LEGO-BRICKS-BASED INSTRUCTION AND ITS INFLUENCE ON STUDENT'S ACADEMIC ACHIEVEMENT IN CHEMISTRY IN SECONDARY SCHOOLS IN LAIKIPIA WEST SUB-COUNTY, KENYA

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DECLARATION

I declare that this thesis is my original work and it has not been presented for certification at any other university or institution. This thesis has been supplemented by publications that have been properly cited. Where content, statistics or tables are derived from other works – including the internet – the sources are properly cited in compliance with anti-plagiarism standards.

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DEDICATION

This work is dedicated to my lovely and supporting wife and Teachers and students from secondary schools where pilot and real study was conducted for their support, cooperation and quality time.

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ABBREVIATIONS AND ACRONYMS

ALT	Academic Learning Time
HOS	Head of subject
KCSE	Kenya Certificate of Secondary Education
KLB	Kenya Literature Bureau
KUCCPS	Kenya University and Colleges Central Placement Services
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
LEGO	Locally Enabled Globally Optimized
MG	Mean gain score
MOE	Ministry of Education
NACOSTI	National Commission for Science Technology and Innovation
SPSS	Statistical Package for Social Sciences
SDT	Self-determination theory
STEM	Science, Technology, Engineering and Mathematics

ABSTRACT

The performance in Chemistry has been lower than that Biology and Physics for several years. The low performance in Chemistry is contributed by inadequate understanding of chemical reactions. At form two, students struggle to understand chemical reactions due to their abstract nature. Chemistry textbooks have explained chemical reactions without any suggestion of resources to enhance understanding. This misunderstanding leads to incorrect chemical reactions, incorrect mole ratio and wrong reacting masses at form three. \The purpose of the study was to determine the influence of LEGO-bricks-based instruction on student's academic achievements in Chemistry in secondary schools in Laikipia West Sub-county. The study was guided by the following objectives; To determine the difference in performance between students taught using LEGO-bricks-based instruction and those taught, To assess the difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks. To correlate the motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks. The study was tested by following null hypothesis; H_0I; There is no statistically significant difference in performance between students taught using LEGO-bricks-based instruction and those taught using without LEGO-bricks. $H_0$2; There is no statistically significant difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks. $H_0$3; There is no statistically correlation between motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks. The significance of the study was to provide learners with hands-on skills that are offer solution to scientific challenges. LEGO-bricks-based instructional approach raises motivation and autonomy in learning that improves the performance in Chemistry. Improved performance in chemistry increases students' enrollments for scientific courses in universities and colleges. The study provides chemistry teachers with revolutionary instructional methods that enhance conceptualization and understanding of chemical reactions among other abstract concept in Chemistry. The study used quasi-experimental research design. Purposive technique of obtaining sample was used to select secondary schools, students and chemistry teachers to obtain the sample. Two secondary schools were Experimental group while the other two were control group. The study targeted thirty-two (32) Secondary Schools and 2749 students in form two in Laikipia West Sub County. The achievement tests were used to collect data on chemistry performance while students' motivation questionnaire was used to collect data on motivation to learn. The SPSS program version 25 was used to analyze the data. Research findings indicated that LEGO-bricks-based instruction improved motivation to learn raised learning interest, promoted comprehension of abstract concepts which improved their Chemistry performance. The general recommendation is that teachers of chemistry should be encouraged and supported to engage learners with instructional strategies that promote conceptualization and visualization hence increasing their motivation and performance in Chemistry

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

This chapter clarifies the study's background, statement of the problem, objectives, hypothesis, significance, limitations, theoretical framework, conceptual framework, and word definitions are all explained in this chapter.

Science and technology expertise is essential, vital, and required in all countries globally in terms of industrial growth and solutions for the challenges people are facing. A study done by Kallerud et al (2011) pointed out that global challenges such as pandemics, food security, public health, water, energy, and sanitation among others requires a sustainable solution. According to a study done by Hicks (2016), science and technology stand out as the main solution to the global challenges of the twenty-first century.

Locally Enabled Globally Optimized (LEGO) is a trademark for the LEGO Group of companies in Denmark, which manufactures and sells LEGO-bricks. LEGO-bricks-based instruction involves using LEGO-bricks as teaching and learning resources to facilitate learning.

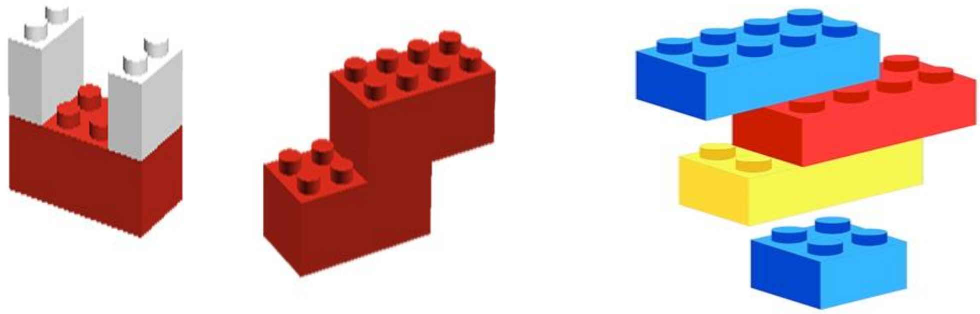


Figure 1.1 Example of Interlocking LEGO-bricks.

The integration of LEGO-bricks into educational settings has drawn a lot of interest lately because of its abilities to enhance learning experiences, foster creativity, and improve student engagement. Globally, studies have shown that LEGO-bricks, particularly through LEGO Education programs, foster the growth of critical thinking, problem-solving, and teamwork abilities in learning. These bricks are used in STEM education and allow scholars to engage in hands-on learning, helping to bridge theoretical concepts with practical applications. Few recent research supported this fact. Uses of LEGO-brick activities encourage active learning, creativity, and the use of information and abilities in practical situations (Nath and Wang, 2019). In particular, learners in STEM fields have demonstrated better academic performance when LEGO-bricks are incorporated into lessons.

LEGO-bricks-based instructional approaches have gained significant attention globally due to their potential to enhance learner motivation and performance. Studies have indicated that incorporating LEGO-bricks into learning activities can improve students' problem-solving skills, creativity, and engagement. For instance, research performed by Li et al (2015) showed that using LEGO-bricks in an engineering design-based approach significantly improved the performance of Grade four pupils in science and improved their problem-solving skills. The hands-on, interactive nature of LEGO-bricks aligns well with constructivist learning theories, which emphasize active learning and knowledge construction through tangible experiences.

In Africa, the adoption of LEGO-bricks in education has been explored as a means to address low student motivation and performance. Research conducted in South Africa by Govender and Subramaniam (2024) observed the positive effects of LEGO-bricks based activities on students' engagement and motivation. The study found that these interactive methods helped students better understand complex concepts and increased their overall academic performance. The study findings also highlighted that gamification of learning environments with LEGO-based activities enhanced students' engagement and reduce cognitive load, thereby improving learning outcomes.

