independent variables; oral, written, nonverbal and gender interactions are closely related and

interdependent hence, the four variables can be reduced to factors that represent them. The technique helped the researcher to group the four variables into factors which were treated as new variables. A factor represents several observed variables and a study may have one or more factors depending on the complexity of the study and number of variables.

Therefore, factor analysis allows the researcher to have few variables that can easily be interpreted and enable the researcher to have easy and statistically significant results. The study used principal component analysis with Vatimax with Kaiser Normalization as the extraction method. The fitness of the variables was tested using Bartlett test and KMO. The two tests were significant and adequate whereby the Bartlett test was statistically significant at 0.0000 while the KMO was 0.82 (meritorious) as suggested by Kaiser (1974) using the guidelines presented in Table 3.4.

Table 3.4. Kaiser guidelines for sampling adequacy

KMO Measure	Recommendation
0.90 to 1.00	Marvelous
0.80 to 0.89	Meritorious
0.70 to 0.79	Middling
0.60 to 0.69	Mediocre
0.50 to 0.59	Miserable
Below 0.00 to 0.49	Unacceptable

Source: Kaiser (1974)

The KMO measure suggested that all of the correlation matrices were appropriate to be used in factor analysis. Table 3.5 summarizes the methods of analysis used in this study.

Table 3.5: Summary of methods of data analysis

Objective	Methods of analysis		
Class talk interaction	Descriptive statistics	One way ANOVA and thematic analysis	Simple Regression
Written interaction	Descriptive statistics	One way ANOVA, content and thematic analysis	Simple Regression
Nonverbal interaction	Descriptive statistics	One way ANOVA and thematic analysis	Simple Regression
Gender interaction	Descriptive statistics	One way ANOVA, thematic analysis and Chi^2	Simple Regression
Relationship between variables	Pearson's Product Moment Correlation Coefficient	Two way ANOVA	Multiple regression
To determine the most important variables that influence classroom interaction	Factor analysis		

Source: Researcher (2021).

3.11Ethical Considerations

As much as research is important in generating knowledge and hence of high value to the society, it is important for a researcher to be cautious not to get it at the expense of human dignity (Oso & Onen, 2016). For instance, privacy, informed consent, and confidentiality are examples of ethical issues that must be upheld and the researcher needs to state how they will be upheld in the study. Before the learners sat for the CAT, they were informed that, the marks will only be used for the purpose of the research and not part of the term's continuous assessment.

The respondents were assured about confidentiality of the information that they gave and that the data was purely for the purpose of research. Respondents were provided with consent forms to fill so that they provide the required data voluntarily. They were advised not to write their names on the research instruments and were allowed to withdraw if they decided to. All the sampled secondary schools were allowed to give their convenient dates to be visited by the researcher.

CHAPTER FOUR

DATA PRESENTATION, DISCUSSION AND INTERPRETATION

4.1 Introduction

This chapter presents data analysis, presentation, discussion and interpretation. The aim of the study was to investigate the effect of selected classroom interactions on learners' academic achievement in Chemistry in public secondary schools in Murang'a County, Kenya. The results are presented in line with the study's objectives; teacher-learner class talk (oral) interaction and learners' academic achievement, learners' written interaction and learners' academic achievement, learners'-teachers' non-verbal interaction and learners' academic achievement and gender interaction and learners' academic achievement in gas laws in chemistry.

4.2. Return rate of the research instruments

From the study, 384 Form 3 learners taking Chemistry, 32 chemistry teachers from 32 public secondary schools, and the CQASO were targeted by this study. The return rate of the research instruments arising from the respondents are as presented in Table 4.1.

Table 4. 1 Return rate of the instruments

Response	schools	Students' Questionnaires	Lesson Observation Checklist	Chemistry Achievement Test	Document Analysis Guide	Students' Discussion Guide	CQASO Interview Guide
Total returned	30	360	30	360	30	28	1
Total expected	32	384	32	384	32	32	1
% Return rate	93.75	93.75%	93.75	93.75	93.75	87.50	100

Source: Researcher (2021)

Table 4.1 indicates that 93.75% of targeted schools responded, 93.75% learners' returned the questionnaires, 93.75% of the targeted chemistry lessons were observed, 93.75% scripts of chemistry achievement test were returned. Further, 93.75% document analysis guides were filled, 87.50% of students' discussion guides were filled while the CQUASO was available for the interview. Therefore, the researcher was able to visit 30 out of 32 targeted public secondary schools in Murang'a County, where all 360 students filled the questionnaires, did the CAT and returned all the questionnaires and scripts.

The researcher further managed to observe 30 lessons, filled the document analysis guide after going through the notes and assignment exercise books in 30 public secondary schools. Finally, the researcher had a discussion session with 28 out of 32 public secondary schools while the only targeted CQUASO was available for an

interview. Two schools did not participate in the study because the teachers did not cooperate. Mugenda and Mugenda (2008), indicated that a rate of 70% and above is considered to be adequate and representative of the target population. This was therefore acceptable for the study because it was considered as a good representation of the sampled respondents.

4.3. Demographic information of the Respondents

In this section, the general information of respondents used in the study is presented. It was important to collect that information because it provided data on the character of the respondents.

4.3.1 Number of Respondents in terms of gender

The study sought details on the number of respondents of this study by gender as shown in Table 4.2. This is because the researcher was interested in finding out if gender factor had any influence on the findings of the study.

Table 4. 2: Number of Respondents in terms of gender

Respondents	Male F	Percentage (%)	Female F	Percentage (%)	Total F	Percentage (%)
Students	186	51.7	174	48.3	360	100
Teachers	16	53.3	14	46.7	30	100
CQUASO	1	100	0	0	1	100

Source: Researcher (2021)

From the study 51.7% boys, 48.3 girls, 53.3% male teachers and 46.7% female teachers were involved in the study. Therefore, results indicate that the number of students and teachers were well represented in terms of gender. Gender balance helps the researcher to avoid any bias in the study, leading to reliable conclusions.

4.3.2 Category of Schools based on Gender

The researcher visited selected public secondary schools which were composed of boys, girls and mixed schools. Table 4.3 presents the distribution of schools based on gender.

Table 4. 3: Distribution of categories of Schools based on Gender

Category of school	Frequency	Percentage (%)	Number and Percentage of national schools	Number and Percentage of extra county schools	Number and Percentage of county schools	Number and Percentage of sub-county schools
Boys only	7	23.33%	0 (0%)	2(6.67%)	5(16.67)	0 (0%)
Girls only	6	20.0%	0 (0%)	2(6.67%)	3(10.00%)	1(3.33%)
Mixed	17	56.7%	0 (0%)	0	2(6.67%)	15(50.00%)
Total	30	100%	0 (0%)	4(13.33%)	10(33.33%)	16(53.33%)

Source: Researcher (2021)

Presented data in Table 4.3 shows majority (56.7 %) of the students were from mixed schools and 23.3% and 20.0% of the students were from boys and girls secondary schools respectively. This is because majority of the public secondary

schools in Murang'a County are mixed with few secondary schools being of one gender. Majority of the mixed secondary schools gave the study an advantage of comparing gender issues within the same environment hence increasing the reliability of the results. The two public national secondary schools in the county were not part of this study because their chemistry mean scores were above 6.0, yet the study targeted mean scores of 4.0-6.0. Hence national schools were not represented in this study. Extra county schools were represented by 2 boys' (6.67%) and 2 girls' (6.67%) public secondary schools.

County secondary schools were represented by 5 boys' schools, 3 girls' schools and 2 mixed schools showing a representation of 16.67%, 10.00% and 6.67% respectively. In the sub-county public secondary schools, the representation was as follows: boy's secondary schools- none, 1 girl's secondary school, and 15 mixed secondary schools showing a representation of 0%, 3.33% and 50.00% respectively.

4.3.3 Age of students

The researcher sought to determine the age of the student respondents. This was meant to identify respondents so as to establish whether the sample selected was suitable as a Form 3 class.

Figure 4. 1: Age group of students
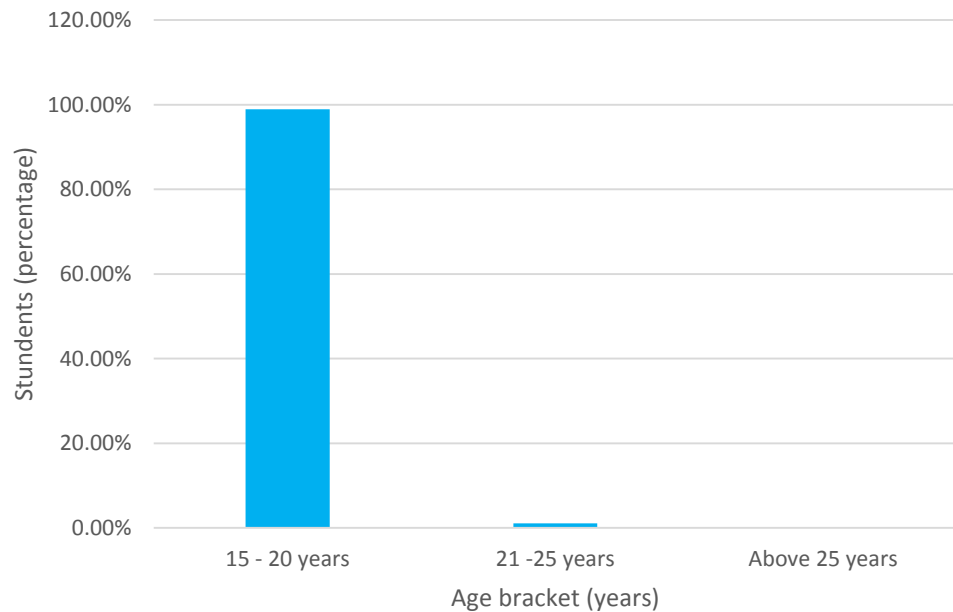
Figure 4.1 shows that the majority of the respondents (98.9%) were in the age bracket of 15-20 years while only 1.1% were in the age group of 21-25 years. There was no student who was above 25 years of age. According to Basic Education Act no 14 of 2013, legal notice no 39, Kenya gazette supplement no 37 section 47, (1), the minimum age of admission into a primary school shall be six years.

Therefore, a Form three student should be of an average age of seventeen years because on average children enter class one in primary school at six years. This is followed by eight years in primary school and then the four years in secondary

school. Therefore, a third year student in secondary school should be approximately 16-17 years. This suggest that nearly all the respondents were suitable to be in a Form 3 class. The age of the students in Form 3 was important to this study because of gender issues. At the age of 15-20 years, students are at their prime age of adolescence where each gender is sensitive to the opposite gender regarding sexual behaviour. At this age the learner is conscious about the attitude of the opposite gender and such attitudes may affect interaction during teaching and learning. For instance, a girl or a boy may be afraid to give a wrong answer in the presence of the opposite gender.

4.3.4 Demographic information of CQUASO

The County Quality Assurance and Standards Officer in Murang'a County during the study period was a male and had worked in that capacity for five years and had a master's degree in education. The CQUASO had interacted with chemistry teachers in SMASSE inset and during the normal school visits and was familiar with interactions as a method used in teaching and learning process. Therefore, from the demographic information CQUASO had adequate knowledge and information about the county related to the current study.

4.4 Performance in Chemistry Achievement Test

To determine the dependent variable for this study, which was the learners' academic achievement in gas laws in chemistry, the researcher marked the test and awarded the marks in percentage. Table 4.4 shows the average scores per gender and average scores for the thirty schools that responded.

Table 4. 4 Scores of Chemistry achievement test in percentage

	School	Category	Mean Score By Gender (%)		Overall Mean Score (%)
			Boys	Girls	
1	Kanyenyaini	Mixed	28.55	25.29	26.92
2	Kiru	Boys	55.75		55.75
3	Kinyona	Mixed	41.34	32.16	36.75
4	Gaturi	Girls		26.56	26.56
5	Kiriaini	Mixed	39.98	44.24	42.11
6	Kigumo	Girls		54.83	54.83
7	VidhuRamji	Mixed	38.76	33.58	36.17
8	Ngurweini	Mixed	26.20	20.30	23.25
9	Weithaga	Mixed	21.54	12.12	16.83
10	Charles Lwanga	Mixed	33.81	38.85	36.33
11	Muthithi	Mixed	40.24	33.98	37.11
12	Kirogo	Boys	58.83		58.83
13	Kariti	Mixed	42.55	24.87	33.71
14	Kamacharia	Girls		38.19	38.19
15	Kiangunyi	Girls		36.17	36.17
16	Kambiti	Mixed	32.92	23.30	28.11
17	Gathera	Mixed	38.25	25.09	31.67
18	Gituamba	Mixed	27.68	20.72	24.20
19	Iyego	Mixed	30.50	39.00	34.75
20	Mutheru	Mixed	12.45	15.91	14.18
21	Nginda	Girls		46.60	46.60

22	Ichagaki	Boys	53.27		53.27
23	Kirwara	Boys	43.00		43.00
24	Mukangu	Mixed	49.24	47.10	48.17
25	Githumu	Boys	81.45		81.45
26	St. Paul	Boys	41.50		41.50
27	Kahuhia	Mixed	28.88	32.58	30.73
28	Thuita	Mixed	28.54	25.80	27.17
29	Kangema	Boys	76.17		76.17
30	Ruchu	Girls		43.67	43.67
Average mean			40.48	32.21	39.47

Source: Researcher (2021)

The CAT was on gas laws in the topic of mole concept and learners had been informed and provided with two weeks to prepare for the CAT. From the results, Githumu boys scored the highest mean score (81.45%) while Mutheru scored the lowest mean score (14.18%). Kigumo girls had the highest mean score (54.83%) among the girls' secondary schools. There was a big disparity between the highest mean scores (81.45%) and the lowest mean score (14.18%). This could be probably as a result of learners' level of preparedness for the CAT in different schools or the way different teachers delivered the content.

On average, girls scored (32.21%) which was lower than boys (40.48%), probably due to the perception that girls are better in humanity based subjects as opposed to boys who are perceived to be better in science oriented subjects. This is supported

by Almut (2017) who noted that, the academic achievement in relation to gender interaction may be affected by socio-cultural differences between girls and boys while the implicit stereotypes are likely to influence the gender differences in motivational beliefs and educational choices. Such attitudes will have an effect on both genders' academic achievement in Chemistry.

The study used the calculated scores as the dependent variable. The researcher consequently investigated the effect of the four independent variables: oral, written, non-verbal and gender interactions on dependent variable which was learners' academic achievement given in terms of scores.

4.5 Test of Hypotheses

The researcher undertook this analysis with the aim of determining the validity and accuracy of the collected data. In testing of the hypothesis, the main focus was either accepting or rejecting the null hypothesis (Kothari, 2012). The following hypotheses **(Ho)** were tested**.**

Ho_1　　There is no statistically significant effect of teacher-learner class talk (oral) on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County.

Ho_2　　There is no statistically significant effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County.

Ho_3　　There is no statistically significant effect of teacher-learner non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County.

Ho_4　　There is no statistically significant effect of gender interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County.

The study used simple regression and Multiple Regression Analysis techniques to test the effect of independent variables on the dependent variable.

4.5.1 Simple Regression Analysis

To establish the effect of each independent variable on the dependent variable Simple Regression Analysis was used. This technique is used to predict level of dependent variable given the levels of independent variables (Oso & Onen, 2016).

The simple regression model for the current study was; $Y = B_o + B_1X_1 + e$

Where:

B_o- is the constant

B_1-is the slope

Y-is the is the dependent variable

X_1-independent variable

e-is the error

Using this model the research data was subjected to simple regression analysis while one way ANOVA was used to test the null hypothesis and findings were reported as shown below.

4.5.2. Testing of null Hypothesis (H_{01})

The first null hypothesis (H_{01}) stated: "There is no statistically significant effect of teacher- learner class talk (oral) interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County." To test

this hypothesis simple regression analysis was used to determine if the independent variable which is the oral interaction predicted the dependent variable which is learners' academic achievement. According to Oso and Onen (2016), this technique is used to predict level of the dependent variable given the levels of independent variables. Table 4.5 shows the outcome of the regression analysis.

Table 4. 5: **Effect of teacher-learner oral interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County**

Model summary				
Model	R	R^2	Adj. R^2	Std. Error
1	0.572	0.328	0.304	11.8891

ANOVA						
Model	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1928.489	1	1928.489	13.643	<0.001[b]
	Residual	3957.842	28	141.351		
	Total	5886.331	29			

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	Beta	Std. Error	Beta		
(Constant) Verbal	-10.919	16.961		-.644	0.525[b]
	21.23	5.748	0.572	3.694	<0.001

Source: Researcher (2021)

a. Dependent Variable: Students' mean score

b. Predictors: (Constant), Verbal interaction

The regression results in Table 4.5 show that, the effect of oral interaction on students' academic performance was significant $[F = 13.643, P < 0.001]$. These

findings indicate that, use of oral interaction through teacher and learner class talk (oral) during the teaching and learning of gas laws played a significant role in determining learners' academic achievement (B=0.572, p<0.001). The findings show that increasing oral interaction by a single unit during the teaching and learning of gas laws, resulted to an increase of mean score by about 0.572 units.