Additionally, a review by Cirak et al (2018) emphasized the potential of blended learning approaches, which often incorporate LEGO-bricks, to enhance learning outcomes in African educational contexts. The study suggested that combining other teaching methods with LEGO-based activities can result in a more engaging and productive learning environment, particularly in STEM education.

In Nigeria, LEGO-bricks-based learning has been incorporated into extracurricular programs to enhance the STEM capabilities of learners. According to Adebayo and Adekola (2018), the use of LEGO-bricks in the classroom and after-school activities has helped Nigerian students develop spatial reasoning and collaborative skills, leading to improved academic performance.

In Kenya, the use of LEGO-bricks in education has been gaining traction, particularly in primary and secondary schools. A study conducted by KICD in 2022 examined the impact of LEGO-based learning on student motivation and achievement in science and arithmetic. The findings revealed that learners who participated in LEGO-based activities showed significant improvements in their problem-solving skills and overall academic performance compared to those who did not. One notable initiative is the "Hands on the Future: Kenya's Young Innovators" project, which incorporates LEGO-bricks to teach problem-solving and innovation in Kenyan primary and secondary schools (Mwangi, 2020).

According to Ochieng and Obara (2022), Kenyan schools that have introduced LEGO-based robotics programs have seen improvements in learners' attitudes toward STEM subjects. In these schools, students not only performed better in science and mathematics but also displayed higher motivation levels to participate in group activities. The use of LEGO-bricks in these cases has proven to promote learner autonomy, critical thinking, problem-solving, communication, and collaborative skills, fostering a more interactive and engaging learning environment.

The Kenyan government has stressed the importance of promoting science and mathematics in attaining industrialization and technological advancement by 2030. As a consequence, the Ministry of Education (MOE) has started offering teaching and learning resources to schools.

The Kenya curriculum was also developed by KICD to assist children develop a positive attitude toward science and mathematics, among other disciplines, thereby motivating them to achieve better results.

Out of three pure sciences offered in Secondary Schools in Kenya, Chemistry is one of the subjects that enable students to acquire knowledge and skills in problem-solving. According to Kenya Universities and Colleges Central Placement Service (KUCCPS) guidelines, the candidate is supposed to have at least a C+ (plus) in Chemistry at KCSE to enroll for Bachelor of Science programs and a C- (Minus) or C (Plain) in Chemistry for diploma of science programs.

Knowledge and skills acquired in Chemistry are useful in many areas of life, including food production, agriculture, health care, and industrial development, to mention a few (Twoli, 2006). As a consequence, effective Chemistry teaching and learning should be emphasized in order to provide learners with knowledge and skills essential for industrialization and technological advancement. Despite this, learners' performance in Chemistry has been consistently low throughout the years, with the mean score for Chemistry being lower than for Physics and Biology.

Table 1.1 National KCSE Performance in percentage for the three Sciences from 2015 to 2019

Year	**Physics**	**Chemistry**	**Biology**
2015	37.25	**23.91**	33.25
2016	34.18	**29.06**	30.42
2017	39.74	**32.11**	35.67
2018	38.20	**33.51**	36.97
2019	35.56	**31.87**	28.14

Source: KNEC report (2020)

Tables 1.1 represent national-level performance disparities in the three sciences from 2015 to 2019. According to data in Table 1.1, Chemistry performance has been lower than that of Physics and Biology for four years. Chemistry performance was dismally lowest in 2015. Low Chemistry performance is further confirmed by statistics in Table 1.2, which shows the mean score difference across the three sciences from 2015 to 2019.

Table 1.2 Laikipia West Mean score for sciences from 2015 to 2019

Subject/ Year	**Physics**	**Chemistry**	**Biology**
2015	5.06	**3.53**	4.40
2016	5.36	**4.17**	4.29
2017	4.79	**3.70**	4.27
2018	5.22	**3.94**	4.24
2019	5.74	**4.95**	4.37

Source: Laikipia West KCSE analyses (2020)

Table 1.2 displays the comparative mean scores for Chemistry, Biology, and Physics in Sub-County. It is apparent that the performance in Chemistry in the Laikipia west Sub-County was lower than that in Biology and in Physics. Table 1.2 also shows a downward trend in performance in Chemistry. Deviation in mean scores of Chemistry compared to other science subjects outlines the performance gap at the national level and Laikipia west sub-county.

The low performance in Chemistry is contributed by an inadequate `understanding of chemical reactions. A report by KNEC (2019) noted persistent weaknesses among candidates in understanding chemical reactions. Another report by KNEC (2020) noted that student struggles with stoichiometry and reaction mechanism. Chemistry textbooks at form two have explained chemical reactions without any suggestion of resources to enhance understanding. For this reason, concepts of chemical reactions which include writing and balancing chemical reactions have remained abstract. Due to the abstract nature of chemical reactions in Chemistry, students are unable to sufficiently conceptualize the chemical reaction process resulting in learners giving incorrect chemical equations in examinations. Misunderstanding of chemical reactions in form two translates to wrong mole ratio and mole calculations at form three.

To improve the performance in Chemistry, an instructional approach that promotes understanding and conceptualization of abstract concepts such as chemical reactions is required. Research performed find out whether use of LEGO-bricks-based instruction could bridge the low-performance gap in Chemistry.

According to a study by Kerstiensa et al. (2017), chemical equations can be made into an activity using blocks and molecular kits. The Blocks and molecular kits represented atoms which enabled learners to understand how reactant combines to form the products.

Interlockable LEGO-bricks are used to present particles of matter. They may be used to construct models of atoms, molecules, and compounds in a chemical reaction. Studies done by Hamon (2008) have shown that the usage of LEGO-bricks model helps students uncover creative connections between their learning experiences and generate new ideas. According to Gauntlett (2011), making models using LEGO-bricks, improves reflective thinking and visualization.

1.2 Statement of the problem

The global and national challenges such as pandemics, food security, public health, and industrialization among others require the knowledge of science and technology for sustainable solutions. Acquisition of knowledge and skills is therefore required to provide solutions to those challenges.

The students' performance in Chemistry at KCSE has been consistently low. As tabulated in tables 1.1 and 1.2 national and Laikipia West mean scores for chemistry has been below 7.0 which is C+ (plus). This prevents students from enrolling in chemistry-based courses at universities and colleges which provide students with knowledge and skills for future careers and scientific solutions to many challenges. To raise the performance in chemistry, an instructional approach that enhances understanding and motivates learners is required.

Ministry of Education (MOE) has been providing teaching and learning materials to improve learner's motivation and performance in chemistry. The ministry has also provided seminars for chemistry teachers to better their instructional methods and teaching abilities. Despite this, the performance of learners in Chemistry has not improved as expected. Instructional strategies that increase student motivation and elevate performance must be used to close the gap.

LEGO-bricks instructional approach has been used in many countries to encourage active learning in sciences and mathematics and also to improve learners' motivation and performance. LEGO-bricks have been used in Chemistry to represent atoms, molecules of reactants, and products in chemical reactions making the concept less abstract for the learners. In Kenya, LEGO-bricks have not been used adequately as teaching and learning resources to enhance understanding of chemical reactions. This study was conducted to investigate whether using LEGO-bricks-based instruction may influence students' academic achievement in Chemistry in secondary schools in Laikipia West Sub-county.