A statistic referred to as a coefficient (R^2) provides the variation that the academic achievement was accounted for by the oral interaction which was the independent variable. The value of $R^2 = 0.33$, meaning the model implies oral interaction explained 33% of the change in academic performance in gas laws in chemistry. The implication of this study is that 33% of the variation, in dependent variable which is the academic achievement of learners was accounted for or predicted by oral interaction which is the independent variable, implying that other factors that contributed to academic performance were not part of the model. The equation model that was obtained was;

$Y = -10.92 + 0.572X_1$

Where,

Y is academic achievement in Chemistry.

X_1 is oral interaction.

Because p-value was less than 0.05, the null hypothesis was rejected, thus: there is a statistically significant effect of teacher-learner class talk (oral) on learners'

academic achievement in gas laws in Chemistry. The findings suggest that oral interactions contribute towards academic achievement of secondary school learners. This can be interpreted to mean that, oral interaction increases the learner's desire and motivation to learn which increases their academic performance.

Therefore, the empirical findings of the study indicate that, the use of oral interaction during the teaching and learning of gas laws had a statistically significant effect on academic achievement of secondary school learners in Murang'a County. Hence, it is important that secondary school chemistry teachers consider use of oral interactions to improve the quality of the lesson. Therefore, what is arising from this study is that, oral interaction is a predictor of learner's academic achievement.

Conforming to the findings of the current study a one-way ANOVA study by Firooz (2016) revealed a significant difference in praise or encouragement during the teaching of mathematics, empirical sciences, and humanities. The conclusion arising from the study was that humanities teachers encouraged students more compared to teachers of mathematics and empirical sciences. Additionally, results from a research study by Skipper and Douglas (2015) on effects of teacher feedback on children's perceptions regarding association between teachers and learners are consistent with results of the current study. In fact, students' opportunity to participate actively through class talk interaction contributes to one of the most important predictors of students' academic achievement. Cheruiyot (2015) study

carried out in Baringo Sub-County revealed a positive relationship between verbal interaction patterns in the classroom and learners' academic achievement in Physics. The study further indicated that, there was more learners' participation in classes where teacher's teaching methods were dominated by indirect verbal interaction compared to physics classes dominated by direct verbal interaction.

However, the results of the current study differs from a study by Nurzali and Khairu'l (2009) which investigated the effects of classroom oral interaction on learners' academic achievement at the international Islamic University Malaysia (IIUM), and observed two lecturers in a classroom oral interaction lessons and its effect on academic achievement of learners. The results revealed that lecturers were effective in their practice of classroom interaction. The results further revealed insignificant impact of classroom oral interaction and learners' academic achievement in the two lessons.

4.5.3. Testing of null Hypothesis (H$_{02}$)

The second hypothesis (H$_{02}$) stated: "There is no statistical and significant effect of learners' written interaction on learners' academic achievement in chemistry in gas laws in public secondary schools in Murang'a County, Kenya". Simple regression analysis and one way ANOVA were used to test the hypothesis where the model $Y = B_o + B_2X_2 + \varepsilon$ was used. Table 4.6 presents the analysis results on the effect of written interaction on students' academic achievement in gas laws in chemistry.

Table 4.6: Effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry

Model summary				
Model	R	R^2	Adj. R^2	Std. Error
1	0.223[a]	0.050	0.016	14.13260

4	ANOVA						
Model	Model	Sum of Squares	Df	Mean Square	F	Sig.	
1	Regression	293.880	1	293.880	1.471	0.235[b]	
	Residual	5592.450	28	199.730			
	Total	5886.331	29				

Coefficients						
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	
	B	Std. Error	Beta			
(Constant)	63.527	10.473		6.066	0.001	
Written	-8.065	6.648	-0.223	-1.213	0.235	

Source: Researcher (2021)

a. Dependent Variable: Student mean score

b. Predictor: (Constant): Written interaction

Results presented in Table 4.6 showed that, the p-value for the test was found to be 0.235. If $p \leq \alpha$, the null hypothesis is rejected. The selected α for the test was 0.05. In this analysis, the null hypothesis was accepted because the p-value (0.235) was greater than selected alpha (0.05) value. This implied "no statistically significant effect of learners' written interaction on learners' academic achievement in Chemistry in the teaching and learning of gas laws". Meaning that students had similar chances to perform well in gas laws even when they were not exposed to written interaction in the post-test exams.

Further, the outcome of this analysis shows that, an increase in written interaction by a single unit in gas laws, increased the academic achievement mean score by about -0.223 units. The statistic coefficient (R^2) provides the variation that is accounted for by the independent variable which is the written interaction. The value of $R^2 = 0.050$, imply the model explain 5% variation in the dependent variable. Therefore, 95% of the learners' academic achievement in gas laws was contributed by other factors that were not part of the model. Therefore, what is arising from this study is that, learners' written interaction is not a predictor of academic achievement.

Findings arising from this study are in conformity with findings from a study by Trautwein (2007) who found classroom interaction through written interactions such as homework had insignificant effect on academic achievement of learners. As noted during the students' group discussion, some students copied from their classmates or from the text books without making any efforts to do their own work resulting to lack of meaningful learning.

Moreover, several authors have different opinions. Haddock (2006) noted that homework was of no value to learners and called for its abolition as it offered no tangible benefits. Bennett and kalish (2006) and kohn (2006) opined that assignment is not useful to learners especially the young ones and, may have insignificant impact on cognitive development of a learner. But bishop (2008) opined that through homework, learners are taught how to concentrate, report

writing, curiosity development, being continuous learners and spending time alone. Therefore, despite the findings of the current study, there is need for further empirical studies.

4.5.4. Testing of null Hypothesis (H_{03})

Simple regression analysis was used to establish the effect of non-verbal interaction on students' academic achievement. The hypothesis stated: "There is no statistically significant effect of non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya." To test this hypothesis, the model $Y = B_o + B_3X_3 + \varepsilon$ was used. Table 4.7 shows the simple regression and one-way ANOVA analysis results on the effect of non-verbal interaction on academic achievement of learners.

Table 4.7: Effects of non-verbal interaction on learners' academic achievement in gas laws in Chemistry

Model summary				
Model	R	R^2	Adj. R^2	Std. Error
1	0.759[a]	0.575	0.560	9.4468

ANOVA						
Model	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	33.538	1	3387.538	37.959	<0.001[b]
	Residual	2498.793	28	89.243		
	Total	5886.331	29			

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-0.664	8.595		-0.077	0.939
Non-verbal	20.478	3.324	0.759	6.161	<0.001

Source: Researcher (2021)

a. Dependent Variable: Student mean score

b. Predictor: (Constant): Non-verbal interaction

The results show that non-verbal interaction had statistical and significant effect on learners' academic performance in gas laws ,$[F = 37.959, P < 0.001]$. The regression had a standardized coefficient of (B=0.759 p<0.001) indicating that increasing use of non-verbal interaction during the teaching and learning of gas laws by a single unit caused an increase in students' performance by 0.759 units.

The statistic coefficient (R^2) provides the variation that was accounted for by non-verbal interaction which was the independent variable. From the model, $R^2 = 0.575$, implying that, non-verbal interaction explained 57.5% of the variation in learners'

academic achievement. Hence, the model explained only 57.5% of change in academic performance, meaning that the remaining 42.5% arise from other factors that were not part of the model. From the findings, the equation model was;

$$Y = -0.664 + 0.759X_2$$

Where Y is academic performance and X_2 is non-verbal interaction.

Because the p-value was less than 0.05, the null hypothesis was rejected and the study concluded: "There is statistically significant effect of teacher-learner non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County". The empirical results of the current study suggest that, non-verbal interaction is an effective pedagogical tool towards the implementation of chemistry curriculum in secondary schools. Therefore, what is arising from the current study is that, non-verbal interaction is a predictor of learners' academic achievement.

The findings are in conformity with findings by Noureen and Manzoor (2012) in a study on teachers' oral behaviour and its effects on learners' academic achievements in Pakistan. A strong and significant relationship was found between use of non-verbal aspects and learners' academic achievement.

The results are also in conformity with a study by Fatima, Khan, Zainab, Shah and Farid (2016) on non-verbal interaction and its effect on quality of learning at secondary level in Pakistan. The study revealed that, use of non-verbal interaction enhances quality of learning during instructional process resulting to improved

learners' academic achievement. Similarly Bunglowala and Bunglowala (2015) observed that non-verbal cues like eye contact, pitch of voice and body movements keep learners alert and help to improve learners' participation in class resulting to high academic outcomes.

The findings of the current study, therefore, suggest that, use of non-verbal interaction should be aligned with the current pedagogical techniques as well as needs of the students in order to improve quality delivery of the curriculum.

4.5.5. Testing of null Hypothesis (H_{04})

The fourth hypothesis (H_{04}) stated: "There is no statistically significant effect of gender interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya. "Testing of hypothesis was done using the model $Y = B_o + B_4X_4 + \varepsilon$. The results of one way ANOVA and simple regression analysis on the effect of gender interaction on students' academic achievement are as presented in Table 4.8.

Table 4.8: Effect of gender interaction on learners' academic achievement in gas laws in Chemistry

Model summary							
Model	R	R^2	Adj. R^2	Std. Error			
1	0.114[a]	0.013	-0.022	14.40521			

ANOVA							
Model	Model	Sum of Squares	Df	Mean Square	F	Sig.	
1	Regression	76.048	1	76.048	.366	0.550[b]	
	Residual	5810.283	28	207.510			
	Total	5886.331	29				

Coefficients						
Model	Unstandardized Coefficients		Standardized Coefficients		T	Sig.
	B	Std. Error	Beta			
(Constant)	49.829	3.487			14.289	0.001
Gender	0.518	0.856	0.114		0.605	0.550

Source: Researcher (2021)

a. Dependent Variable: Student mean score

b. Predictors: (Constant): Gender interaction

Simple regression analysis results in Table 4.8 show that the effect of gender interaction on learners' academic achievement in gas laws was not statistically significant. The two-tailed p-value was found to be 0.550. In relation to the decision rule: If $p \leq \alpha$, the null hypothesis is rejected. Therefore, since 0.550>0.05, the null hypothesis was accepted. Therefore the conclusion arising from this study is: "There is no statistically significant effect of gender interaction on learners' academic achievement in gas laws in chemistry in public secondary schools in Murang'a County."

Additionally, the outcome of this analysis shows that an increase in gender interaction during the process of instructions by a single unit, increased the learners' academic achievement in gas laws mean score by about 0.114 units. The statistic coefficient (R^2) provides the variation that was accounted for by the independent variable which was the gender interaction. The implication value of $R^2 = 0.013$, is that, the model explained 1.3% variation in learners' academic achievement in gas laws in chemistry which is the dependent variable in the study. This implies that, 98.7% change in learners' academic achievement was contributed by other factors that were not part of the model.

The implication of this study is that, gender interaction contributed 1.3% on learners' academic achievement in gas laws in chemistry and it can therefore be concluded that gender interaction has no statistically significant effect on learners' academic achievement in gas laws. On the basis of these findings, gender interaction is not a predictor of learners' academic achievement.

The study's findings are consistent with several studies. For example, a study by Firooz (2016) which used independent t-test, showed insignificant difference between female and male talk and the style of teaching and academic performance. Dania (2014) study on impacts of gender on learners' academic performance in post-primary school social studies suggested that academic achievement of learners' in high school Social Studies was based on techniques of classroom interaction used and are not affected by gender. Findings showed that gender

interaction (male/female) insignificantly affected learner's academic achievement in Social Studies. The study recommended that gender should be disregarded during teaching and learning and instead both gender should be provided with equal chances and similar encouragement levels.

However, the findings are inconsistent with findings of several studies. For example, Dee (2013) established that assigning a student teacher of same gender has a significant positive effect on academic achievement of students of both genders. For instance, a girl views science as useful for her future when assignment is given by a female science teacher. This has the likelihood of such a girl performing well in that subject.

A study by Lee, Rhee and Rudolf (2007) analyzed the association between the teacher's gender and that of the learners and the learners' achievement in mathematics and reading. The findings of the study showed that learners instructed by females showed higher academic achievements than learners who received instructions from male teachers. The results further revealed that, the liking and academic performance of a subject was higher when learners received instructions from the same-gender teacher.

The findings of this study seems to suggest that, gender stereotyping in academic context is prevalent in teachers and students of both genders. Additionally, the findings of the current study differ from a study by Nnamani and Oyibe (2016) which sought to investigate academic achievement of high school students by

gender in social Studies in Nigeria. From the findings boys' mean score was lower than the mean scores of girls. The study further revealed that learners of both genders taught by a male teacher had a higher average score compared to when a female teacher taught them. Same study revealed that, when female learners were taught by male teachers they performed better than the male learners taught by a male teacher and vice versa. The study further established that variation in mean achievement in social sciences based on gender was significant among high school learners.

The results are also in contrast from findings of a study by Okeke (2007) that was done in Nigerian that found that female students are discriminated by teachers overtly and covertly, deliberately and involuntarily which certainly disadvantages the girls' in terms of achievement during classroom interaction especially in science related subjects.

The findings disagreed with Oleabhiele (2011) who held that the performance of male learners was better compared to that of the female learners in any classroom interaction activities that involve science education. These contrasts are probably arising after teachers become more sensitive to gender issues and change of attitude that girls have equal intellectual capacity to boys during learning. This is supported by findings of Ganai and Muhammad (2013) study on "Comparative Study on Adjustment and Academic Performance of College Students. "Based on gender, the researcher investigated the learners' academic achievement in different subjects.

The study's findings revealed that, the female students were better in terms of enrolment and academic achievement in all the categories of subjects.

This can be interpreted to mean that, the stereotype of classifying particular subjects as belonging to a certain gender is changing. This means that, the gender factor should not be an excuse in learning or teaching of any subject across the available curriculum. In fact, teachers are currently motivating girls by telling them: "What a boy can do, a girl can do even better."

4.5.6 Multiple Regression Analysis

To establish the effect of the combined independent variables on the dependent variable, Multiple Regression Analysis was used in this study. Multiple regression model can be used to predict the level of the dependent phenomenon given the levels of combined independent variables (Kothari, 2012).

The model for multiple regression in this study was;

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4 X_{4\ldots\ldots} + e$$

where

Y is achievement in chemistry

B_0 is the constant.

X_1 is teacher & learner class talk.

X_2 is written interaction.

X_3 is non-verbal interaction.

X_4 is gender interaction.

B_1, B_2, B_3 and B_4 are coefficients.

e is the error term.

Therefore, Multivariate Regression Model was used to test the combined effect of the four variables as shown in the next section of this study

4.5.7 Effect of the four independent variables on dependent variable on learners' academic achievement

The researcher further sought to establish the combined effect of the four independent variables: oral interaction, written interaction, non-verbal interaction and gender interaction on the dependent variable which was learners' academic achievement, through multiple regression analysis. Table 4.9 presents the results.

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Table 4.9: Effect of the four independent variables on dependent variable on learners' academic achievement

Model summary							
Model	R	R^2	Adj. R^2	Std. Error			
1	0.803[a]	0.645	0.588	9.1432			

ANOVA

Model	Model	Sum of Squares	Df	Mean Square	F		Sig.
1	Regression	3796.343	4	949.086	11.353		<0.001[b]
	Residual	2089.988	25	83.600			
	Total	5886.331	29				

Coefficients						
Model	Unstandardized Coefficients			Standardized Coefficients	T	Sig.
	B		Std. Error	Beta		
(Constant)	-18.527		15.882		-1.167	-1.167
Oral interaction	9.348		5.095	0.252	1.835	<0.078
Non-verbal interaction	18.045		4.062	0.668	4.443	<0.001
Written interaction	-1.206		4.542	-0.033	-0.265	<0.793
Gender interaction	-0.557		0.596	-0.122	-0.935	<0.359

Source: Researcher (2021)

a. Dependent Variable: Student mean score***p<0.001

b. Predictors: (Constant), oral interaction, non-verbal interaction, written interaction and gender interaction.

The multiple regression model results revealed that the four predictor variables and the response variable which is academic achievement were strongly correlated (R=0.803). The amount of variation explained by the predictor variables is identified by the value of R^2=0.645. From the findings, 64.5% variation in academic

achievement in gas laws was accounted for by oral interaction, non-verbal interaction, written interaction and gender interaction.

To estimate the population, the value of adjusted R^2 is preferred and can be applied in making comparisons in values of R^2 between models having varying number of predictor variables. As indicated by the findings, the Adjusted R^2 was 0.588, which illustrates that 58.8% variation in response variable (academic achievement), was contributed by changes in the predictor variables (oral interaction, non-verbal interaction, written interaction and gender interaction).

The beta (B) value for oral interaction is (B= 0.252, $p < 0.0.078$), non-verbal interaction (B=0.668, $p < 0.001$), written interaction (B=-0.033, $p < 0.793$) and gender interaction (B=-0.122, $p < 0.359$). The findings indicate that oral and non-verbal interaction were statistically significant at 10% and 5% confidence level respectively. Hence, by keeping other factors constant, if there was 1 unit change in the value of oral and non-verbal interaction during the teaching and learning of gas laws, then students' academic achievement in chemistry would have increased by 0.252 units and 0.668 units respectively. The resultant model for multiple regression analysis was;

$Y = -18.527 + 0.252X_1 + 0.668X_2 - 0.033X_3 - 0.122X_4$

Where Y = academic achievement in chemistry, X_1= oral interaction, X_2 = non-verbal interaction, X_3 =written interaction and X_4 = gender interaction.

Since the p-values of oral and non-verbal interaction were statistically significant the null hypotheses for these variables were rejected. Therefore, the conclusion of the study was that: there was a statistically significant effect of teacher-learner oral and non-verbal interaction on learners' academic achievement in gas laws in chemistry. The findings arising from this section confirms the findings from section 4.5.2, 4.5.3, 4.5.4 and 4.5.5 that indicate oral and non-verbal interactions as predictors of learners' academic achievement while written and gender interactions were not.

The findings were in conformity with findings from several studies. For instance, Maulana and Opdenakker (2013) study, revealed that, good teacher-student relationships through oral and non-verbal interactions are crucial in order to maintain adolescents' interests and engagement in learning. A study by Noureen and Manzoor (2012) that was carried out in Pakistan to compare the effect of mean oral behaviour and non-verbal behaviour of teachers on learners' academic achievement revealed that, the two behaviours were consistent with one another and were positively correlated with learners' academic achievement.

This is supported by Frymier and Houser (2000), who asserted that, oral and non-verbal interaction promotes a social component that reduces the perception of distance between teachers and learners and eventually reduces the physical and psychological gaps between the two parties. As a result the learners' desire to learn is raised, improving the quality of learning and making learning meaningful. Hence,

learners with positive classroom interactions with their teachers are likely to perform better in examinations. The implication of the current study is that oral and non-verbal interactions enhance mutual understanding between the teacher and the learner which results in high learners' academic achievement in chemistry. Finally, the findings can be used to strengthen the results of other similar studies.

4.6 Analysis of relationship between variables

This study intended to establish the association between the dependent and independent variables. To work out the degree of association between the variables, Pearson's Product Moment Correlation (PPMC) Coefficient was used.

4.6.1 Pearson's Product Moment Correlation Coefficient (PPMC)

In this study PPMC Coefficient test was applied to establish the existence of a significant association between oral, non-verbal, written and gender interaction with students' academic performance which was provided in terms of learner's mean score in the Chemistry achievement test that was based on gas laws. Table 4.10 presents the results.

Table 4.10: Inter-Correlation between independent-independent variables and independent-dependent variables

Variables	Academic achievement	Oral Interaction	Non-verbal interaction	Written interaction	Gender interaction
Academic achievement	1				
Oral Interaction	0.5724**	1			
Non-verbal Interaction	0.7586**	0.4887**	1		
Written Interaction	-0.2234**	-0.1004**	-0.2196**	1	
Gender Interaction	0.1137**	0.0795**	0.3303**	0.1468**	1

** Correlation is significant at $p<0.05$ level (2-tailed)

Source: Researcher (2021)

Results indicate that the correlation coefficients for the relationships between learner's' academic achievement in chemistry and oral, non-verbal and gender interactions are linear and positive except for written which was negative ranging from substantial to strong correlation coefficients. From the findings presented in Table4.10, oral interaction and students' academic performance were found to be strongly and positively related ($r = 0.5724$, $p < 0.05$). Further, a strong and positive relationship was found between non-verbal interaction and learners' academic performance ($r = 0.7586$, $p < 0.05$). A value of r greater than 0.5 can be said to be a strong relationship between any two values (Kothari, 2012). Therefore, oral and non-verbal interaction and academic achievement were strongly and positively related.

The findings are consistent with the findings from Simple Regression Analysis in Table 4.5 which revealed that "the effect of oral interaction on learners' academic achievement in Chemistry was statistically and significantly related" The findings

are also in conformity with the findings of Simple Regression Analysis in Table 4.7 which revealed that "the effect of non-verbal interaction on learners' academic achievement in Chemistry were statistically and significantly related."

Moreover, the findings of the current study are in conformity with several other studies. For instance, a study by Noureen, Chaudhry and Manzoor (2012) in Pakistan on teachers' oral behaviour and its effects on academic achievement of learners revealed that, the non-verbal interaction of teachers was consistent with their oral interaction and had a significant influence on students' academic performance. Results from a study by Firooz 2016) showed a statistically significant difference between praise or encouragement and quality of teaching mathematics and humanities.

Sukris (2018) revealed that oral interaction had a significant and positive influence on achievement of learners in English while York's (2014) study on non-verbal immediacy role on student learning noted strong positive associations between non-verbal interaction and learners' academic achievement. The findings of the current study thus reveal positive association between non-verbal and oral interaction and learners' academic achievement in gas laws in chemistry. Teachers should therefore make use of the two interactions to enhance quality teaching and learning for higher academic achievement.

Written interaction had weak negative weak relationship (r = -0.2234) with students' academic performance in gas laws in chemistry. Therefore, the findings

established that written interaction had statistically insignificant and negative effect on learners' academic achievement. The findings are consistent with the findings of Simple Regression Analysis on the effect of written interaction on students' academic achievement in Table 4.6 which established that "effect of written interaction on learners' academic achievement in gas laws in Chemistry was statistically insignificant."

However, some few studies that were available differed with the results of the current study. For instance Lindsay and Rosa (2000) in a study done in Los Angeles revealed that feedback from teachers improve the writing skills of learners while Matsumura, Patthey-Chavez,Valdes, and Garnier (2002) in their study on writing assignment in English language revealed that corrections of grammar and punctuation reduced the writing convention errors. The two studies were silent on learners' academic achievement. Therefore, the area of written interaction need to be researched more because from the reviewed literature, there was little research studies on written interaction and its effect on academic achievement.

Gender interaction had weak positive relationship (r = 0.1137) with students' academic achievement in gas laws in chemistry indicating that gender interaction had insignificant effect on learners' academic performance. The findings are in conformity with findings from Simple Regression Analysis on the effect of gender interaction on students' academic performance in Table 4.8, which indicated that

"the effect of gender interaction on learners' academic achievement in chemistry was statistically insignificant."

Several studies are in conformity with the current study. A study by Oluwatosin and Ogbeba (2017), for instance on influence of gender on achievement of senior secondary school learners in stoichiometry in Chemistry with the use of hands-on activities established that there was insignificant variation in average achievement score for learners of both genders taught stoichiometry with the use of hands-on activities. The findings of a study by Dania (2014) on influence of Gender on learners' Academic performance in Secondary School SST provide empirical proof that the achievement of learners in SST is based on the teaching methodology used and not the gender of the student. Based on these studies, the implication is that, the gender of the student has no influence or effect on effectiveness of the method used in teaching.

However, the results of this study are contradicted by several studies; Fatokun and Odagboyi (2010) for instance, asserted gender as a major factor in learners' academic achievement in Chemistry as a result of interaction. Torberg and Linn (2011) explored gender gaps and the schemes on educational evaluation in learners' academic achievement in Norway. The study revealed that, girls attain higher scores when tested by a male teacher, while in mathematics girls attain higher scores from inexperienced teachers. One implication of the findings was that, teachers favoured girls, either deliberately or not. Therefore, further research on

gender is necessary especially considering the fact that majority of Kenyan public secondary schools are mixed.

Table 4.10 further presents the association between the selected variables. From the results all correlations are significant (p <0.01). The association between oral interaction and non-verbal interaction were statistically significant (r = 0.4887, p <0.01), oral interaction and written interaction (r = 0.1004, p <0.01) and oral interaction and gender interaction (r = 0.0795, p <0.01). The result further indicate that, non-verbal interaction and written interaction were substantially negatively correlated (r = -0.2196, p <0.01), non-verbal interaction and gender interaction (r = 0.3303, p <0.01), which at 99% confidence interval is statistically significant.

Finally, there exists a positive relationship between written interaction and gender interaction (r = 0.1468, p < 0.01) which was statistically significant at 99% confidence level. Hair, Black, Anderson and Tatham (2006) indicated that the correlation coefficient value between a pair of predictor variables should not be more than 0.9. This is because if the values exceed 0.9, then the data is considered to have serious issues of collinearity (Hair *et al*., 2006). The results indicate that 0.7586 was the highest correlation coefficient which was between learners' academic achievement and non-verbal interaction which was below 0.90. Therefore, the assumption was that multi-collinearity issues among the variables did not exist.

Except for the substantial negative correlation between non-verbal interaction and written interaction (r = -0.2196, p <0.01), the findings of the study indicated some positive significant correlation between any two independent variables in the current study with the dependent variable which is learners' academic achievement. This suggest that a combination of all the independent variables can improve the academic achievement of learners.

The study's findings are in conformity with results of a study by Sukris (2018) that a combination of oral and non-verbal interactions, significantly and positively affect learners' achievement in English. Therefore teachers need to strategize on how to use effective interactions in order to successfully deliver the intended curriculum to learners through using a combination of several interaction patterns. Comparisons were then made between the findings of the study's hypothesis and the findings in descriptive analysis.

4.7 Comparative Interaction Analysis by Gender

This study sought to establish whether there was statistical significant difference between female and male teachers and learners' academic achievement in relation to class talk during teaching and learning process and the statistical significant difference between female and male teachers teaching in mixed schools in relation to class talk. The results are discussed under the following sub-themes.

4.7.1 Gender comparative analysis of teachers' oral/classroom talk scores

The study sought to establish if there was statistical significant difference between the oral scores of male and female teachers and learners' academic achievement. The researcher observed the teachers during the instructional process using a likert scale of 1-5. The researcher recorded the extent to which teachers by gender used the oral behaviour under investigation. A very strong behaviour was indicated by 5, strong-4, moderate-3, weak-2 and very weak-1. Data was analyzed using means and one-way analysis of variance (ANOVA). Table 4.11 presents the findings.

Table 4.11: Comparison between Male and Female Teachers of oral/classroom talk Behaviour Scores

Teacher Verbal Behaviour	N	Group	Mean	SD	Sem	F	P-value
While accepting students' feelings	16	Male	2.63	0.806	0.202	0.298	0.589
	14	Female	2.79	0.802	0.214		
While praising or encouraging students'	16	Male	2.50	0.816	0.204	1.043	0.316
	14	Female	2.21	0.699	0.187		
While asking questions	16	Male	3.13	0.885	0.221	0.04	0.951
	14	Female	3.14	0.663	0.177		
While lecturing	16	Male	3.38	0.719	0.180	0.269	0.608
	14	Female	3.21	0.975	0.261		
While giving directions	16	Male	2.94	0.854	0.213	1.524	0.227
	14	Female	3.36	1.008	0.269		

Source: Researcher (2021)

From Table 4.11, the results in terms of means indicate that, in regard to accepting the feeling of learners,' when asking questions and providing directions, female teachers were better compared to male teachers. Male teachers were slightly better than female teachers while praising or encouraging students and in lecturing. However, the results from ANOVA shows that all the p-vales for the teachers' oral/classroom talk scores were greater than 0.05 level of significance which was at 95% confidence level.

Hence, even though there was a slight difference in oral/classroom scores as shown by the means between the male and female teachers, the difference was statistically insignificant. Implying there is no statistical significant difference in the oral cues that was used by female and male teachers. The findings revealed that both gender were utilizing oral interaction in the same way. Moreover, the results were similar to results of a study done in Pakistan by Noureen and Manzoor (2012) that revealed no statistic significant impact between the mean oral behaviour scores of male and female teachers.

The two studies with similar results emanating from different continents with different cultural and traditional beliefs is an indicator that, teachers globally are becoming sensitive to gender issues. This probably explains why gender interaction had no significant statistical difference on learners' academic achievement.

4.7.2 Gender comparative analysis of oral/classroom talk Behaviour of Teachers Working in Boys, Girls and Mixed Schools

The study aimed at exploring whether there is a statistical difference between teachers' oral behaviour and learners' academic achievement of teachers working in boys', girls' and mixed schools. The 30 teachers were observed teaching in class while the researcher recorded the extent to which the teachers used the oral behaviour under investigation in boys', girls' and mixed schools by rating them using a Likert scale of 1-5. A very strong behaviour was indicated by 5, strong-4, moderate-3, weak-2 and very weak-1. One-way analysis of variance (ANOVA) was used to analyze the data. The findings of the study are reported in Table 4.12.

Table 4.12: Comparison of oral/classroom talk Behaviour of Teachers Working in Boys', Girls' and Mixed Schools

Teachers' oral Behaviour		Sum of Squares	Df	Mean Square	F	Sig.
		ANOVA				
Accept feelings	Between Groups	1.051	2	0.525	0.822	0.450
	Within Groups	17.249	27	0.639		
	Total	18.300	29			
Praises or encourages	Between Groups	0.037	2	0.018	0.029	0.971
	Within Groups	16.930	27	0.627		
	Total	16.967	29			
Asks questions	Between Groups	1.747	2	0.873	1.500	0.241
	Within Groups	15.720	27	0.582		
	Total	17.467	29			
Lectures	Between Groups	0.156	2	0.078	0.104	0.901
	Within Groups	20.144	27	0.746		
	Total	20.300	29			
Gives direction	Between Groups	1.597	2	0.798	0.903	0.417
	Within Groups	23.870	27	0.884		
	Total	25.467	29			

Source: Researcher (2021)

From the results presented in Table 4.12, all the p-values were greater than the desired significance level of 0.05, implying that insignificant effect was revealed between oral behaviour scores of teachers teaching gas laws in boys', girls' and

mixed schools. The results show that both genders utilized oral interaction during the teaching of gas laws in the same way. Therefore, from the results gender does not affect learning and therefore no effect on academic achievement. The findings are consistent with the findings in Table 4.4 regarding Pearson Product-Moment Correlation Coefficient between gender interaction and academic achievement showing weak positive association (r = 0.1137). Therefore there is no significant effect of gender interaction on academic achievement in gas laws in chemistry.

The study's findings conform to several studies. Omenesa (2015) for instance revealed that, although girls were not as active as males in the classroom interaction during the process of teaching and learning, the academic achievement of the students of both genders were statistically insignificant. Findings of a study by Adigun, Onihunwa, Irunokhai, Sada and Adesina (2015) indicated nonexistence of significant relationship between academic achievement of learners' in computer studies and gender of the learner; meaning there is no distinction in cognition, effective and psychomotor achievement of skills for learners based on gender. This implies that academic achievement of learners has nothing to do with gender of a learner.

However, some previous studies have revealed that girls are discriminated against during teaching and learning. Okeke (2007) study in Nigerian found that female students suffer discrimination from teachers. This is probably due to cultural beliefs that girls are inferior to boys. Such discrimination may affect the girls leading to

low esteem and consequently low academic performance of girls compared to boys. The current study has revealed that teachers are becoming more sensitive to gender issues than before. This is very encouraging because girls may stop feeling inferior to boys hence making them equal participants during the learning process.

4.8 Descriptive and thematic analysis of research findings

To increase the reliability of the findings, the researcher further analyzed the data mainly through descriptive analysis and results presented in bar chart, pie chart, frequency tables, percentages, mean and standard deviations. Qualitative data was further analyzed through thematic analysis to enrich the results of this study. The analysis in this section was done based on the objectives of the study which were:

i.   To establish the effect of teacher-learner class talk (oral) interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

ii. To examine the effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

iii. To determine the effect of teacher-learner non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

iv. To examine gender interaction effect on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

The findings of the study are reported under the following sub-themes based on the objectives of the study.

4.8.1. Effect of teacher-learner class talk (oral) interaction on learners' academic achievement.

The first objective of this study was to establish the effect of teacher-learner class talk (oral) interaction on learners' academic achievement in gas laws in chemistry in public secondary schools in Murang'a County, Kenya.

4.8.2 Responses of learners on the use of class talk (oral) interactions

The researcher sought details on the students' responses on the use of class talk (oral) interactions in their schools and Table 4.13 presents the findings.