1.3 Purpose of the Study

Primary goal of this research was to investigate the influence of LEGO-bricks-instructional approach on students' academic performance in Chemistry in secondary schools in Laikipia West Sub-county.

1.4 Objectives of the Study

The research study was directed by the objectives below;

(a) To determine the difference in performance between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks

(b) To assess the difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

(c) To correlate the motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

1.5 Hypotheses of the study

During the investigation, hypothesis listed below were tested;

$H_0$1: There is no statistically significant difference in performance between learners who learned with LEGO-bricks-based instruction and those taught using without LEGO-bricks.

$H_0$2: There is no statistically significant difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

$H_0$3: There is no statistically correlation between motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

1.6 Significance of the Study

The study is aimed to improve understanding of chemical reactions. The study provides chemistry teachers with revolutionary instructional approach that improve conceptualization and understanding of chemical reactions. LEGO-bricks-based instructional approach enhanced learner's engagement in meaningful learning activities. The study provides valuable insights into LEGO-bricks instruction as innovative pedagogy that can be adopted by other chemistry educators to improve learning of abstract concepts in Chemistry. The study enabled Chemistry Teachers to embrace LEGO-bricks-based instruction to improve the motivation and performance of Chemistry in Laikipia County, Kenya and other Countries.

The students were able visualize the reacting atoms hence creating conceptualization and understanding of the chemical reactions. This helped students to write and balance chemical equations correctly resulting to correct stoichiometric coefficients and mole ratios which are applicable in determination of reacting masses. LEGO-bricks-based instruction made learning more interactive and enjoyable, increasing student motivation and interest in chemistry. Using LEGO-bricks as physical models, enabled students to better grasp abstract concepts, leading to improved comprehension and retention of chemical reaction improving their performance.

Improved performance in chemistry increases students' enrollments for scientific courses in universities and colleges. Use of LEGO-bricks-based instruction in chemistry benefit students by providing them with hands-on experiences and equipping them with skills such as collaborative skills as learners work together to build and understand models. The skills embraced are important in providing solution for various scientific challenges.

The study is aimed to enable Ministry of Education to acquire and facilitate secondary schools with LEGO-bricks as instructional tools to improve teaching and learning process in Chemistry. Focusing on Laikipia West Sub-County, the study addresses specific educational challenges and opportunities within this region, potentially leading to innovative and skilled students in providing solution to scientific challenges.

1.7 Delimitations and Limitations of the study

This section presents the deliberate choices made by the researcher in order to set boundaries for the study (delimitations) plus the characteristics of the study that influenced the interpretation of the findings (limitations).

1.7.1 Delimitations of the study

The research study was restricted to secondary schools in Laikipia west Sub-county in Laikipia County, Kenya, which might have limited the generalization of the findings to other regions. The research study focused specifically on Chemistry, so the results may not be directly applicable to other subjects. The study was limited to form two students only and their Chemistry teachers and therefore students from other classes and their chemistry teachers could not be incorporated in the study. The study was restricted to chemical reaction and the content under the study is in Form two Chemistry syllabuses. The study was confined to LEGO-bricks instructional approach in order to determine its influence on academic achievements. Students from experimental group (schools A and C) were limited to learning chemical reactions with LEGO-bricks-based instructional approach. Students from control group, (schools B and D) were limited to learning chemical reactions without LEGO-bricks.

1.7.2 Limitations of the Study

(i) The outcomes of this research were applicable to Laikipia west sub County and were not generalized to other sub counties.

(ii) The study limited itself to the use of LEGO-bricks-based instructional approach and to determine its influence on student's motivation to learn and Chemistry performance.

(iii) The research study duration had limited timeframe as indicated on work plan (appendix I) that might have not fully captured the long-term influence of LEGO-bricks-based instruction on students' academic achievement.

(iv) Students' self-reported motivation levels might be influenced by social-desirability bias, leading to inaccuracies in the data.

1.8 Scope of the Study

The study examined LEGO-bricks as instructional tool for learning reactions in secondary schools. The research focused on form two students and form two Chemistry instructors in Laikipia West Sub-County's high schools. The study explored how LEGO-bricks-based activities can be integrated into the chemistry curriculum and their influence on student's academic achievements which is mainly motivation and performance. The study involves collecting data on motivation to learn and performance in Chemistry. Data on motivation to learn chemical reactions using student’s motivation questionnaires while data on performance was collected using achievement tests, pre-test and post-test to evaluate the usefulness of instructional method. The research is conducted over a specified academic period, allowing for the observation of both immediate and short-term effects of the instructional approach.

1.9 Assumptions of the Study

During the research, the following assumptions were made:

It was assumed that Chemistry teachers from experimental group (school A and C) used LEGO-bricks-based instructions consistently while Chemistry teachers from control group (school B and D) facilitated learning of chemical reactions without LEGO-bricks as outlined in the study’s guidelines. This assumption was made to ensure a consistency in Teaching Methodology:

It was also assumed that Form two Students respondents were truthful when filling out the motivation questionnaires and students and Chemistry teachers from the selected secondary schools cooperated well during the study

Chemistry Teachers from school A and C that were involved in use of LEGO-bricks during the study were assumed to have undergone adequate training (appendix F) on the use of LEGO bricks as instructional tools in teaching and learning chemical reactions.

To ensure Homogeneity of the students' sample, it was assumed that the students selected for the study come from similar socio-economic backgrounds and have comparable prior knowledge in chemistry.

1.10 Theoretical Framework

The study was based on two theories: constructivism and self-determination. According to the constructivism theory by Brunner (1996) and Piaget (1980), learners develop knowledge in their minds by active learning, interactions with their environment, and prior experiences. Therefore learning is an active process. When a learner is given LEGO-bricks and instructions, he or she may build models of reactants and products based on their ideas, which helps them learn and grow as a person. It was established by Piaget (1980) that a student may learn well when they are actively engaged in process of learning. Piaget's philosophy of constructivism emphasizes on students' interaction as a way of learning.

Making LEGO-bricks models is a conceptual exercise that builds knowledge. When students are engaged with educational resources like LEGO-bricks, they develop new ideas, discoveries, and experiences as a consequence of the interaction process between themselves and the educational materials.

A learner-centered approach is supported by constructivism theory, which emphasizes on engagement as part of the learning process. Learners who use LEGO-bricks acquire valuable hands-on experience such as arranging, classifying, and handling the bricks as part of their education. The learner develops an understanding of the chemical reactions that lead to the formation of new substances. Visualizing and conceptualizing chemistry helped the learner establish a good attitude about writing and balancing chemical equations.

People's motivation to learn is a key component of self-determination theory simply because they have an intrinsic desire to do so. According to Ryan and Deci (2000) the theory builds a concept of freedom seeing students as self-directed, determined, and self-guided agents.

Self-determination is a reflection of the essential human ability to organize and guide behavior toward certain objectives or learning outcomes. Students' self-determination and autonomy in learning raise their learning interest and improve their concentration and attainment of set learning objectives. Chemical reactions may be better understood when students are more interested in the subject matter and more engaged in the learning process. LEGO-bricks-based instruction may improve students' motivation, conceptualization, and understanding of chemical reactions raising their chemistry performance. The goal of this study was to determine whether LEGO-bricks-based instruction may influence motivation of learners and chemistry performance in secondary schools in the Laikipia West Sub-county.

1.11 Conceptual Framework of the Study

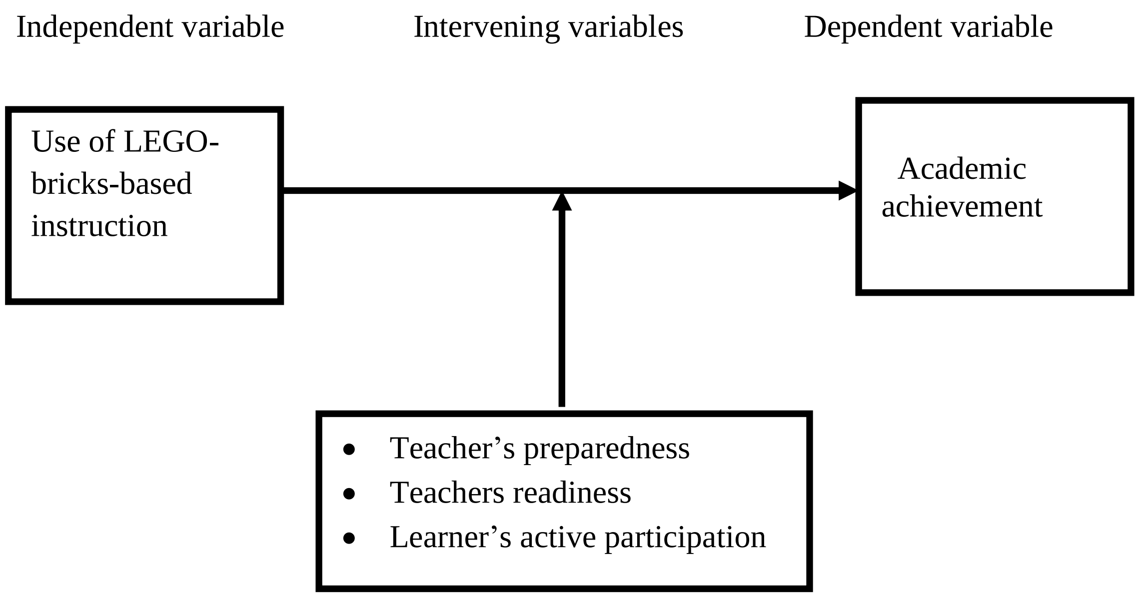


Figure 1.2 Conceptual Framework of the Study

Source: Researcher's construct

Structure of conceptual framework Figure 1.3 outlines the correlation between independent variables, dependent and intervening variable. Use of LEGO-bricks-based instructional approach is independent variable. LEGO-bricks-based instruction represents a pedagogy that was used by chemistry teachers in experimental group (schools A and C) in teaching and learning chemical reactions. In the experimental group, students learned chemical reactions using LEGO-bricks-based instruction, while in the control group; students learned chemical reactions without LEGO-bricks. Dependent variable was student's academic achievements. As the arrow from independents to dependent variable on the framework diagram suggest, employing LEGO-bricks-based instruction has the ability to influence performance of learners. Students' academic achievement depends on the instructional methods used.

Intervening variables mediate the relationship between LEGO-bricks-based instruction and academic achievement. The intervening variables were teacher's preparedness, teacher's readiness and learner's active participation. Teachers needed adequate training to ensure their readiness and effectiveness in using LEGO-bricks in teaching learners chemical reactions. Teacher's preparedness was managed by conducting training (appendix F) for chemistry teachers from schools A and C on teaching and learning using LEGO-bricks.

Students' active class participation was controlled by chemistry teachers who ensured learners had access to LEGO-bricks and worked in manageable groups. Student's active participation was also controlled by the school administrators and class teachers who ensured that none of the students was sent out for fees during the study hence students had very good lesson attendance. All Intervening variables were controlled in order to ensure they did not interfere with student's academic achievements.

Arrow connecting intervening variable to independent and dependent variables suggest the mediating factors that could have influenced student's academic achievement when controlled not properly controlled. When chemistry teachers are not well-inducted on use of LEGO-bricks-based instruction they lack adequate skills and confident to use LEGO-bricks in learning chemical reactions. The presence of learners and their readiness to learn could have affected their performance. When students are organized in groups and well monitored in class, they are actively involved in class.

According to the researcher, instructional methods used by teachers were considered a significant factor in whether or not students could understand chemical reactions.

1.12 Operational Definition of Terms

Abstract concepts:	Concepts and ideas that are challenging to the learners.
Achievement test:	It's a test given to students to gauge their comprehension of the concept they've just studied before or after study.
Conceptual understanding:	It refers to a student's capacity to explain or apply what they have learned in various contexts.
LEGO-bricks-based instruction	Use of LEGO-bricks as teaching and learning to enhance conceptualization of chemical reactions in chemistry.
Motivation to learn:	Students self-drive and desire to learn more as results of understanding an abstract concept like chemical reaction.
Stoichiometry:	Writing and balancing of chemical reaction to determine the mole ratio and masses of the reactants and products (Brown, 2013).
Visualization:	It is a student's capacity to visualize an abstract concept and to create a clear mental picture.

Academic learning time	Time spent by students in active learning
LEGO-based robotics programs	They are programs that incorporate the use of LEGO products such as LEGO-bricks, LEGO-Robots and LEGO-based Robotics competitions

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

2.1 Introduction

The chapter entails literature reviewed on the influence of the use of LEGO-bricks-based learning on student's academic achievement. The literature is organized into the following objectives; the influence of LEGO-bricks-based learning on motivation to learn, the influence of LEGO-bricks-based learning on performance, relationship between motivation to learn and performance. The chapter finishes with description of the gaps appearing in the literature review.

2.2 Influence of LEGO-bricks-based Instruction on Performance

Various studies have suggested that LEGO-bricks-based instruction positively influences academic performance particularly in Chemistry and other Science Subjects. The hands-on, engaging nature of LEGO-bricks activities helps students understand complex concepts and fosters a positive attitude towards learning. The hands-on learning experience provided by LEGO-bricks allows students to develop critical thinking, problem-solving, and conceptual understanding, all of which contribute to improved academic outcomes. Research study done by Smith and Jones (2010) demonstrated that learners who were engaged with LEGO-bricks-based lesson confirmed better intellectual capacity of molecular structures compared to those who learnt with conventional approaches. The hands-on nature of LEGO-bricks allowed students to visualize and manipulate models of molecules, leading to improved comprehension and retention.

LEGO-bricks have also been used to enhance learning in other Science Subjects. Brown et al (2015) did a research on use of LEGO-based Robotics on physics Education. Their findings indicated that students who engaged in LEGO-based Robotics projects demonstrated a significant improvement in problem-solving skills and conceptual understanding of physics principles.