Table 4. 13: Students Responses on the use of class talk (oral) interaction

Statement	SD%	D%	NS%	A%	SA%	Mean	Std. dev
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications	2.2	3.3	1.7	18.9	73.9	4.59	0.863
I enjoy asking questions during the chemistry lessons	7.8	7.2	5.8	37.8	41.4	4.12	2.948
I enjoy answering questions during the chemistry lessons	6.9	5.6	3.1	37.2	47.2	4.12	1.157

SA=Strongly Agree, A=Agree, NS= Not Sure, D=Disagree, SD=Strongly Disagree

Source: Researcher (2021)

From Table 4.13 majority (73.9%) of respondents strongly agreed that their chemistry teacher encouraged them to actively participate during instructions. Therefore, chemistry teachers seem to know the importance of teacher-learner oral interaction which make the learners active and consequently leading to meaningful learning. In addition, (41.4%) and (37.8%) of respondents strongly agreed and agreed respectively, that they enjoyed answering questions and asking questions during the Chemistry lessons respectively.

The implication is that, learners were given conducive atmosphere to be actively involved during teaching and learning. Therefore, the results clearly indicate that there was proper use of teacher and learner class talk and the students had positive

perception towards the use of oral interactions. These can also be attested by the high means of 4.59, 4.12 and 4.12 for the statements in relation to the perceptions of the students. Therefore, from the results, chemistry teachers were encouraging class participation during instructional process, hence avoiding passive learning.

The researcher gathered qualitative data from the learners through students' discussion guide and from the CQASO during the interview. The interview and the discussion focused on research topic concerning gas laws. Learners were asked if their chemistry teacher encouraged them to interact with one another and with the teacher during the teaching of gas laws. They were all in agreement that their teacher encouraged them. On enquiring how the teacher encouraged them, one group had this to say:

> "The teacher always asked us questions when teaching and insisted that everyone must answer at least a question before the end of the lesson. Those unable to answer were told to stand up, but he told us to ask where we do not understand. But I hate to be told to stand up when unable to answer. Those who answered were appreciated" (students' group discussion, school 20, February, 2018).

Asked whether they enjoyed interacting with teachers and classmates during the teaching of gas laws, majority said yes because the topic involves calculation and they understand more during such discussions. However, one group said,

> "No because chemistry is a difficult subject and gas laws involves a lot of calculation which discourage us. The teacher is very fast and

does not give us time to understand. Therefore, I had nothing to discuss because I did not understand the topic. But practical was interesting because the teacher allowed us to help him in setting the apparatus and making observations" (Students' group discussion, school 22, February, 2018).

CQASO was requested to base his answers and arguments on lessons he observed in the months of January and February, 2018, regarding gas laws in chemistry. Asked if during assessment exercise learners were given adequate time to participate during teaching and learning process through talking like answering of questions and discussion, he said "yes". The following were stated as the common oral interactions, "asking and answering of questions, clarifications of ambiguous statements, teacher-learner oral discussions and learner-learner encouragement remarks like; good attempt, keep it up" However, the CQUASO was quick to point out that:

"Some teachers were not keen on use of verbal interaction and I tend to think this is because teachers are focused on finishing the syllabus, rather than helping students understand the content, despite exposing them to the best teaching practices during SMASSE insets. Some schools have dull students where there is little teacher-learner and learner-learner oral interaction, while you cannot be sure if what I observed is the same as when I was not present. But I can confirm that most teachers encouraged teacher-learner oral interaction while

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teaching gas laws and where no oral interaction was practiced, I can confidently blame the chemistry teacher" (CQUASO, Murang'a County, February, 2018).

Thematic analysis of this study reveals that, chemistry teachers encouraged oral interaction but the extent to which they practiced it, was noted to be varied. Mahmoodi (2016) noted that, it is imperative to involve learners during teaching and learning process in order to achieve high academic achievements.

However, it was noted that teachers are still using punishment method to make learners active. This is not a good practice in teaching because it causes fear as a negative reinforcement and when that kind of reinforcement is withdrawn learning stops. A common negative reinforcement used was punishment when a learner failed to answer a question or gave the wrong answer. For meaningful learning, teachers need to develop methods of motivating learners to enjoy learning.

4.8.3 Teacher Oral Behaviour Scores

The researcher intended to establish the influence of teacher's oral behaviour during the teaching of gas laws in Chemistry. The researcher observed the chemistry teachers while teaching and scored them in terms of the oral behaviour under investigation. Using a Likert scale of 1-5, the researcher indicated the extent to which the teacher portrayed the behaviour under investigation. A scale of 5 indicated a strong behaviour, 4-strong, 3-moderate, 2-weak while 1 indicated a

weak behaviour. Mean, Standard Deviation and Population Mean of Teachers' Verbal Behaviour Scores of the analysis are provided in Table 4.14.

Table 4.14: Mean, Standard Deviation, Standard Error of Mean and Population Mean of Teachers' oral Behaviour Scores

Teacher oral Behaviour	Sample mean	SD	SEm	Min	Max
While accepting students' feelings	2.70	0.794	0.145	1	4
While praising or encouraging students	2.37	0.765	0.140	1	4
While asking questions	3.13	0.776	0.142	1	4
While lecturing	3.30	0.837	0.153	2	5
While giving directions	3.13	0.937	0.171	1	5

Source: Researcher (2021)

Results presented in Table 4.14 revealed that teachers had high mean score of 3.30 while giving lectures. This means that the majority of chemistry teachers still preferred lecture method of teaching indicating the teachers have not fully embraced that learners can also generate knowledge. In relation to asking questions and giving directions the teachers had similar mean scores of 3.13 respectively.

The implication of this study is that, the majority of teachers were moderately involving learners during the instructional process. For instance, asking of questions is a method of provoking the learners to be critical thinkers, hence developing the intellectual and cognitive abilities of the learner. On the aspect of

giving directions the sample mean was 3.13 which is also a behaviour that is above average indicating that, teachers were guiding the learners moderately. Teachers should not assume that, whatever they ask is clear to all students. Therefore, guidance and direction is very critical during learning. After all, learners who are shy may not be able to seek direction if stuck and Chemistry being a subject that consists of concepts that may be challenging like manipulation of data requires the teachers' guidance.

Other oral behaviour such as accepting students' feelings and praising or encouraging students had a mean response of 2.70 and 2.37 respectively. The two types of interaction show that the teachers are below average in the two behaviours. This probably explains the high mean score of 3.30 of teachers while giving lectures giving little attention to learners' feelings. When a teacher accepts a student's feelings the student feels as being part of the learning process while when the learner is praised with words like thank you, well done, a good attempt, keep it up, the learner feels encouraged and feels motivated. The learners' desire or incentive to attempt answering, asking questions and seeking clarification is also raised.

The findings revealed praising and encouragement of learners as the lowest utilized. This denies the learners an important aspect of motivation or incentive. Learners are encouraged by teachers who praise and encourage them, leading to liking of the subject due to good rapport. As a result, the learners will attempt to impress the teacher by asking and answering questions leading to meaningful learning. These

findings are in conformity with Mahmoodi (2016), who found that, good teachers have stronger leadership, kind behaviour and accept student's feelings. When a teacher is classified by learners as good, the learners will be interested in the teachers' lesson which create the desire to learn.

This study revealed that teacher's class talk interaction both direct and indirect was found to be moderate, hence need improvement. An effective classroom teacher should be concerned with the learner in class to ensure the learner is physically and psychologically in class. When a teacher accepts the feelings of the learners, praises them, asks questions, gives directions and avoids lecture method, the learners are exposed to a suitable learning environment. Therefore, as pointed out by Shahabi (2012), the teacher's praise and encouragement are correlated positively with students' positive attitude and achievement towards learning. Brophy and Evertson (1981) found that the frequency of encouragement and praise are usually correlated positively with students' achievement.

4.8.4 Rating of Students' Oral Behaviour during Teaching of Gas Laws

The study sought to score students oral behaviour in class which were based on the following characteristics: give reports, response, ask a question, enquire or seek clarification, discussion, peer teaching and silence. The researcher observed the students in the classroom during the instructional process and rated the extent at which the behaviour under study was used. Ratings of scores was done using Likert scale of 1-5 where 5 indicated a very strong behaviour, 4-strong behaviour, 3-

moderate behaviour, 2-weak behaviour and 1-very weak behaviour. The results are presented in Table 4.15.

Table 4. 15: Students Verbal Behaviour during Teaching of Gas Laws

Students Verbal Behaviour	VW%	W%	M%	S%	VS%
Give reports	50.0	23.3	20.0	6.7	0.0
Response to teacher's questions	0.0	36.7	30.0	30.0	3.3
Ask a question	83.3	6.7	6.7	3.3	0.0
Enquire or seek clarification	90.0	6.7	3.3	0.0	0.0
Discussions	80.0	3.3	3.3	10.0	3.3
Peer teaching	46.7	36.7	10.0	6.7	0.0
Silence	8.0	24.0	11.0	13.7	43.3

Source: Researcher (2021)

VS= Very Strong behaviour, S=Strong, M=Moderate, W=Weak and VW=Very Weak

Results in Table 4.15 indicate that the majority of the learners were very weak in five areas: enquiring clarifications (96.7%), asking questions (90.0%), discussing (83.3%), giving reports (73.3%) and peer teaching (83.4%). The five areas are very critical during the process of teaching and learning because they involve participation of learners. It can be taken as a learners' desire to learn or what is referred in the area of educational psychology as internal motivation to learn. A subject like Chemistry can only be well understood when learners seek clarifications, ask questions, discuss and give reports of their experimental or discussion findings. That enthusiasm to interact leads to meaningful learning which

is likely to raise learners' academic achievement. Furthermore, the learner becomes part of learning and owns the knowledge generated during the lesson.

In addition, 36.7% of the learners were found to be weak when answering questions, while 43.3% of them remained silent in class such that, they did not even make an attempt to talk. Failing to answer questions and remaining silent in class make the class inactive which demotivates the teachers leading to low quality learning. However, the silence of learners is an indicator of the teachers' weakness in creating an active interactive classroom environment. Enquiring clarifications and asking questions scored very low probably due to language challenges. Learners with language barrier are unlikely to ask questions but need to be encouraged. Discussion and giving reports enhance confidence of the learner leading to higher academic achievement (Parmeh, 2014).

Peer teaching helps the learners to identify their strengths and weaknesses leading to quality learning and therefore learners need to be encouraged to take part in peer teaching. The percentage of learners who opted to be silent (43.3%) was high because it is like half of the respondents opted to be silent meaning very minimal interaction. Therefore, half of the respondents were inactive with no meaningful learning taking place. The results of the current study imply that majority of the students were not active during the Chemistry lessons and there was minimal usage of oral behaviour among the students. Lack of active participation during the Chemistry lesson leads to rote learning where learners are denied the opportunity

to contribute what they already have. Teachers need to encourage learners to generate knowledge and avoid passive learning so that they build on what they have, making learning meaningful.

This implies that, chemistry teachers must be creative in developing ways to motivate learners rather than coercing them. This would help the learners to contribute and generate the new knowledge making learning meaningful and create confidence to learners as well as increase their participation in class. Further, teachers should be more indirect, should ask more questions and deliver fewer lectures to enhance a learner centred learning environment.

4.9 Effect of learners' written interaction on learners' academic achievement

The second objective stated: "To examine the effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry". To achieve this objective, the researcher used the following sub-themes.

4.9.1 Students Responses on the use of Written Interaction

The researcher purposed to establish the perception of students towards various written interactions they were subjected to during the Chemistry lessons. The learners were given questionnaires and guided by the researcher on how to fill depending on the extent they agreed with the statement. Rating was done using Likert scale and presentations done in Table 4.16.

Table 4.16: Nature of Various Written Interactions during teaching and learning of gas laws

Statement	SD%	D%	NS%	A%	SA%	Mean	Std.dev
We are given a lot of work for homework	5.3	15.3	4.4	65.6	9.4	3.59	1.028
We report in class what we have done in our homework	8.6	6.4	4.7	36.7	43.6	4.00	1.232
We cover part of the syllabus through homework	20.0	11.4	2.8	45.3	20.6	3.35	1.439

SA=Strongly Agree, A=Agree, NS= Not Sure, D=Disagree, SD=Strongly Disagree

Source: Researcher (2021)

Findings from Table 4.16, revealed that the majority of students (75.0%) agreed that they were given a lot of work for homework, 80.3% of the students further agreed that they reported in class what they have done in their homework and 65.9% of the students agreed that they covered part of the syllabus through homework.

The results revealed thorough use of written interactions in classes through use of homework and the majority of the students were reporting their assignments in class. Challenging questions for homework stimulate the minds of learners by making them active while seeking knowledge. For instance, the learners read on their own as they sought for answers. Reporting in class gave the learners an opportunity to express themselves, raise their self-esteem and allow the teacher to guide the students while using written interactions by ensuring that the students did the assignment and they got the right answers and methods on the task given.

However, section 4.8.4 of this study contradicts these findings because the section indicated that the respondents were weak at giving reports. Section 4.8.4 may be more reliable than the findings of the current section because it involved the observation by the researcher during the instructional process which reflects a true reality on the ground. The findings of the current section are dependent on the learners' opinion which to some extent may be biased or subjective. Therefore, there is need for more research.

4.9.2 Evidence of group assignment in gas laws

The researcher intended to determine if learners were provided with assignments after lesson that were related to gas laws. The learners responded by the show of hands. Figure 2 shows a pie chart indicating the percentages of yes and no responses.

Fig 4.2: Students' responses on whether they were given assignments related to gas laws
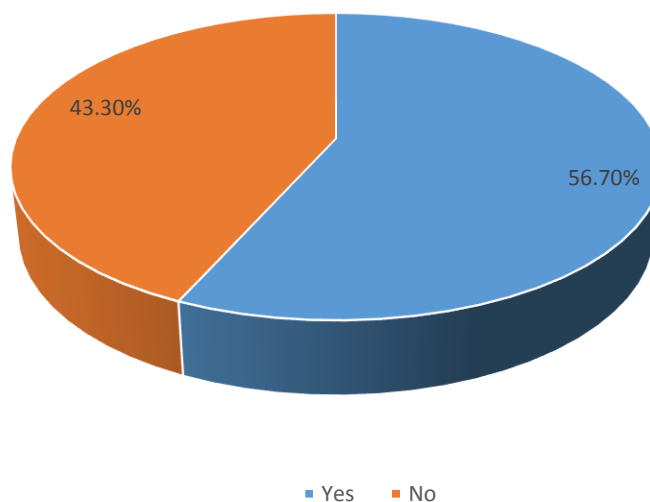
Source: Researcher (2021)

The pie chart indicates that most teachers (56.7%) gave group assignments compared to 43.3% who had not given. The 43.3% is a significant percentage, noting that assignments are necessary for teacher's self-evaluation. This implies that, there is need for those schools which did not show any evidence of group assignment to develop strategies to ensure students work in groups.

This is important because group work promotes an environment where there is collaboration and cooperation among students which could lead to better results and understanding of challenging concepts. Topics like mole concept requires manipulation of data and therefore learning becomes more meaningful when learners share their learning experiences. Moreover, a concept that is discussed is

easily recalled by learners. Therefore, the results of the current study indicated that, adequate assignments were not given to learners during the instructional process involving gas laws. This is supported by learners' responses during students' discussion with the researcher. Asked if they were given assignments after the lessons and the common method used for marking, the respondents had this to say:

> "We were given assignments but not always and each student marked own work in the next lesson guided by our teacher (Students' group discussion, school 21, February, 2018); The teacher gave us homework to do at home and then everyone marked one's own work with the help of the teacher (Students' group discussion, school 21, January, 2018); When the teacher gave us the assignment she told us to look for the answers (Students' group discussion, school 15, January, 2018). Yes, the teacher gave us assignments but never marked them (Students' group discussion, school 30, February, 2018). Yes, we were given assignments which were marked through self-marking. Sometimes we were told to discuss the answers in groups which I enjoyed (Students' group discussion, school 21, February, 2018)"

Self-marking is where a teacher takes learners through a question while the learners mark their own work. This method has the advantage of fast marking hence time saving but has its own shortcomings since the teacher does not identify the strength and weaknesses of the learner and therefore affects the quality of learning. The

researcher wanted to find out if students were given "challenging" assignments during the teaching and learning of gas laws. The term challenging was clarified by the researcher to make it clear to students. There were mixed reactions from the respondents. The majority of respondents stated that assignments given were not difficult and they sought answers from their notes, text books and through discussions in groups of two or more. However, the researcher cited a few responses:

"Very difficult and because of fear of being told to answer on the board during the next lesson, we copy from textbooks or from our friends (Students' group discussion, School 17, January, 2018); Not easy and not difficult but we use our text books to look for answers (Students' group discussion, School 9, February, 2018); Moderate questions and we sometimes discuss when the question is difficult (Students' group discussion, School 13, January, 2018); Questions from gas laws are not difficult but some classmates do not want to discuss with others; Some think they know, while others are lazy and want to copy from others (Students' group discussion, School 27, January, 2018)."