Subang's (2018) research study compared LEGO-bricks with traditional ball-and-stick models for teaching and learning molecular chemistry among secondary school students. The results demonstrated comparable effectiveness between the two methods. LEGO-bricks accessibility among students raised academic performance and spatial reasoning. Furthermore, the tactile interaction with LEGO-bricks fostered a more engaging and enjoyable learning experience, positively influencing student motivation to learn. A systematic review by Zendy (2020) revealed that LEGO-bricks-based teaching and learning materials effectively support diverse educational needs for conceptual understanding of abstract concepts. These teaching and learning materials are adaptable for illustrating molecular structures, chemical reactions, and principles of periodicity. The study emphasized the importance of aligning LEGO-bricks-based activities with learning objectives to maximize their pedagogical skills.

In related research, Pazos, (2019) conducted a study involving middle school students in Spain, focusing on impact of LEGO-bricks on performance in biology. The study revealed that students who participated in LEGO-bricks-based learning outperformed their peers who learned with conventional methods in terms of understanding and retaining key concepts. The researchers attributed this improvement to the active learning environment facilitated by LEGO-bricks, where students could visualize abstract scientific concepts and apply them practically.

Comparative studies have shown that LEGO-bricks-based instruction can be more effective than traditional teaching methods. Williams and Black (2018) compared the performance of students in a biology course who used LEGO-bricks-based models to their counterpart who learnt with other pedagogies. The study revealed that the learners who used LEGO-bricks-based instructional approach outperformed the control group.

A study conducted by Kahn and Ross (2020) in Kenya examined the impact of LEGO-bricks instruction on students' performance in physics. The results indicated that students who engaged with LEGO-bricks in constructing physical models of physics phenomena showed significant improvement in test scores compared to those taught via lecture-based methods. The study concluded that LEGO-bricks-based instruction promotes deeper conceptual understanding, allowing students to close the knowledge gap existing between theory and practical application.

A study conducted by Akinsola and James (2021) revealed use of LEGO-bricks in learning science and mathematics and significantly enhanced students' performance. The study highlighted that the hands-on activities provided by LEGO-bricks improved knowledge of scholars in problems solving.

When LEGO-bricks are employed in Chemistry Education, they promote visualization of abstract concepts, such as molecular structures and chemical; reactions. Students can physically construct chemical models, enhancing their understanding of spatial relationships and chemical bonds. According to Bonomi (2022), LEGO-bricks-based instructional approach provides immediate feedback as students assemble models, improving both accuracy and engagement in learning activities. Such methods simplify complex topics and abstract concepts making them accessible even to younger students, fostering an intuitive understanding of chemical processes.

2.3 Influence of LEGO-bricks-based learning on motivation

Motivation, according to Brown (2007), is an internal urge, drive, feeling, or desire that propels a person to take a specific activity. Martin (2003) defines learning motivation as a student's propensity, vigor, and drive to learn, work efficiently, and accomplish his or her set targets. Motivating the learner to learn is an important key to curriculum implementation because motivation is an influential factor in teaching and learning process. Success and performance of the learner largely depends on whether the learner is motivated or not (Mayuri, 2021). A research performed by Bakar (2014) indicated that motivation stimulate learner think, concentrate and study effectively. Motivation increases with increase performance of a learner. Learning is an active process which requires a participative role. It influences the desire to learn, retention of what the student learn and the content covered within a given time (Mayuri, 2021). He also documented that when students are not motivated well, they learn very little with difficulties in understanding. Students are not able to concentrate in a lesson.

The use of LEGO-bricks as instructional resources in science education has gained popularity over the past years because of to its ability to raise motivation to learn and enhance learners' engagement, particularly in STEM subjects. The hands-on nature of LEGO-bricks fosters active learning, creativity, and collaboration, which are crucial in maintaining student interest and motivation in science education. Several studies have shown that incorporating LEGO-bricks into the learning process significantly increases student enthusiasm and motivation to learn. For instance, Kaberman and Dori (2015) conducted a study in Israel using LEGO-bricks as instructional tools to teach chemistry concepts to secondary school students. They found that students who engaged with LEGO-bricks-based learning demonstrated higher levels of motivation compared to those who learned using conventional methods. The study noted that the interactive and playful nature of LEGO-bricks made the learning process enjoyable, thus sustaining students' intrinsic motivation and enthusiasm to learn.

Wang et al. (2017) investigated the effects of LEGO-bricks-based activities in Taiwan on student engagement in physics lessons. The study findings showed a positive correlation between LEGO-bricks use and increased motivation, with students expressing higher levels of interest in the subject matter. The study concluded that using tangible and manipulable objects like LEGO-bricks helps demystify complex scientific concepts, thereby fostering a more motivating learning environment.

Research has consistently shown that LEGO-bricks-based instruction increases student engagement and motivation. Garcia and Lee (2020) reported that students involved in LEGO-bricks-based projects were more enthusiastic and participated more actively in class discussions. This increased learner's engagement which is linked to higher academic performance and a deeper interest in learning of science subjects.

Additionally, in a cross-cultural study in South Africa, Otieno and Serem (2019) reported that the use of LEGO-bricks in the classroom enhanced both intrinsic and extrinsic motivation among middle school students. The study emphasized that LEGO-bricks offered a non-threatening and stimulating platform for students to experiment their scientific ideas, making them more eager to participate and learn.

Another research study conducted by Ryan and Deci (2009) highlighted that learners' involvement is related to their motivation because motivation is an important determinant of conceptual understanding. When learners are engaged in classroom activities, they learn better and develop learning interest. According to study by Glynn and Koballa (2006), motivation has been pointed out as an important factor in Science Education in determining student’s levels of understanding. They also found out that motivating student toward learning of science makes learning more effective in attainment of learning outcomes. In LEGO-bricks-based instruction, students learn chemical reaction using interlockable LEGO-bricks. Through interaction, they interlock them to represent atoms, molecules, reactants and products. This interactions and hands-on skills promote learning interest engaging learners with learning activities which raises their motivation to learn hence better academic performance

According to Cavas, (2011) learning motivation arouses learning behavior, motivation learner and promotes construction of learner’s conceptual understanding. Longitudinal studies provide insight into the long-term effects of LEGO-bricks-based instruction on student motivation. Harris and Thompson (2021) followed a cohort of students over three years and found that those who were exposed to LEGO-bricks based learning in their early years of science education maintained higher levels of motivation and interest in science subjects compared to their peers who did not have the same exposure.

As stated by Rizwan et al (2015) drive to learn Science has a significant role in determining pupils' performance. Teaching and learning activities are important such that they increase learners’ motivation and help them to reflect positively on the learning process (Hyland, 2003). Therefore use of proper teaching and learning resources gives a reason to the students to learn better because it increases their interests.