From the study, written interaction was not adequately used denying the learners the opportunity to practice writing yet examinations will be done through writing. Through writing the learner gets the skills of answering questions. A learner who has not practiced writing is likely to encounter challenges during examinations

hence their academic achievement being affected. However, this study's findings contradict the findings of Babelan (2012) study in Albania, on group learning effects on the academic achievement of learners of institutions of higher learning. A number of lecturers from the universities were found to have transformed the large classes to groups that allow their students to be more involved, both socially and academically.

Therefore, for assignments to be effective, quality assignment, supervision and effective marking of learners' work must be well planned and executed by the teacher. Hence, there is a need for further empirical studies using quality assignment to determine its effect on academic achievement. For instance, the findings from Table 4.10 of this study revealed that written interaction had a negative weak relationship (r = -0.2234) with students' academic achievement. Therefore, the findings established that written interaction has insignificant and negative effect on learners' academic achievement.

Additionally, the findings of Regression Analysis on the relationship between written interaction and students' academic performance in Table 4.6 established that the effect of written interaction on learners' academic achievement in Chemistry were statistically insignificant. Probably the teachers involved in the current study did not give quality assignment or did not supervise the assignments, a phenomenon that is open for further research.

4.9.3 Rating of assignments given to students.

The study sought details on the rating of assignments that were given to students during the teaching and learning of gas laws lessons. This was to understand the extent to which assignments were used as a tool for learners to interact with written work during instructional process. The rating involved the following features: quality of assignments; nature of teachers' remarks; adequacy of assignments to engage learners in the learning process; extent of marking of assignments by the teacher and the extent of reporting by the learners during learning. Rating was done using 5-point Likert scale where 1= very poor 2= poor 3= good 4= very good and 5= excellent. The findings are presented in Table 4.17.

Table 4. 17 Rating of Assignments related to gas laws given to Students

Statements		Very poor	Poor	Good	Very good	Excellent
Quality of assignments	Frequency	16	12	2	0	0
	Percentage	53.3	40.0	6.7	0.0	0.0
Nature of teachers' remarks	Frequency	22	5	3	0	0
	Percentage	73.3	16.7	10.0	0.0	0.0
Adequacy of assignments to engage learners in the learning process.	Frequency	13	15	2	0	0
	Percentage	43.3	50.0	6.7	0.0	0.0
Extent of marking of assignments by the teacher.	Frequency	8	21	0	1	0
	Percentage	26.7	70.0	0.0	3.3	0.0
Extent of reporting by the learners during learning	Frequency	21	9	0	0	0
	Percentage	70.0	30.0	0.0	0.0	0.0

E=Excellent, VG=Very Good, G=Good, P=Poor and VP=Very Poor.

Source: Researcher (2021)

The findings indicated in Table 4.17 shows that the quality of assignments, the nature of teachers' remarks and adequacy of assignments to engage learners in the learning process was poor in the majority of schools sampled with 93.3%, 90.0% and 93.3% respectively. In relation to the extent of marking of assignments by the teacher, the rating was poor with 96.7% while in relation to the extent of reporting

by the learners during learning, the rating was very poor (70%) and 30.0% poor. The results indicate that the schools were generally performing poorly in relation to assignments given to students which may negatively influence the academic achievement in Chemistry. Results indicate that, chemistry teachers in Murang'a County are not taking assignments seriously probably because of time taken to mark or are in a hurry to complete the syllabus.

This argument is in conformity with findings from a study by Lisa (2011) in the USA which revealed that, teachers are no longer using written interactions effectively because of the time limits that education stakeholders have put in place. In the process, written teacher interaction is given very little time and attention. One of the conclusions from this study was that students require written teacher remarks for effective academic achievement. Therefore, teachers needed to use assignments as an interactive tool of involving learners to achieve effective learning.

As much as possible the teacher should mark the learners' assignment to identify their strengths and weaknesses. Group assignments are also critical in providing students with an opportunity to further develop their skills through peer interactions which aids in refining their understanding through discussion and explanation. This is in conformity with Caruso and Woolley (2008), who emphasized that group assignments can help students develop a host of skills that are important in the cognitive development of the learner. However, this section contradicts section

4.9.1 of students' responses on the use of written interaction whereby majority of the students indicated that, there was thorough use of written interactions in classes through use of homework and majority of the students were reporting their assignments in class. According to the study the document analysis which is likely to be more reliable contradicted the learners' responses on written interaction in gas laws.

Therefore, from this study, it can be argued that written interaction was not well utilized during the gas laws lessons and was likely to negatively affect quality learning on learners. Probably the learners were not well supervised hence some never contributed while others just copied the work of others leading to low quality learning. These findings are supported by the learners' responses during group discussions. Asked if teachers gave challenging questions the study revealed that giving moderate questions was the most common practice. Challenging questions may help the learner to read more, consult and stimulate their minds leading to meaningful learning and higher academic achievement.

During the interview with CQASO regarding written interaction on gas laws, the researcher asked: "Comment on the quality of questions, frequency of assignments and questions, marking of assignments by the teacher and usefulness of assignments and note writing in the teaching of gas laws" He responded as follows:

> "Assignments in gas laws are crucial for teacher's self-evaluation and
>
> to establish the strengths and weaknesses of learners, because the topic

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involves practical activities and calculations. I noted the following things from the schools I have visited during the teaching of gas laws; inadequate and low quality assignments, probably because the teacher wanted to rush over the syllabus, while majority of the schools used the self-marking style by the learners. In my opinion teachers need to focus more on assignments. Regarding the notes on gas laws, very few teachers had made comments on the learners note books, an indication that teachers may not be sure if learners were writing the notes correctly" (CQASO, Murang'a County, March, 2018).

The findings suggest that, written interaction was not effectively utilized resulting to insignificant effect on learners' academic performance. The findings in this section probably confirm the results from Pearson Product Moment Correlation Coefficient in section 4.6.1 of this study.

4.10 Effect of learners' and teachers' non-verbal interaction on learners' academic achievement.

Objective three of the study stated: "To determine the effect of learner-teacher non-verbal interaction on learners' academic achievement in gas laws in Chemistry in Murang'a County, Kenya. Findings of the study are discussed under the following sub-themes.

4.10.1 Learners' Rating of Teachers' use of Non-Verbal Interaction during Chemistry lessons on gas laws

This section intended to identify the leaners' perception on teachers' use of non-verbal interactions during teaching of gas laws. The researcher took the learners through the questionnaire and guided them on how to fill by putting a tick in the appropriate box. Likert scale was used to rate the extent at which learners agreed with each statement. Table 4.18 shows the outcome of learners' responses.

Table 4. 18: Learners' Rating of Teachers' use of Non-Verbal Interaction during Chemistry lessons on gas laws

Statement	SD%	D%	NS%	A%	SA%	Mean	Std. dev
Our chemistry teacher is friendly while teaching	0.3	1.9	2.8	41.1	53.9	4.46	0.675
Different moods like anger, happiness in our chemistry teacher affect my learning	29.2	19.7	10.0	23.3	17.8	2.81	1.509
Our chemistry teacher always appreciates any answer that you give by actions such as nodding and facial expression.	5.0	3.9	3.3	28.3	59.4	4.33	1.061
Our chemistry teacher encourages us to appreciate others when they participate, for instance by clapping	3.9	5.0	5.6	33.9	51.7	4.24	1.032

SA=Strongly Agree, A=Agree, NS= Not Sure, D=Disagree, SD=Strongly Disagree

Source: Researcher (2021)

The findings arising from this section revealed that, 95% of the respondents were in agreement that chemistry teachers were friendly during instructions. The implication of this finding is that, learners are likely to associate with the subject where the teachers are friendly. When a learner likes a teacher, this translate to liking the subject and putting effort to impress the teacher and hence higher academic achievement. Teachers who exhibit unfriendly characteristics are hated by learners resulting to hating their subjects and consequently low academic achievements. The results further revealed that, majority of respondents (48.9%) were not in agreement that, different moods exhibited by their chemistry teachers affected learning.

However, (41.1%) of respondents agreed with the statement. Although (48.9%) disagreed with the statement, the 41.8% of respondents who disagreed cannot be taken for granted. Therefore, the results indicate that, different moods exhibited by a teacher may have an effect to some extent on the learning process, affecting quality learning which impacts on learners' academic achievement.

The findings further revealed that 87.7% of respondents were in agreement that, their responses or answers were appreciated by their chemistry teachers through non-verbal expressions and another 85.6% were in agreement that, they were encouraged to appreciate their classmates who participated during the instructional process.

The way a teacher and classmates reacts towards another learner's response can either motivate or demotivate a learner towards learning. A good example is when a teacher shows approval of a learners' answer with a thump up. This is likely to raise the morale of the learner which may result to quality learning.

Several studies are in conformity with findings of the current study. For instance a study by Babelan (2012) revealed a significant correlation between teachers' immediate non-verbal behaviours and students' academic achievement. Gholipour (2007) noted that, appreciating a learner through non-verbal cues is an important motivational factor towards quality learning. The findings suggest that, teacher's use of non-verbal behaviour facilitate the attention of learners and create desire to learn.

The students' perception in the current study is therefore an evidence that teachers used non-verbal behaviour interaction well to enhance learning. This was also evidenced by the high mean rating from learner's responses in Table 4.18. The researcher further used students' group discussions to find out more about non-verbal interaction in the classroom during teaching and learning. To establish further about the use of non-verbal interaction students' group discussions were utilized.

Asked how their chemistry teacher made the class lively during gas laws lessons, by using non-verbal interaction, the respondents said:

"Making fun, cracking jokes, calling us by names and being smartly dressed (Students' group discussion, school 3, February, 2018); by walking around; smiling, watching those sleeping or dozing (Students group discussion, school 7, January, 2018); using a loud voice and looking at us throughout the lessons and sometimes telling us interesting stories (Students group discussion, school 3, February, 2018).

The researcher asked the CQASO if in his opinion non-verbal interaction like nodding and gestures during teaching and learning of gas laws can improve academic achievement and if yes to name at least three types of non-verbal interaction. He responded as follows:

"Yes to some extent if it is well factored in the lesson plan so that the teacher knows what to do when and must be done in a way to avoid distracting the learners. Good examples of non-verbal interaction behaviour are a friendly face; listening keenly; appreciating learners through nodding and change of tone during teaching," (CQASO, Murang'a County, March, 2018).

Although this study established that teachers practiced non-verbal interaction during the instructional process, the researcher was not able to establish if the non-verbal interactions practiced by the teachers during the teaching of gas laws were

deliberate or not. This can be explored by further research using quasi-experimental design.

Conforming to the findings of the current study Najafi and Rahmanzade (2013) noted that non-verbal interaction is an effective pedagogical method of teaching compared to verbal interaction. It was further revealed that, when teachers use non-verbal cues skillfully, learners' concentration and attention are easily captured. This facilitate better understanding of concepts through motivating and exciting learners with low concentration resulting to meaningful learning (Najafi & Rahmanzade, 2013).

4.10.2 Teachers' rating on use of Non-verbal Interactions in teaching of Chemistry

The purpose of the study was to establish the rate at which teachers exhibited various non-verbal characteristics during the instructional period under investigation. A lesson observation checklist was used to rate the following non-verbal interaction: eye contact, gestures, body language and tone variation. Table 4.19 shows the findings.

Table 4.19 Researchers' rating of Teachers on use of non-verbal interactions during Chemistry lessons on gas laws

Statement	HI%	MI%	PC%	MC%	HC%
Teacher maintenance of eye contact with the students when asking questions.	3.3	10.0	26.7	60.0	0.0
Teacher shows a variety in gestures.	23.3	63.3	10.0	0.0	3.3
When guiding learners, teachers' non-verbal behaviour motivates the participation of students.	16.7	26.7	40.0	13.3	3.3
Teachers' nonverbal behaviour encourages when they accept ideas of learners.	6.7	36.7	43.3	13.3	0.0
Teacher ensures variety in tone and variation.	26.7	33.3	26.7	13.3	0.0

HI=Highly Inconsistent, MC= Moderately Consistent, PC= Partially Consistent, MI=Moderately Inconsistent, HC= Highly Consistent.

Source: Researcher (2021)

The results of Table 4.19 established that, majority of teachers (60.0%) were moderately consistent in maintaining eye contact with the learners. This probably might imply that, a learner is likely to be provoked by the attention of the teacher. Such provocation force the learner to think, participate, share experiences resulting to meaningful learning. The findings of the current study further revealed that 63.3% of teachers moderately and inconsistently exhibited a variety of gestures. Approval or appreciation of a teacher through a non-verbal interaction like nodding and gestures is likely to encourage learners to contribute towards the learning process.

Supporting the findings of the current study Khabaz (2013), revealed that, learners can lose interest in learning if teachers pay no attention to them, through non-verbal interactions like gestures and facial expression. This hinders meaningful learning resulting to undesired academic achievement of learners.   Additionally, 40.0% of the teachers were partially consistent, 16.7% highly inconsistent and 26.7% moderately inconsistent in using non-verbal behaviours while guiding the students.

Therefore, the results revealed that majority of teachers were weak in the use of interactive body behaviour with learners. Indeed, learners are very observant on the interactive body behaviour of teachers which may significantly influences learning. The study further revealed, 43.3% of the teachers as partially consistent, 36.7% as moderately inconsistent and 6.7% highly inconsistent in the usage of non-verbal behaviour regarding acceptance of students' ideas.

The implication of the results is that teachers needed to improve in accepting students' ideas during the teaching of gas laws. Whether correct or wrong, student's ideas need to be appreciated, accepted and improved on. This encourages learners to bring out and share what they know and build on it (Salimi, 2014).

Additionally, 26.7% of the teachers were rated as highly inconsistent, 33.3% as moderately inconsistent and 26.7% partially consistent in tone variation. It is the opinion of the current researcher that, teachers should vary their tones consciously depending on circumstances. A good example is a teacher gifted with loud voice who need to vary the tone from time to time. The findings show that the majority

of teachers were moderately inconsistent, closely followed by partially consistent in the use of non-verbal interactions in class during the teaching of gas laws. This conclusion was drawn from working out the mean percentage of each response from the five statements in which, HI=15.34%, MI=34.0%, PC=29.34%, MC=19.98% and HC=1.32%. The implication arising from this study is that, despite utilizing non-verbal interactions teachers were not consistent.

Therefore to improve teacher's pedagogical skills they should be encouraged to use non-verbal interactions during instructional process to improve learners' desire to learn leading to quality learning. These results conforms to a study by Mortazavi (2013) who carried out a meta-analysis of patterns of interaction in Mathematics. The results revealed that, collaborative, supportive, and emotive methods can enhance effective learning of Mathematics through body interaction. Although the focus of this section was teachers, the study recommend learners to be encouraged to use non-verbal interaction to enhance quality learning. This is because even teachers need to be encouraged by learners through non-verbal interactions.

4.11 Gender interaction effect on learners' academic achievement in gas laws in Chemistry.

This section presents the findings of the fourth objective which sought to examine gender interaction effect on learners' academic achievement in Chemistry, in Murang'a County, Kenya. Data was analyzed using descriptive analysis and because gender provides categorical data, Chi-square was also used.

4.11.1 Learners Responses on Gender Interaction during the teaching and learning of gas laws

The learners were required to put a tick in the appropriate box that described their extent of agreement on statements relating to gender interaction and their learning during the teaching of gas laws. Table 4.20 presents the responses of learners on influence of gender interaction on their learning during the teaching of gas laws. In Table 4.20, letters A, B, C and D represent statements that were rated by the respondents:

A- I prefer boy/boy, girl/girl interaction during learning.

B-I am shy to interact in a class where boys are present.

C-I am shy to interact in a class where girls are present.

D-I prefer/would prefer interacting with men teachers during the teaching of chemistry.

E-I prefer/would prefer interacting with lady teachers during the teaching of chemistry.

Table 4.20: Learners Responses on the Gender Interaction during the teaching of gas laws

Students rating in terms of the following statements		SD %	D%	NS %	A%	SA %	Mean	Std. dev	Chi^2
A	Male	26.8	5.4	6.5	36.0	25.3	3.25	1.547	0.802
	Female	26.4	6.9	7.5	36.8	22.4			
	Male	16.7	52.2	5.3	8.6	17.2	3.17	1.493	23.452***
B	Female	38.5	2.9	4.0	39.7	14.9			
	Male	35.5	4.3	4.8	34.4	21.0	3.24	1.517	17.605***
C	Female	20.1	48.9	8.0	5.8	17.2			
D	Male	11.3	3.8	7.0	55.9	22.0	3.60	1.317	16.395***
	Female	18.4	8.1	10.9	35.6	27.0			
E	Male	21.0	15.1	9.7	35.5	18.7	3.33	1.410	16.982***
	Female	17.8	5.2	5.2	51.7	20.1			

SA=Strongly Agree, A=Agree, NS= Not Sure, D=Disagree, SD=Strongly Disagree

*** *represents significance level at 1%.*

Source: Researcher (2021)

The findings indicated in Table 4.20 shows a statistically significant variation in the opinion of the two groups in relation to the statements except on the statement 'I prefer boy/boy, girl/girl interaction during learning'. However, regarding the respondents' perception, 61.3% of boys agreed that, they prefer boy/boy interaction

while 59.2% of girls preferred girl/girl interaction. The findings from the learners' perception indicate that learning would be more effective in one gender class. This is probably because at this level of adolescent each gender fears to display their academic weaknesses.