Cavas (2011) conducted a study to identify the different motivational factors that positively or negatively affect student performance in science. In the study, it was found out that, learner’s motivation plays a central role in learning of science which enables a learner to construct conceptual understanding. The study also highlighted that intrinsic motivation had a stronger impact on students' science performance than extrinsic motivation. This increase students desire to learn and to develop self-confidence. The uses of LEGO-bricks instruction enhance motivation by engaging learners with learning activities and conceptualization of reactants and products which promote understanding. Motivation is a significantly important factor for academic learning performance across childhood.

As stated by Ryan and Deci (2009), learners who are inspired at all their studies perform poorly in examinations and obtain low grade point average (GPA). Low performance in chemistry in national and Laikipia West Sub County (Table 1.1 and 1.2) may be attributed by instructional methods that does not motivate learners and promote their learning interest. This study focused on bridging the motivational and performance gap using LEGO-bricks based instruction.

2.4 Relationship between Motivation and Performance

In educational psychology, the relationship between academic achievement and motivation to learn is well-established. Motivated learners are more likely to be actively involved in process of learning, exert effort, and persist in challenging tasks, which ultimately leads to better academic performance. The use of LEGO-bricks-based learning appears to influence both motivation and performance, and these two factors are closely interrelated.

Deci and Ryan (2017) found that self-determination theory (SDT) confirmed that motivated students those who find joy and satisfaction in learning perform better academically. The incorporation of LEGO-bricks-based learning in science has been shown to satisfy students' needs for autonomy, competence, and relatedness, all of which are critical components of motivation according to SDT. A Study conducted by Lindgren and Foreman (2022) in Sweden found that students who were highly motivated by the interactive and exploratory nature of LEGO-bricks-based learning exhibited higher performance in physics and chemistry. The researchers noted that motivation and performance were mutually reinforcing, as students who experienced success with LEGO-bricks activities were further motivated to engage with the material.

Johnson and Miller (2019) conducted a case study in a middle school setting, where LEGO-bricks were used to teach basic principles of chemistry. According to the survey, students were more enthusiastic to participate in lesson and had a stronger desire to continue their scientific education. The hands-on activities provided a break from traditional lecture-based teaching, making learning more dynamic and interactive.

Furthermore, a meta-analysis conducted by García et al (2023) reviewed some studies across various countries and found a strong positive correlation between motivation fostered through LEGO-bricks-based instruction and improved academic performance in STEM-based subjects. The study emphasized that LEGO-bricks allowed students to build confidence in their abilities by providing a playful and low risk environment for experimentation, which in turn led to enhanced performance outcomes.

In South Africa, Otieno and Serem (2019) echoed these findings by reporting that motivation took a significant interceding role in the correlation between use of LEGO-bricks in learning and performance in science subjects. They postulated that students who were more motivated by LEGO-bricks instruction not only participated more actively in class but also achieved higher grades in science assessments.

As documented by Glynn and Koballa (2007), students who are motivated in learning science are more likely to achieve their set target goals. In their study, they emphasized that learners who are motivated to study have more chances to meaningfully engage in the education process and have a deeper comprehension of their subject matter.

Cavas (2011) highlighted that motivation plays a key role in studying science, which allows students to build conceptual understandings of the subject matter. The study noted that motivation is increased by using LEGO-bricks teaching, which involves students in learning activities, encourages the conceptualization of abstract concepts and improves their performance.

The hands-on nature of LEGO-bricks-based instruction encourages active participation and critical thinking. As students collaborate on constructing chemical models, they develop soft traits for example teamwork, communication, and solution to scientific problems. These skills are crucial in STEM disciplines. Bonomi (2022) reported that classroom discussions and collaborative projects using LEGO-bricks stimulated curiosity and facilitated deeper learning, creating a more interactive classroom environment.

LEGO-bricks-based instruction has demonstrated significant potential in enhancing chemistry education. By providing a tactile and engaging platform for learning, LEGO-bricks-based instruction facilitates the visualization of abstract concepts, fosters student engagement, and nurtures critical skills. While challenges remain, particularly regarding cost and accessibility, the advantages of LEGO-bricks based pedagogy is that it is learner centered and learner remain active throughout the lesson. Further research and investment in cost-effective, scalable solutions could expand its impact, ensuring broader accessibility and inclusion in classrooms globally.

2.5 Gaps Existing in Literature Review

Rizwan et al (2015) did a research in Pakistan on learner's motivation and performance in science. Their study showed that motivated students performed better than those who lacked motivation. Their study did not focus on LEGO-bricks instructional tools and chemistry as subjects.

A study by Mayuri (2021) in India on motivation in learning showed that learners' academic achievement depends on motivation. The study focused on specific motivational factors in various educational settings. The study did not focus on abstract concepts and specific instructional methods.

In England a study conducted by Chrissi and Craig (2014) indicated use of LEGO-bricks-based learning in Arts enhanced the visualization of abstract concepts and the discovery of new ideas through reflection. Their study was limited to arts subjects and did not focus on Chemistry.

Kerstiensa et al (2017) performed a study in America about untangling kinetics through tangible and visual representation of matter in Chemistry indicated that those learners who used model blocks and molecular kits to learn chemical reactions had better performance. Their study did not focus on the use of LEGO-bricks.

In china, a study done by Hyland (2003) on motivation in learning showed that learning activities increased learner's motivation to learn and to reflect positively on the learning process. Their study did not focus on LEGO-bricks-based learning as instructional tools.

Wang et al (2017) explored the influence of LEGO-bricks-based activities on student engagement in physics lessons. Their study emphasized on physics and not chemistry. In addition, they did not focus on students' performance.

Pazos et al (2019) conducted a study involving middle school learners in Spain, focusing on the effect of LEGO-bricks on performance in biology. Their study was confined to middle school learners and strictly on performance. Their study emphasized on biology.

In South Africa, a study conducted by Otieno and Serem (2019) emphasized in relationship between motivation and performance. They reviled that use of LEGO-bricks played a significant role on motivation and improved performance in science subjects. Their study did not focus on chemistry as a subject.

This study focused on LEGO-bricks-based learning and whether if may influence student's motivation and performance in Chemistry in Secondary Schools in Laikipia West Sub-county.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter entails research design, variables, study locale, target population, sampling methodologies, size of the sample, piloting to guarantee reliability and validity of the research tools, methods of gathering data and the instruments, analysis of data, and finally ethical considerations.

3.2 Design of the Study

As defined by Creswell (2014), Research design is the strategic framework or blueprint that outlines how a research study will be conducted. There are various research designs; Descriptive design, Experimental, Correlational, Quasi-Experimental, Case Study Designs, Longitudinal and Cross-Sectional Designs and Mixed Methods Designs (Creswell & Creswell, 2018).

The research study was performed using quasi-experimental design, specifically pre-test and post-test approaches. As explained by Shadish et al (2002), Quasi-experimental design is used in Science Education to evaluate the effects of an intervention without the use of random assignment. This research design was used because random assignment of groups was impractical and impossible. Control groups and Experimental groups were similar, homogeneous and of equal ability in terms of academic performance table 3.2. Quasi-experimental design enabled the researcher to compare the motivation and performance of the two independent groups in pre and post-test to draw conclusion. Experimental groups learned chemical reactions using LEGO-bricks-based instruction while control groups learned using without LEGO-bricks as clarified in Table 3.1.