The chi square p-value was statistically significant at 5% confidence level for the following statements; I am shy to interact in a class where boys are present, I am shy to interact in a class where girls are present, I prefer/would prefer interacting with men teachers during the teaching of chemistry and I prefer/would prefer interacting with lady teachers during the teaching of gas laws. X^2 can only be used on data that is discrete. Chi-squared test is the independence test, the idea that one variable is not affected by another variable or is related with another variable. The test does not provide the level of the association but rather it estimates the likelihood that other factors aside from chance contribute to particular relationship (Best & Kahn, 2011).

In relation to the statement, "I am shy to interact in a class where boys are present," the majority of the male students (68.9%) disagreed, compared to 54.6% of female students who agreed. While in relation to the statement, 'I am shy to interact in a class where girls are present', majority of female students (69%) disagreed, compared to 55.4% of male students who agreed with the statement. The findings of the current study indicate that the gender of a student plays a critical role during the learning process. This is because both the male (55.4%) and the female students

(54.6%) were not comfortable to relate with their male and female counterparts respectively.

The findings are in conformity with findings of a study by Okon and Archibong (2015) who found that gender interaction has effect on learners' academic achievement. Hence, there is a dire need to encourage both the male and female learners to interact freely among themselves without any fear of intimidation. In relation to the student-teacher interaction based on gender, 77.9% of male students prefer interacting with men teachers during the teaching of gas laws compared to 62.6% of female students.

While in relation to classroom interaction with lady teachers, 71.8% of female students agreed to the statement, compared to 54.2% of male students. The results imply that learners preferred to be taught by teachers of the same gender. The implication is: male learners prefer being taught by male teachers while female learners prefer being taught by female teachers. This might be because of the fact that teachers belonging to the same gender as students understand the challenges the students go through. Hence, they can relate well with each other compared to another gender. Another reason could be cultural issues as revealed by a study by Toni, Julija and Gordana (2018) where boys feel that females are inferior to males. Therefore boys may look down upon a female teacher as not suitable to teach them. Such an attitude will lower the academic achievement of the learner.

The results of the current study conform to findings from a study done in England and USA by Ammermüller and Dolton (2006) on the effect of teacher-learner gender interaction on the scholastic results. The findings established that, the performance of girls was better when they received instructions from female teachers while boys were found to perform better when they received instructions from male teachers.

Results further indicated that gender interaction between teachers and learners had positive and significant effects on teaching of Mathematics in England and not in the USA. This implies that in England, with all the other factors held constant, teaching of Mathematics would be effective if male learners received instructions from male teachers and female learners received instructions from female teachers. It was also noted that in both countries female teachers constituted of 75% of the entire population of teachers. It was therefore suggested that more male teachers should be recruited in the teaching profession to narrow the disparity of male: female ratio as well as avoid disadvantaging the boy child.

During the students' group discussion, the researcher asked the respondents in mixed schools if the presence of the opposite gender affected their participation in class. The respondents gave a variety of responses:

"Yes, because boys will make fun of you after the lesson (Students' group discussion, a girl in School 18, February, 2018); Yes, (Students' group discussion, School 11 February 2018); No, we are alright

(Student group discussion, School 16, February, 2018); Yes, because

the boys tell us that, we want to show off (Students' group discussion,

a girl in School 8, February, 2018); Yes, because the girls are favoured

by teachers (Students' group discussion, a boy in School 18, February,

2018); No, because we do not fear one another (Students' group

discussion, a boy in School 22, February, 2018)."

From the learner's verbatim responses, it remain unclear whether gender hindered

learning in the current study.

The researcher then sought more qualitative data from the CQUASO by asking him

if interactions of learners during the learning process in mixed secondary schools

is affected by the presence of learners of the opposite gender. He had this to say:

"Of course and this is why mixed secondary schools do not perform well

as compared to one gender schools. The issues of social life outside the

classroom like coupling impact negatively on learning. A girl with a

boyfriend in the same class is afraid of being active to avoid making a

mistake in the presence of her boyfriend and other boys. Girls also tend to

shy from working hard in the subjects stereotyped as to belong to boys

like Mathematics, Physics and Chemistry (CQUASO, Interview, March,

2018)."

From the CQASO remarks, gender issues are prevalent in mixed public secondary schools and they affect academic achievement of learners. The researcher further asked the students, "Do you prefer to be taught by a male or female teacher?"

Majority of the respondents stated that, they preferred same gender because their needs and challenges are the same with teacher of same gender. However, four students had contrary opinion and this is what they said:

> "I prefer to be taught by a male teacher because female teachers always have a grudge against girls (Students' group discussion, a girl in School 3, January, 2018); I prefer female teachers because they are friendly, kind and motherly whereas male teachers may at times become harsh (Student group discussion, a boy in School 30, February, 2018); I prefer male teachers because they listen and are patient especially when a student is asking a question (Student group discussion, a boy in School 23, February, 2018); I don't care so long as the teacher teaches well (Student group discussion, a boy in School 9, February, 2018).

From the learners' verbatim responses, there were mixed reactions regarding learners' teacher preference without a clear explanation. The implication of the learners' responses, is that, the gender of chemistry teacher may not have had a significant effect during the instructional process. Therefore, the findings of the current study established that, the gender of a learner or a teacher during the process of instructions was not a predictor of learner's academic achievement. This is an

indicator that learners and teachers are changing from stereotyping the potential of either gender.

4.11.2 Gender Interactions between the teachers and the students during the teaching of gas laws

The study purposed to establish the gender interaction between teachers and students in various activities in gas laws lessons in mixed secondary schools. The interaction activities included raising of hands; answering questions; asking questions; doing demonstrations; reading and doing other activities. The researcher observed the frequency at which each gender was involved in each interaction activity. The interaction behaviours were tallied using the observation checklist and the findings presented in percentages in Table 4.21.

Table 4.21: Gender Interaction between the teachers and the students during the teaching of gas laws

Interaction	Gender	Frequency	Percentage (%)
Raises hands	Male	17	44.7
	Female	21	55.3
Answers questions	Male	22	50.0
	Female	22	50.0
Asks a question	Male	11	50.0
	Female	11	50.0
Demonstrates	Male	6	31.6
	Female	13	68.4
Reads	Male	6	46.2
	Female	7	53.8
Does other activities	Male	5	41.7
	Female	7	58.3

Source: Researcher (2021)

Results in Table 4.21 shows the ratings of various gender interactions between teachers and students during the instructional process. In relation to students who raised their hands while in class, 55.3% were female, while 44.7% were male. Girls were slightly more active than boys. The results further indicate that there was an equal number (50%) of students who answered questions and asked questions in the class respectively.

However, in relation to undertaking demonstrations in class, majority (68.4%) of girls were involved compared to 31.6% of the boys. From the results of this study girls appeared more active undertaking the demonstrations in class than boys. The students were also involved in reading and majority of the girls (53.8%) were involved in reading compared to 46.2% of boys. Girls were therefore slightly active compared to boys in reading during learning and teaching of gas laws.

Finally, apart from engagement in classwork, 58.3% of the females were involved in other activities such as helping the teacher rub the chalk board and taking the science apparatus to the laboratory store after class compared to 41.7% of the male students. The findings revealed girls as generally more interactive compared to boys.

The findings are in agreement with several studies like O'Connor, Dearing, & Collins (2011) study which revealed that, the preference of boys is working alone and whenever they are working in groups they will argue on who should lead as opposed to girls who have a higher likelihood of cooperating and working effectively in groups, discussing issues and ideas pertaining a particular task.

Vinson (2013) found that, the variation in treatment of students by teachers based on gender was significant in that male teachers normally favoured girls while female teachers favoured boys. Hyacinth (2000) asserted that, the nature of teacher-student interaction shows some bias in favour of girls. Although teacher-student interaction for boys did not correlate with academic performance, the interactions

observed raised gender equity and moral issues that have implications on the teacher's role.

The outcome of this study could explain, results of a study by Milun, Mardesic and Kovac, (2011), which investigated whether age and gender impacted on learners' academic success. The study revealed that, female learners achieved higher scores in seven academic areas: Basic economics; Accounts, Commerce and law; Management accounts; Banking accounts; Information systems in accounts; and Business in marketing. In addition, male learners did not achieve higher scores than their female learners in the seven academic areas.

Additionally, a study by Chua and Mageswary (2015), established that the attitudes of female students regarding chemistry lessons were more positive than that of male students across the grade levels. Female students could be performing better because they interacted more than male students. However, teachers should ensure that both genders are equally involved especially in gas laws lessons to promote interaction in both gender and develop basic science process skills like critical thinking, measuring, observation and recording.

Therefore, from the current study girls were found to be more interactive with the teacher compared to boys during the chemistry lesson. However, a study by Onyegegbu (2004) noted that boys participated more in interactions than girls hence contradicting the findings of this study. From the findings of the current study there

appears to be varying results regarding effects of gender and academic achievement. Therefore, there is need for further empirical studies.

4.12 Factor analysis on classroom interaction during the teaching of gas laws

To improve the reliability of the findings of the current study, data on learners' responses on classroom interactions were subjected to factor analysis. Findings are presented in Table 4.23.

Table 4.22 Factor analysis results on classroom interactions

	Component				
	1	2	3	4	5
We report in class what we have done in our homework	0.680				
We are given a lot of homework	0.559				
We cover part of the syllabus through homework	0.548				
Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.		0.476			
Our chemistry teacher encourages us to appreciate others when they participate for instance by clapping		0.686			
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications		0.513			
I am shy to interact in a class where girls are present.				0.400	
Different moods like anger, happiness in our chemistry teacher affect learning			-0.726		
I enjoy answering questions during the chemistry lessons			0.582		
I enjoy asking questions during the chemistry lessons			0.463		
Our chemistry teacher looks very friendly while teaching			0.455		
I prefer boy/boy, girl/girl interaction during learning.				0.706	
Respond to this item if you are a girl: I am shy to interact in a class where boys are present.				0.651	
I prefer/would prefer interacting with lady teachers during the teaching of chemistry.					0.723
I prefer/would prefer interacting with lady teachers during the teaching of chemistry.					-0.537

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Source: Researcher (2019)

Factor 1 variables included: we report in class what we have done in our homework;

we are given a lot of work for homework and we cover part of gas laws through

homework. The variables had high loadings of 0.680, 0.559 and 0.548 respectively

on factor 1. The three variables together can be called 'written interactions through

gas laws assignments'. These results indicate that active interaction through assignments in gas laws is key for academic performance which conforms to Chen (2009), who believes in active engagement of learners through homework assignments as a way of developing their own learning capacity.

For factor 2, it was observed that the chemistry teacher "encouraged students to appreciate others when they participated, through clapping and also encouraged students to participate actively in class through talking, asking of questions and seeking clarifications" and "our chemistry teacher always appreciated any answer that one gave through nodding and facial expressions" have high loadings of 0.686, 0.513 and 0.476 respectively and they are together termed as 'verbal encouragement'.

As for factor 3, four variables had high loadings and they were related to students actively participating in class and teachers being friendly while teaching. The variables that were in this component included: "different moods like anger, happiness in our chemistry teacher affects learning, I enjoy answering questions during the Chemistry lessons, I enjoy asking questions during the Chemistry lessons and our chemistry teacher looks very friendly while teaching" had high loadings of -0.726, 0.582, 0.463 and 0.455 respectively. These four variables are combined together and named as 'active participation through oral and non-verbal interaction' during gas laws lessons. Thus, both oral and non-verbal interactions play a critical role in balancing and harmonizing the academic programme due to

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its usefulness in developing skills in all areas of the curriculum (Hill & Kathleen, 2006). Therefore, teachers need to embrace use of oral and non-verbal interactions to enhance their teaching and make it more effective and efficient.

For factor 4 only two variable loaded highly which were; "I prefer boy/boy, girl/girl interaction during learning, I am shy to interact in a class where boys are present" and "I am shy to interact in a class where girls are present" which were 0.706, 0.651 and 0.400 respectively. These factors can be termed as 'gendered bias interaction among students'. Moreover, for factor 5 it is observed that "boys preferred interacting with female teachers during the teaching of chemistry and girls preferred interacting with female teachers during the teaching of chemistry" have high loadings of 0.723 and 0.537.

Therefore, the two variables can be joined together into a single factor called "gendered bias interaction among students and teachers." It is imperative to note that, there is differential interaction between students of both genders in secondary schools and in addition between teachers and students. The findings of this section reveals that a combination of the four independent variables can improve learners' academic achievement if effectively used. However, oral and non-verbal interactions would yield better results than written and gender interactions. It can therefore be argued that, the four classroom interactions which are the focus of the current study were a fundamental need for quality teaching and learning of gas laws which will consequently lead to learners' high academic achievements.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary and conclusions of the major findings in addition to making recommendations and suggestions for further research based on the results of this study.

5.2 Summary of the study

The overall objective of the study was to investigate the effects of selected classroom interactions on learners' academic achievement in Chemistry in public secondary schools in Murang'a County, Kenya.

The study was guided by the following research objectives:

i. To establish the effect of teacher and learner class talk (oral) interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

ii. To examine the effect of learners' written interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

iii. To determine the effect of learners' and teachers' non-verbal interaction on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

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iv. To examine gender interaction effect on learners' academic achievement in gas laws in Chemistry in public secondary schools in Murang'a County, Kenya.

Review of related literature focused on describing the dependent variable (learners' academic achievement in Chemistry); studies on interaction of learners during the instructional process; studies on the role of a teacher in classroom interaction during the instructional process; studies on teacher-learner class talk (oral) interaction; studies on written interaction; studies on non-verbal interaction and studies on gender interaction on learners' academic achievement. From the reviewed literature, the researcher developed a conceptual framework showing the association between the dependent variable and predictor variables. The study was guided by Vygotsky Social development theory (1980).

After the comprehensive review, the following research gaps were identified which formed the basis of this study; research design, methods of analysis, data collection instruments, subject area, sample size and varying results providing no clear interpretation regarding the effect of oral, written, non-verbal and gender interactions on learners' academic achievement. Descriptive survey design was adopted for this research and the study was conducted in 30 public secondary schools in Murang'a County. The study involved 360 Form three learners and 30 Chemistry teachers from academically average performing secondary schools.

During data collection, 93.75% secondary schools responded, 93.75% of the students' questionnaires were returned while the researcher was also able to visit 30 out of 32 secondary schools that gave 93.75% return rate on lesson observation checklist. To ensure gender balance the researcher used stratified random sampling thus selecting 7 boys' secondary schools, 6 girls' secondary schools and 17 mixed secondary schools.

The study's null hypotheses were tested using simple and multivariate regression analysis, chi^2, ANOVA and Pearson's Product-Moment Coefficient of Correlation (r). Comparing the contribution of independent variables to the dependent variable which was the performance in the Chemistry Achievement Test was done by computing Regression analysis. Piloting of this study, validation and reliability of the instruments were done.

Descriptive statistics was used in analyzing data that was collected using the questionnaires and were analyzed with the use of SPSS version 23 and presented in percentages, frequency tables, pie chart and means. Documentary evidence and qualitative data were analyzed and striking responses from participants quoted to enhance the study. The summary of the findings based on the objectives is as presented in subsequent sub-sections: -

5.2.1 To establish the effect of teacher-learner class talk (oral) interaction on learners' academic achievement in gas laws in Chemistry

The findings of the study established that academic achievement in gas laws, was positively statistically and significantly influenced by class talk interaction (β=0.572, p<0.001). The regression model of F-statistic=13.643 which was significant, P<0.001 and R^2 = 0.33, showed that oral interaction explained 33% of the variation in academic achievement in gas laws. The study found that increasing oral interaction by a single unit results in a corresponding increase in gas laws mean score by about 0.572 units. A one-way ANOVA analysis also confirmed that oral interaction as a classroom interaction and the academic performance in gas laws were strongly related.