Table 3.1 Research design

School A and C	Experimental group	**0_1**	X	**0_3**
School B and D	Control group	**0_2**	$\otimes$	**0_4**

- **0_1** and **0_2** represent the pre-test.
- **0_3**and **0_4** represent the post-test
- **X** indicates **intervention** and $\otimes$ indicates **no intervention**.

Experimental group consisted of students from school A and C while control group were students from school B and D. A similar pre-test was undertaken by students from control group and experimental groups at the beginning of the research to determine their entry behavior in term of mean score. After the pre-test, students in the experimental group learned chemical reactions using LEGO-bricks-based instruction while those in the control group did not get any intervention; instead, they learned chemical reactions without LEGO-bricks. Experimental group and control group were finally subject to the post-test to determine the difference in motivation and performance.

3.3 Variables

Variables are features, attributes and quality of an individual that can vary or take on different values, and is often studied to determine its relationship with other variables in educational research (Creswell, 2014).

Three variables make up the study: independent, intervening, and dependent variables. To find out how the independent factors affect the dependent variable, the researcher manipulates the independent variables.

3.3.1 Independent variables

As explained by Orodho (2005) independent variable is the variable that influences the dependent variables. LEGO-bricks-based instruction was independent variable. In the experimental group, scholars learned chemical reactions with LEGO-bricks-based learning, while their counterpart learned chemical reactions without LEGO-bricks.

3.3.2 Intervening variables

As defined by Gay et al (2009) intervening variables are aspects that intermediate the relationship between the two main variables of any study. Cohen et al (2011) on the other hand documented that an intervening variable is a third variable that is positioned between dependent variable and independent variables and accounts for the connection between the two variables. The intervening variables of the study were teacher-related, student-related, and school-related characteristics. Teacher-related characteristic was teachers' preparedness to teach chemical reactions using LEGO-bricks as instructional tools. Teacher preparedness to teach was managed by conducting special training (Appendix F) for Chemistry teachers from Experimental group schools A and C on use of LEGO-bricks as teaching and learning resources for enhancing conceptualization of chemical reactions. Another intervening variable was students-related characteristics that involved students' lesson attendance and students' active participation in class. Student's lesson attendance was controlled by the school administration which ensured that none of the students was sent out for fees during the study. Students' active participation was controlled by chemistry teachers who ensured learners had access to the LEGO-bricks.

3.3.3 Dependent variables

As according by Fraenkel et al (2019) dependent variables are what the scholar intend to measures during the study. It is the effect or outcome that is expected to change as a result of manipulating the independent variables. The dependent variable was academic performance of a learner. Use of LEGO-bricks-based instruction influenced academic achievement which is mainly students' motivation to learn and performance in Chemistry. According to the researcher, instructional methods used by teachers were considered a significant factor in whether or not students could understand chemical reactions.

3.4 Location of the Study

Location of study refers to the geographical or institutional context in which the research is carried out, offering a structure for gathering and analyzing data (Ary et al 2019). The research was carried out in Laikipia West Sub-County in Laikipia County, Kenya. Laikipia West Sub-County is one of five sub-counties in Laikipia

County. Laikipia West Sub-county is located about 23 kilometers from Nyahururu on the way to Malaral and 60 kilometers from Nanyuki on the way to Rumuruti. The researchers choose the locale because of reasons bellow;

(i) No study of this kind had been carried out in Laikipia West Sub-county.

(ii) The performance of Chemistry has been very low in previous years.

(iii) The researcher has a clear understanding in geographical location of secondary schools.

(iv) Most Secondary schools were accessible in terms of better roads which enabled convenience of research.

3.5 Target Population

According to Johnson and Christensen (2020), the target population is the group from whom the sample is taken and to which the researcher hopes to generalize the study's findings. Data for target population was obtained from Laikipia west Sub county Education office authorized by sub county director of Education. The study targeted all public secondary schools in Laikipia West Sub-County, which contains 32 secondary schools and 2749 form two students. Twenty nine (29) of those secondary schools were public while three (3) were private. Out of 2749 Students in Form Two, one thousand, five hundred and seventy (1570) were boys while one thousand, one hundred and seventy nine (1179) were girls. The study targeted all the thirty two (32) Secondary schools, seventy six (76) Chemistry

Teachers and two thousand, seven hundred and forty nine (2749) Form two students. The key rationale for selecting Form Two learners is because the concept of chemical reactions is studied at form two Chemistry syllabuses. In addition, Form Two is not a National Examination class.

3.6 Sampling techniques and sample size

Sampling is defined as the procedure used to choose a part of the population to represent the whole population in research (Cohen et al 2018). There are five sampling methods according to Orodho (2003) namely, systematic sampling, cluster sampling, purposive sampling, stratified sampling, and simple random sampling. The study used purposive sampling technique. Purposive sampling is a non-probability sampling technique in which the investigator chooses individuals according to particular traits or specific qualities that align with the purpose of the study, ensuring the sample characteristics relevant to the study (Orodho 2003).

A purposive method of collecting sample was used to select Four (4) Secondary schools of the same ability in terms of academic performance (table 3.2) where two (2) Secondary schools were Boy's Secondary schools while the other two (2) were Girl's Secondary schools. Two (2) schools (schools B and D) formed the Control group, whereas one (1) school for boys and one (1) school for girls (schools A and C) formed the Experimental group. To choose one class, the purposeful sampling technique was used in cases where Secondary school sampled contained more than one Form Two Stream. That one class was selected based on academic performance which was compared with school performance at KCSE. In every school selected, only one class was involved in the study. Using purposive sampling, Chemistry subject teachers from selected classes were selected. Chemistry teachers for those sampled classes were retained to avoid interfering with timetabling and other school programs. The study sample involved Form Two students because the concept of chemical reactions is learned at form two.

Table 3.2 Sample School characteristics

School	School Category	Students Gender	Class Enrolment	KCSE Mean Score
A	**Extra-county**	Boys	51	**5.127**
B	**County**	Boys	43	**4.974**
C	**County**	Girls	47	**5.030**
D	**Extra-county**	Girls	49	**5.097**
Total			**190**	

Source: CSO Office, Laikipia West Sub-County (2020)

A total of one hundred and ninety (190) students formed students sample from four (4) secondary schools. Each and every secondary school had one chemistry teacher which formed a total of four chemistry teachers. Chemistry teachers and students formed total of one hundred and four (194) respondents. According to Kothari (2004), a good sample meets the criteria of efficiency, dependability, and representation of the whole population. The sample size chosen was sufficient to generalize the population's findings (Creswell, 2002).

3.7 Research instruments

Those are structured tools or techniques applied in data collection to ensure reliability and validity in research outcomes (Johnson and Christensen 2020). The tools used in the study were Achievement Tests and Students' Questionnaires.