In addition, Pearson's Product-Moment Coefficient of Correlation between oral interaction and learners' academic achievement in gas laws showed a strong positive (r = 0.5724) relationship between the two variables. Hence, it is imperative to include class talk interaction in the teaching of Chemistry so as improve Chemistry performance in secondary schools. This is because when there is free interaction between the teachers and the students, the learners are able to ask questions in the areas they do not understand. Moreover, while answering the questions the teacher is able to identify their level of understanding hence enhancing quality learning.

From the findings, teacher-learner class talk (oral) as a classroom interaction was practiced by 85.5% of the schools in Murang'a County during the process of teaching and learning of gas laws. Therefore, the results clearly indicate that there was effective use of teacher-learner class talk interaction and the students had positive responses towards the use of oral interaction during the teaching and learning of gas laws. This can also be attested by the high means of 4.59, 4.12 and 4.12 for the statements in relation to the responses of the students. Majority of the students (92.8%) revealed that chemistry teachers encouraged active participation in class.

Moreover, majority of the respondents (84.4%) and (79.2%) positively stated that they enjoyed answering questions and asking questions during the gas laws lessons respectively. These findings show that teachers were practicing teacher- learner class talk interaction hence increasing student class motivation and academic achievement. However, the researcher established that learners were very weak in asking questions (83.3%); seeking clarifications (90.0%); weak in giving reports (50.0%); peer teaching (46.7%); while 43% were absolutely silent throughout the lesson and 13.7 % were fairly silent.

5.2.2 To examine the effect of learners' written interaction on learners' academic achievement.

One of the basic practices that is believed to enhance improvement of academic performance of students in Chemistry is involving them with homework and assignments. However, the study found statistically insignificant association between written interaction and academic achievement of learners. The two-tailed p-value associated with the test was 0.235 which was greater than 0.05, so the null hypothesis was accepted.

The value of (R^2) referred to as statistic coefficient gives the variation that account for the written interaction which was the independent variable during the teaching and learning of gas laws. The value of $R^2 = 0.050$, implied the model explained only 5% variation in dependent variable which is the learners' academic achievement in this study. This implies that, other factors that were not part of the model contributed 95% change in academic achievement.

Further, the Pearson Product-Moment Correlation Coefficient between written interaction and learners' academic achievement revealed a weak negative relationship ($r = -0.2234$) between the two variables. This means that the students had the same chance of performing well in gas laws even when they were not exposed to written interaction in the post-test exams. Therefore, so long as the chemistry teacher explained the concepts well and involved the students through verbal interactions, they could still have performed well in the gas laws test.

However, these findings contradict many other studies an indication for further empirical studies.

The study found that 75% of schools were giving assignments on gas laws to their students. In addition, 80.3% of the students stated that they were made to report in class what they had done as assignment. The results through observational schedule further revealed that written interaction was not well utilized during teaching and learning process while the quality of assignments was rated as poor. The implication of the current study is that, written interactions in public secondary schools was poorly practiced by chemistry teachers.

5.2.3 To determine the effect of learners-teachers non-verbal interaction on learners' academic achievement in gas laws in chemistry

The study sought to determine the effect of learners and teachers non-verbal interaction on learners' academic achievement in gas laws. The findings established that, non-verbal interaction had statistical and significant effect on learners' academic achievement in gas laws, $[F = 37.959, P < 0.001]$. The regression had a standardized coefficient of (B=0.759 p<0.001) indicating that increasing use of non-verbal interaction by a single unit would lead to an increase in students' performance in gas laws by 0.759 units.

With $R^2 = 0.58$ in the model, this implied non-verbal interaction explained 58.0% of the variation in performance in gas laws. Therefore, the model explained only 58.0% of change in academic performance, meaning that the remaining 48.0% can

be explained by other factors that were not part of the model. Further, Pearson Product Moment Correlation Coefficient between non-verbal interaction and learners' academic achievement were strongly and positively correlated ($r = 0.759$) between the two variables.

Hence, if secondary school chemistry teachers considered use of non-verbal interaction, improved quality learning would be achieved. The results further revealed that, majority of students 95.0% stated that, their chemistry teachers were friendly while teaching gas laws, 85.6% stated that, their chemistry teachers encouraged them to appreciate one another during class participation while 87.7% agreed that, the teacher always appreciated all the responses given by learners through non-verbal means. However, despite the fact that, non-verbal interaction predicted learners' academic achievement most teachers were not consistent with non-verbal behaviour.

5.2.4 To examine gender interaction effect on learners' academic achievement in gas laws in chemistry

The study found insignificant statistical association between gender interaction and learners' academic achievement in gas laws. The two-tailed p-value was found to be 0.550. In relation to the decision rule: When $p \leq \alpha$, null hypothesis is rejected. Therefore, since 0.550>0.05, the null hypothesis was accepted and concluded that gender interaction has no statistical significant effect on learners' academic achievement in gas laws.

The value of $R^2 = 0.013$, implied that, gender interaction contributed 1.3% variation in academic achievement which was the dependent variable. The implication is that 98.7% change in academic achievement was contributed by other factors which were not part of the model. These findings differ from several studies leaving a gap that needs to be addressed by further studies.

The findings from this objective further indicated that girls were slightly more active than boys in various classroom interactions. For instance; in relation to the students who raised their hands while in class, 55.3% were girls while 44.7% were boys. In relation to undertaking demonstrations in class, majority (68.4%) of girls were involved compared to 31.6% of the boys during experiments in gas laws. Majority of girls (53.8%) were involved in reading compared to 46.2% of boys.

Further, 58.3% of the girls were involved in other activities such as helping the teacher clear the board and helping the teacher carry apparatus to the laboratory store after class compared to 41.7% of the boys. Although carrying of chair and rubbing of board may not be directly linked to learning one can argue that, such activities shows the readiness of the learner to interact in many other classroom activities.

However, the results further indicated that there was an equal number (50%) of students who answered questions and asked questions in the class respectively. Additionally, respondents preferred to be taught by teachers of the same gender while, girls were found to be generally more active in class than boys. From this

study the teachers were trying to involve both genders equally while interacting with students which is an important factor since it increased students' esteem in both genders.

5.3 Conclusions

Based on the findings of this study it was revealed that, teacher-learner class talk (oral) interaction can be an effective teaching methodology to improve academic achievement of learners. The implication is that, class talk interactions enhances the quality of learning. This is supported by the fact that, when students are encouraged to interact actively through class talk, their level of motivation increase while their minds are stimulated making learning meaningful leading to higher academic achievement.

When teachers and learners are actively involved through oral interaction learning becomes interesting increasing the desire to seek more knowledge. Therefore, if teachers and learners use oral interaction effectively, the outcome would be quality teaching and learning leading to higher academic achievement. There was statistically insignificant relationship between written interaction and learners' academic achievement in gas laws among the secondary school learners.

Therefore, so long as the chemistry teacher explains the concepts well and involves the students through verbal and non-verbal interactions, they are likely to perform well in the Chemistry examinations. In addition, some of the learners may have good cognitive skills and prior knowledge and for this reason written interactions

like assignments may not be useful to them. It was also revealed that, teachers do not supervise the assignments, a situation where learners copy from text books or from their classmates. Teachers need to train the learners to seek for the answers like using collaborative learning so as to make the learning meaningful. Lack of marking of assignments by teachers also made the learners reluctant to aggressively seek for answers.

From the study non-verbal interaction had a positive and statistical effect on learners' academic achievement. Therefore, beside other interactive methods of teaching, chemistry teachers can make the lessons more effective through use of non-verbal interaction. Non-verbal behaviour like smiling, nodding, paying attention, friendly appearance to a learner increases the learners' desire to interact during the implementation of chemistry curriculum. Learners are therefore, motivated to learn by teachers who portray friendly non-verbal behaviour during instructions. However, most teachers were not consistent with non-verbal interaction.

The study revealed no statistical significant effect of gender interaction on learners' academic achievement. The implication of the study is that; with all other conditions remaining constant, academic achievement of learners is not affected by gender. This is probably due to the fact that chemistry teachers were ensuring that both genders equally participated in the classroom interactions during the instruction period. Therefore, the findings of the current study reveal a paradigm

shift in the teachers' and students' perception of learners' ability by gender. Hence, the perception of classifying particular subjects as belonging to certain gender is gradually changing. Therefore, the study concludes that irrespective of gender, students have equal chances of performing better in Chemistry in any classroom interaction. Finally the current study provide a highlight of interactive areas where pedagogical skills of teachers may be sharpened.

5.4 Recommendations

The following were the recommendations of the current study:

i. The department of Quality Assurance and Standards in the Ministry of Education and Kenya Institute of Curriculum Development need to use the findings of this study to improve the pedagogical skills of teachers.

ii. Since assignments were not taken seriously teachers should give challenging assignments, supervise and mark so as to identify the learners' strengths and weaknesses. This will ensure the learners get the skills of seeking knowledge on their own as well as the skills in writing.

iii. Teachers should continue to ensure that both genders are equally involved to promote equal opportunity in learning to eliminate gender stereotypes from learners. This is because negative gender-biased cultural beliefs are still deep rooted in some communities.

iv. Chemistry teachers need to use the new knowledge arising from this study to improve their pedagogical skills.

5.5 Suggestions for further research

The following suggestions were made:

i. There is need for similar studies to be done in different parts of the world to compare the findings.

ii. Further research to establish the perception of teachers on use of oral and non-verbal interaction as a tool to enhance students' academic achievement in Chemistry need to be conducted.

iii. Further research using different subjects and level of learners need to be carried out to establish if the findings would be similar to those of the current study.

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APPENDICES

Appendix I: Introduction Letter

University of Nairobi.

Department of educational Administration and Planning.

P.O Box 30197,

Nairobi.

12th January 2018

The principal,

_____Secondary School

Dear Sir/Madam,

RE: ASSISTANCE IN DATA COLLECTION

I am a doctorate degree student in curriculum studies at the University of Nairobi, conducting a research on: Effect of selected classroom interactions on learners' academic achievement in chemistry in public secondary schools in Murang'a County, Kenya.   Your school is among those targeted for this research study. I am kindly requesting for your assistance in collection of data. The study is purely for academic purposes and therefore confidentiality of the respondents' identity will be strictly observed. Your assistance in this endeavour will be highly appreciated.

Yours faithfully,

NEWTON MWANGI

APPENDIX II: PARTICIPANT CONSENT FORM

All participants in this research are advised to read the consent carefully and understand the contents before filling and signing.

Title of research study: Effect of Selected Classroom Interactions on Learners' Academic Achievement in Chemistry in Public Secondary Schools in Murang'a County, Kenya.

I…………......have agreed voluntarily to take part in this research study. Further, I understand that I can withdraw from this study at any time if I wish to, without any consequences and I can withdraw or have data collected from me deleted within three weeks after collection. The purpose of the data was explained to me in that I will not benefit directly from the outcome of this study, while I also understand that, this study is purely academic. This exercise will involve filling a questionnaire/ interview/focus group discussion/ being observed in the class during teaching and learning process for 80 minutes. I will also sit for a chemistry test for one hour whose marks will not be part of my continuous assessment tests, neither will the marks be revealed to anyone (Tick the appropriate one). Finally, my involvement in this study will remain confidential and this will be achieved by not writing my name on the research papers, changing my name and disguising my personal details.

Signed: Participant……………Witness: Newton Mwangi (Doctoral candidate, UoN)…………..Dated………………………

APPENDIX III: STUDENTS' QUESTIONNAIRE

SECTION ONE: DEMOGRAPHIC INFORMATION.

This questionnaire is entirely for the purpose of carrying out a study on educational matters. Put a tick (√) in the appropriate box provided. Do not write your name on this questionnaire.

a) Gender: Male ☐   Female ☐

B) Age. 15-20 yrs ☐   21-25 ☐   Above 25 yrs ☐

SECTION TWO

In a scale of 1-5 indicate the extent to which you agree with the statement in the Table below, where 1-strongly disagree, 2-disagree, 3-not sure, 4-agree and 5-strongly agree.

	STATEMENT	1	2	3	4	5
1	Our chemistry teacher is friendly while teaching.					
2	Different moods like anger, happiness in our chemistry teacher affect learning					
3	Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.					
4	Our chemistry teacher encourages us to appreciate others when they participate e. g. clapping					

5	We are given a lot of homework					
6	We report in class what we have done in our homework					
7	We cover part of the syllabus through homework					
8	Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications					
9	I enjoy asking questions during the Chemistry lessons					
10	I enjoy answering questions during the Chemistry lessons					
11	I prefer boy/boy, girl/girl interaction during learning.					
12	Respond to this item if you are a girl: I am shy to interact in a class where boys are present.					
13	Respond to this item if you are a boy: I am shy to interact in a class where girls are present.					
14	Respond to this item if you are a girl: I prefer interacting with male teachers during the teaching of Chemistry.					
15	Respond to this item if you are a boy: I prefer interacting with female teachers during the teaching of Chemistry.					

THANKS FOR YOUR COOPERATION

APPENDIX IV: LESSON OBSERVATION CHECKLIST

Section one (Demographic information).

This Checklist is entirely for the purpose of carrying out a study on educational matters. Put a tick (√) in the appropriate box provided. Do not write the school name on this questionnaire.

1. Category of school: Boys only ☐   Girls only ☐   Mixed ☐
2. Enrolment: Boys ☐   Girls ☐

Section two: Class talk.

The researcher will put a tick in the appropriate box as guided below.

In a scale of 5 indicate the extent to which each behaviour was used by the teacher where, 1 will indicate very weak behaviour, 2-weak, 3-moderate, 4-strong and 5 - very strong behaviour.

Teacher-student interaction	1	2	3	4	5
Teacher talk					
Indirect influence					
Accept feelings					
Praises or encourages					

Direct influence					
Ask questions					
Lectures					
Give directions					
Students talk					
Give reports					
Response to teacher's questions					
Ask a question					
Enquire or seek clarification					
Discussions					
Peer teaching					
Silence					

A Modification from Flanders Interaction Analysis Category System (FIACS)

Section Three: Nonverbal interaction:

The researcher will put a tick in the appropriate box as guided below.

In a scale of 1 to 5 indicate the extent to which each behaviour was used: 1= Highly Inconsistent, 2=Moderately Inconsistent, 3= Partially Consistent, 4= Moderately Consistent and5=Highly Consistent.

	Statement	1	2	3	4	5
1	Teacher maintenance of eye contact with the students when asking questions.					
2	Teacher shows a variety in gestures.					
3	When guiding learners, teachers' non-verbal behaviour motivates the participation of students.					
4	Teacher's non-verbal behaviour encourages when they accept ideas of learners.					
5	Teacher ensures variety in tone variation.					

Adapted and modified from: Noureen, Chaudhry and Manzoor (2012).

Section Four: Gender interaction

a) In the Table below put a tally when a boy or girl answers or ask a question, demonstrates an activity or reads something (Applicable to mixed schools).

Gender	Raises hand	Answers	Asks a question	demonstrates	Reads	Any other
Girl						
Boy						

Modified from FIACS

APPENDIX V: DOCUMENT ANALYSIS ON WRITTEN INTERACTION

This document is entirely for the purpose of carrying out a study on educational matters. The researcher will put a tick (√) in the appropriate box provided. The name of the school should not appear on this questionnaire.

Evidence of group assignment? Yes ☐   No ☐

Researcher to fill the Table below using a scale of 1-5 where 5 indicates excellent, 4- very good, 3- good, 2-poor and 1-very poor.

	Statements	5	4	3	2	1
1	Quality of assignments					
2	Nature of teachers' remarks					
3	Adequacy of assignments to engage learners in the learning process.					
4	Extent of marking of assignments by the teacher.					
5	Extent of reporting by the learners during learning					

APPENDIX VI: CQASOS' INTERVIEW GUIDE

The researcher introduces himself and mentions the purpose of the interview to the interviewee. CQASO is informed that, the interview was based on gas laws in Chemistry.

SECTION ONE

Demographic information

    a. Gender

    b. For how long have you been a CQASO in the county?

    c. Kindly mention the time period you have been involved in SMASSE in sets in Murang'a County?

    d. What is your professional qualifications?

    e. What were your teaching subjects before joining Quality Assurance Department in the Ministry of Education?

SECTION TWO

    a) During the assessment exercise were learners given adequate time to participate during teaching and learning through talking like answering of questions and discussions?

      If the answer is "yes", the researcher will enquire the nature of interaction.

      If the answer is "no" the researcher will enquire what could be the reason.

    a) Comment on the quality of questions, frequency of assignments and marking of assignments by the teacher and usefulness of assignments and note writing in the teaching of gas laws.

b) In your opinion, do you think non-verbal interaction like nodding and gestures during teaching and learning can improve academic achievement in chemistry in gas laws?

If the answer is "yes" the researcher will ask the CQASO to name at least three methods of non-verbal interaction that were commonly observed in class during assessments during the teaching of gas laws.

If the answer is "no" the researcher will enquire why CQASO holds such an opinion?

c) Were interactions in mixed schools affected by the presence of the opposite gender?