3.7.1 Achievement tests

Achievement tests were used to collect data on the performance in chemistry for experimental and control groups. Pre-test (Appendix A) was applied to determine the learner’s achievement before the study. Questions for the pre-test were obtained from previously covered content to determine students' entry behavior. Post-tests (Appendix B) were used to determine the learner’s achievement after study. Post-tests were given to independent groups after treatment to determine the deviation in chemistry score form pretest.

3.7.2 Students' Questionnaire

Students' Questionnaires (Appendix C) were used to collect data on student's motivation to learn Chemistry in experimental and control groups. Students questionnaires was developed using both positive and negative responses. Positive responses were coded using a five-point Likert scale: strongly agree (1), agree (2) unsure (3), disagree (4), and strongly disagree (5). Negative responses were developed with reverse coding using a five-point Likert scale: strongly disagree (1), disagree (2), unsure (3) agree (4), and strongly agree (5). Both positive and negative responses were used to ensure balanced responses and respondent feelings on motivation to learn chemical reactions. Students were not restricted to positive or negative responses which eliminated biases.

3.8 Piloting Study

According to Muasya and Mulwa (2023), a pilot study is a small-scale preparatory investigation carried out prior to the main research to assess the project's viability, time, cost, risk, and unfavorable outcomes. It ensures that the primary study will be carried out efficiently by helping to improve the research design and methodologies. Pilot studies merely increase the likelihood of success, but they do not ensure that researchers will be successful in the main study (Berg 2008). The researcher conducted Piloting study in one public mixed secondary school in the Laikipia West sub-county. The secondary school chosen was not part of the sample schools. Piloting study was done to test the research instruments in order to ensure research tools are valid and reliable for use.

3.9 Validity of research instruments

According to Cornell (2024), research validity is the degree to which a study measures what it is supposed to measure. Validity confirms the credibility and reliability of the findings. Internal validity, construct validity, content validity, criterion validity, external validity, face validity, and statistical conclusion validity are the several forms of validity that each focus on distinct facets of the study process. The study adopted both Construct validity and Content validity for the achievement tests. The degree to which theory and evidence back up the interpretations of test results for the suggested applications of tests is known as construct validity (Fraenkel et al., 2019). On the other hand Polit & Beck (2021) defined content validity as the degree in which a measurement tool effectively samples domain of interest and represents the intended content area. Head of subject (HOS) for chemistry and other two chemistry teachers from the pilot school assessed the achievement tests and ensured they were valid. It was found out that the content achievement test was appropriate to the level of form two chemistry learners and was in line with chemistry syllabuses. The university supervisors also had a great input in ensuring that the achievement test used for data collection instruments portrayed content validity. Discussion with fellow chemistry teachers also contributed to the content validity of the questionnaires and interview schedule.

3.10 Reliability of the Research Instruments

Reliability, according to Kombo and Tromp (2006), is a gauge of how consistently test results are obtained. Reliability, as explained by Mugenda and Mugenda (2003), is a measure of how consistent study outcomes will be following repeated trials. As documented by Kimberlin and Winterstein (2008), there are various types of Reliability in Scientific Research Methods namely; Inter-Rater Reliability, Parallel-forms, Internal Consistency, Split-Half Test-Retest, and Intra-Rater reliability. The study adopted Test-Retest Reliability for student's motivation questionnaires. Bolarinwa (2015) explained that

Test-retest reliability determines the consistency of outcomes obtained by administering the same test to the same sample at several intervals. High test-retest reliability indicates stability over time.

Students' motivation questionnaires were subjected to a reliability test one week after the validity of the achievement test was established. Students' motivation questionnaires were retested over a whole week to verify their Consistency.

Twenty five students from one Secondary school that wasn't included in the real study were involved in pilot testing to answer the questionnaires and their responses were recorded. After one week the students were given similar questionnaires to fill and their responses were recorded. The results were compared with Cronbach's Alpha Factor using the formula below.

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum SDt^2(1)}{SDt^2}\right)$$

Where α = Reliability

$\sum SDt^2$ = Sum of the variance of individual item in the questionnaire

SDt^2 = Variance of the entire questionnaire

K = Number of the items in the questionnaire

Reliability analysis results obtained from two consecutive trials indicated that (α) value was equal to 0.852. This value is higher than the generally accepted coefficient of 0.7 in social science research. The test-retest reliability findings indicated that motivation questionnaires were reliable.

3.11 Data collection procedure

Study permission was acquired from (NACOSTI) (appendix G) which allowed investigator to visit the sample secondary schools after receiving clearance from the Kenyatta University Graduate School (Appendix H). It was necessary to make an appointment for a pilot study with the HOS, teachers, and students in that Secondary school. The researcher came to pilot school on the agreed-upon day to verify the validity of the achievement tests. The researcher reported to pilot school on another mutually agreed-upon day to administer the questionnaires to the students and assess their reliability. One month was allotted for the pilot study. To begin the main research, each secondary school was given a pre-test and students completed motivation questionnaires to determine the entry mean. Afterward, the researcher presented a motivation questionnaires and post-tests to the same schools to determine whether instructional methods affect their motivation and performance.

3.12 Data analysis

According to Pallant (2020), data analysis is the methodical process of looking over, classifying, and analyzing unprocessed data in order to extract valuable insights, identify patterns in testing hypotheses. It is a critical step in research that ensures data is used effectively to determine the objectives and test hypotheses.

Qualitative and quantitative data were the two categories of data gathered from the study (table 3.3).

Table 3.3 data analysis techniques per objective

Objective	Research Instrument	Type of Data	Data Analysis Technique
Objective 1: To determine the difference in performance between students taught using LEGO-bricks-based instruction and those taught.	Achievement tests	Quantitative	Means, T-Test and Gain-score analysis
Objective 2: To determine the difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught.	Student's Questionnaires	Quantitative	Means, T-Test and Gain-score analysis
Objective 3: To correlate the motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.	Achievement test and Student Questionnaire	Quantitative	Means, Gain-score analysis

Quantitative data on student's motivation to learn Chemistry was obtained from closed-ended students questionnaires where student's responses were coded into Likert scale. Quantitative data on Chemistry performance was obtained from achievement test in form of student's scores in pre-test and pot-test. Quantitative data collected from the research instruments was examined using the statistical package for social sciences (SPSS) version 25 to produce descriptive and inferential statistics. Descriptive statistics involved the determination of the mean score and gain-score for the two independent groups. Inferential statistics were conducted using Levene's independent sample t-Test to compare the motivational and performance means of experimental and control group. This was conducted to ascertain whether the two independent groups have any statistical significant variance. It was observed that the groups were homogeneous having the same ability before the start of the study.

Inferential statistics also involved the use of Gain Scores analysis in hypothesis testing. Gain-score analysis refers to statistical technique that quantifies the change in scores between pre and post-test (Becker, 2015). This method entails subtraction between the two tests for each learner to obtain the gain-score.

$$\text{Gain Score} = \text{Post-test Score} - \text{Pre-test Score}$$

The impact of a treatment or intervention is then assessed by analyzing these gain scores. A positive gain-score in analysis denotes an improvement, whereas a negative gain score denotes a decline. Research in psychology and education frequently employs this technique to assess the