If the answer is "yes" the researcher will enquire the common behaviour that supports the "yes" answer.

APPENDIX VII: STUDENTS' DISCUSSION GUIDE

The researcher introduced himself and mentioned the purpose of the discussion to the learners and that the discussion focused on gas laws lessons only.

a) During the instructional process does your teacher encourage student-student and student-teacher interaction? If the majority answer "yes" the researcher will enquire the extent and nature of interaction.

b) Do you enjoy talking or interacting with the teacher and your class mates during the gas laws lessons? Whether yes or no, the researcher will probe to get an insight of the behaviour in question from the students.

c) Are you given assignments after the lessons in gas laws? Where the majority say "yes", the researcher will probe the common methods of marking used. Where the answer is "no", then the researcher will skip question (d) and proceed to question (e)

d) Does the teacher give challenging questions in gas laws? (The researcher will explain what the term "challenging" means).

e) How does your chemistry teacher encourage/make the class lively during teaching and learning using non-verbal means?

f) This question is applicable to learners in mixed schools:

    i)   Does the presence of girls/boys affect your participation in class?

    ii)   Do you prefer to be taught by a male or female teacher?

In part (i) and (ii), the researcher will enquire the reasons of each answer provided

Thank you for your cooperation

APPENDIX VIII: CHEMISTRY ACHIEVEMENT TEST

This test is entirely for the purpose of carrying out a research study on educational matters. Your name as well as the school name should not be written on the answer sheet.

Answer the following questions in the spaces provided. Time: 1 hour.

1. A fixed mass of gas has a volume of $230dm^2$ at -17^oC and 750mmHg. What is the temperature of the gas that would occupy $448cm^3$ at 770mmHg? (3mks)

2. A certain gas has a temperature of 10^0C, volume of $20\ dm^3$ and a pressure of 770mmHg. Calculate the volume occupied by the gas at standard temperature and pressure. (3mks)

3. A certain gas occupies a volume of $214cm^3$ at -27^oC and 710 mmHg pressure. Work out its pressure if it occupies a volume of 315 cm^3 and $170^0\ C$. (3mks)

4. (i) Differentiate between real and ideal gas (1mks)

   (ii) What is the importance of the ideal gas equation in gas laws? (1mk)

   (iii). Give the ideal gas equation. (1mks)

5. State Graham's law of diffusion. (1mks)

6. The molar masses of gas W and X are 16.0 and 44.0 respectively. Assuming the rate of diffusion of gas W through a porous material is $12cm^3s^{-1}$, what is the rate of diffusion of gas X through the same material? (3mks)

7. The relative rates of diffusion of gas P and Q are given in the ratio of 3:2 respectively. Given the relative formula mass of Q is 108g find the relative formula mass of P (3mks).

8. 100cm^3 of oxygen diffuses through a porous plug in 128 seconds while it takes 150 seconds for the same volume of gas to diffuse through the same plug under the same conditions. Calculate the molecular mass of X. (3mks).

9. A certain volume of Ozone (O$_3$) gas takes 96 seconds to diffuse through a given tube in 96 seconds. How long will an equal volume of carbon (IV) oxide take to diffuse under the same conditions? (O=16.0, C=12.0). (3mks)

(Total marks = 25 X 4=100 marks)

APPENDIX IX: ACHIEVEMENT TEST MARKING SCHEME (25MKS)

1. $\dfrac{750 \times 230}{256} = \dfrac{448 \times 770}{T_2}$ ………………..1mk

    $T_2 = \dfrac{448 \times 770 \times 256}{750 \times 230}$ ……………1mk

    $= 511.90$ K…1mk or 0.5119K where a student uses 230000cm^3

2. $\dfrac{770 \times 20}{283} = \dfrac{760 \times V_2}{273}$ …………………………………..1mk

    $V_2 = \dfrac{770 \times 20 \times 273}{283 \times 760}$ …………………………………….1mk

    $=19.55$dm^3 ………………………………………………………1mk   Or

    19550cm^3 or 19547 cm^3

    $\dfrac{710 \times 214}{246} = \dfrac{315 \times P_2}{290}$ …………………………………..1mk

    $P_2 = \dfrac{290 \times 710 \times 214}{246 \times 315}$ …………………………………………..1mk

    $=568.6$ mmHg…………………………………………………1mk

5. Under the same conditions of temperature and pressure, the rate of diffusion of gas is inversely proportional to the square root of its density.

6. $\dfrac{12}{R} = \sqrt{\dfrac{44}{16}}$ ………………………………1mk

    $\dfrac{144}{R^2} = \dfrac{44}{16}$ ………………………………1mk

    $R^2 = \dfrac{16 \times 144}{44}$ ………………………………1/2mk

R= 7.236 ………………………………..1/2mk

7. $\frac{RP}{RQ} = \sqrt{\frac{RMMQ}{RMMP}}$

$\frac{3}{2} = \frac{108}{RMMP}$………………………………..1mk

$2.25 = \frac{108}{RMMP}$……………………………1mk

RMM P= $\frac{108}{2.25}$………………………………1mk

=48………………………………1mk

8. RMM O_2=32…………………………1mk

$\frac{150}{128} = \sqrt{\frac{X}{32}}$ …………………………….1mk

X =1.37329 ×32…………………………..1mk

X=43.94 or 44……………………………..1mk

9. Rmm O3 =48…………………………1/2mk

Rmm CO2 =44………………………1/2mk

$\frac{96}{T} = \sqrt{\frac{48}{44}}$ …………………………………………1mk

$\frac{96}{T}$ =1.044466…………………………..1mk

T=91.91…….1mk. (Score X 4)%

APPENDIX X: SCHOOLS INVOLVED IN THE STUDY

		Category			
	Sub-County	**Boys**	**Girls**	**Mixed secondary**	**Total**
1	1.Mathioya	1.Kiru	1.Kamacharia	1.Kiriaini 2.Thuita	4
2	1.Kangema	1.Kangema	1.Kiangunyi	1.Kanyenyaini 2.Iyego	4
3	1.Kahuro	1.Kirogo	-	1.Kahuhia 2.Mukangu 3.Weithaga	4
4	Murang'a East	1.St. Paul	1.Gaturi	VidhuRamji	3
5	Murang'a South	1.Ichagaki	1.Nginda	1.Gathera 2.Kambiti	4
6	Kigumo	-	1.Kigumo	1.Muthithi 2.Kinyona	3
7	Kandara	1.Githumu	1.Ruchu	1. Charles Lwanga 2. Ngurweini 3. Mutheru 4. kariti	6
8	Gatanga	1.Kirwara		1.Gituamba	2
	Total	**7**	**6**	**17**	**30**

APPENDIX XI: FACTOR ANALYSIS

Descriptive Statistics

Elements	Mean	Std. Deviation	Analysis N
Our chemistry teacher looks very friendly while teaching	4.46	.675	360
Different moods like anger, happiness in our chemistry teacher affect learning	2.81	1.509	360
Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.	4.33	1.061	360
Our chemistry teacher encourages us to appreciate others when they participate like by clapping	4.24	1.032	360
We are given a lot of homework	3.59	1.028	360
We report in class what we have done in our homework	4.00	1.232	360
We cover part of the syllabus through homework	3.35	1.439	360
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications	4.59	.863	360
I enjoy asking questions during the chemistry lessons	4.12	2.948	360
I enjoy answering questions during the Chemistry lessons	4.12	1.157	360
I prefer boy/boy, girl/girl interaction during learning.	3.25	1.547	360
Respond to this item if you are a girl: I am shy to interact in a class where boys are present.	3.17	1.493	360
Respond to this item if you are a boy: I am shy to interact in a class where girls are present.	3.24	1.517	360
Respond to this item if you are a girl: I prefer/would prefer interacting with male teachers during the teaching of Chemistry.	3.60	1.317	360
Respond to this item if you are a boy: I prefer/would prefer interacting with female teachers during the teaching of Chemistry.	3.33	1.410	360

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.821
Bartlett's Test of Sphericity	Approx. Chi-Square	269.795
	Df	105
	Sig.	.000

Commonalities

	Initial	Extraction
Our chemistry teacher looks very friendly while teaching	1.000	.480
Different moods like anger, happiness in our chemistry teacher affect learning	1.000	.619
Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.	1.000	.359
Our chemistry teacher encourages us to appreciate others when they participate like by clapping	1.000	.518
We are given a lot of homework	1.000	.538
We report in class what we have done in our homework	1.000	.478
We cover part of the syllabus through homework	1.000	.421
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications	1.000	.308
I enjoy asking questions during the Chemistry lessons	1.000	.295
I enjoy answering questions during the Chemistry lessons	1.000	.489
I prefer boy/boy, girl/girl interaction during learning.	1.000	.543
Respond to this item if you are a girl: I am shy to interact in a class where boys are present.	1.000	.498
Respond to this item if you are a boy: I am shy to interact in a class where girls are present.	1.000	.445
Respond to this item if you are a girl: I prefer/would prefer interacting with male teachers during the teaching of Chemistry.	1.000	.358
Respond to this item if you are a boy: I prefer/would prefer interacting with female teachers during the teaching of Chemistry.	1.000	.561

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.063	13.750	13.750	2.063	13.750	13.750	1.512	10.083	10.083
2	1.324	8.824	22.574	1.324	8.824	22.574	1.487	9.911	19.993
3	1.245	8.303	30.877	1.245	8.303	30.877	1.427	9.511	29.504
4	1.157	7.714	38.591	1.157	7.714	38.591	1.267	8.446	37.950
5	1.121	7.473	46.064	1.121	7.473	46.064	1.217	8.113	46.064
6	.990	6.597	52.660						
7	.978	6.517	59.177						
8	.949	6.328	65.505						
9	.861	5.739	71.244						
10	.829	5.525	76.769						
11	.771	5.137	81.906						
12	.761	5.074	86.980						
13	.694	4.626	91.606						
14	.634	4.225	95.831						
15	.625	4.169	100.000						

Extraction Method: Principal Component Analysis.

Scree Plot
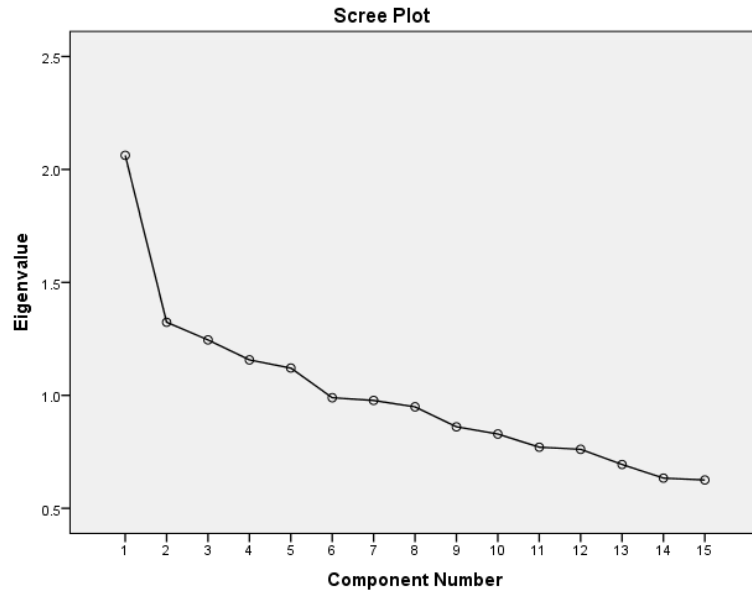
Component Matrix[a]

	Component				
	1	2	3	4	5
Our chemistry teacher looks very friendly while teaching	.578			-.347	
Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.	.546				
Our chemistry teacher encourage us to appreciate others when they participate like by clapping	.541				
I enjoy answering questions during the Chemistry lessons	.506		-.369		
We report in class what we have done in our homework	.481			.409	
I enjoy asking questions during the Chemistry lessons	.474				
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications	.420				
We cover part of the syllabus through homework	.403		.386		
Respond to this item if you are a girl: I am shy to interact in a class where boys are present.		.501		.440	
I prefer boy/boy, girl/girl interaction during learning.		.499		.459	
We are given a lot of work for homework		-.498		.427	
Respond to this item if you are a boy: I prefer/would prefer interacting with female teachers during the teaching of Chemistry.			.586		-.450
Respond to this item if you are a girl: I prefer/would prefer interacting with male teachers during the teaching of Chemistry.			-.495		
Respond to this item if you are a boy: I am shy to interact in a class where girls are present.		.448	.478		
Different moods like anger, happiness in our chemistry teacher affect learning		-.302			.667

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Rotated Component Matrix^a

	Component				
	1	2	3	4	5
We report in class what we have done in our homework	.680				
We are given a lot of homework	.559				
We cover part of the syllabus through homework	.548				
Our chemistry teacher always appreciates any answer that you give e.g. through nodding and facial expression.	.476				
Our chemistry teacher encourages us to appreciate others when they participate like by clapping		.686			
Our chemistry teacher encourages us to participate actively in class through talking, asking of questions and seeking clarifications		.513			
Respond to this item if you are a boy: I am shy to interact in a class where girls are present.					.400
Different moods like anger, happiness in our chemistry teacher affect learning			-.726		
I enjoy answering questions during the Chemistry lessons			.582		
I enjoy asking questions during the Chemistry lessons			.463		
Our chemistry teacher looks very friendly while teaching			.455		
I prefer boy/boy, girl/girl interaction during learning.				.706	
Respond to this item if you are a girl: I am shy to interact in a class where boys are present.				.651	
Respond to this item if you are a boy: I prefer/would prefer interacting with female teachers during the teaching of Chemistry.					.723
Respond to this item if you are a girl: I prefer/would prefer interacting with male teachers during the teaching of Chemistry.					-.537

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Component Transformation Matrix

Component	1	2	3	4	5
1	.589	.583	.536	-.155	-.048
2	-.480	.401	.300	.720	-.002
3	.187	.256	-.366	.137	.864
4	.618	-.384	-.085	.661	-.161
5	.073	.536	-.694	.039	-.474

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

APPENDIX XII: UNIVERSITY LETTER TO NCSTI

UNIVERSITY OF NAIROBI
COLLEGE OF EDUCATION AND EXTERNAL STUDIES
SCHOOL OF EDUCATION
DEPARTMENT OF EDUCATIONAL ADMINISTRATION AND PLANNING

Telephone: 020-2701902
Telegram: "CEES"
E-mail: dept-edadmin@uonbi.ac.ke

P.O. Box 30197-00100, NRB
OR P.O. Box 92-00902 KIKUYU

Our Ref: UON/CEES/SOE/A&P/1/3

December 20, 2017

The Secretary
National Commission for Science, Technology & Innovation
P. O. Box 30623 – 00100
NAIROBI - KENYA

Dear Sir/Madam

MWANGI NEWTON IRUNGU – E96/82441/2011

This is to certify that **Mwangi Newton Irungu** is a PhD student in the Department of Educational Administration and Planning, University of Nairobi. He is a fully registered student with the University.

Mr. Mwangi has successfully defended the proposal for his PhD thesis at the school and departmental level and will soon be proceeding to do his fieldwork. He is currently working on his research proposal titled *"Effect of Selected Classroom Interactions on Learners' Achievements in Chemistry in Public Secondary Schools in Murang'a County, Kenya"*. His area of specialization is Curriculum Studies.

Any assistance accorded him will be highly appreciated.

Thank you.

Yours faithfully

JEREMIAH M. KALAI, PhD
CHAIRMAN
DEPARTMENT OF EDUCATIONAL ADMINISTRATION AND PLANNING

JMK/rwn

APPENDIX XIII: RESEARCH AUTHORIZATION

**NATIONAL COMMISSION FORSCIENCE,
TECHNOLOGY ANDINNOVATION**

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/18/96302/20761**

Date: **26th January, 2018**

Newton Irungu Mwangi
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on *"Effect of selected classroom interactions on learners' academic achievement in chemistry in public secondary schools in Murang'a County, Kenya"* I am pleased to inform you that you have been authorized to undertake research in **Muranga County** for the period ending **26th January, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Muranga County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

G.P Kalerwa
**GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO**

Copy to:

The County Commissioner
Muranga County.

The County Director of Education
Muranga County.

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

APPENDIX XIV: NCSTI RESEARCH CLEARANCE PERMIT

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 17272

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. NEWTON IRUNGU MWANGI
of UNIVERSITY OF NAIROBI, 826-10200
Muranga, has been permitted to conduct
research in *Muranga   County*

on the topic: *EFFECT OF SELECTED CLASSROOM INTERACTIONS ON LEARNERS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN PUBLIC SECONDARY SCHOOLS IN MURANG'A COUNTY, KENYA*

for the period ending:
26th January, 2019

Permit No : NACOSTI/P/18/96302/20761
Date Of Issue : 26th January, 2018
Fee Recieved : Ksh 2000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation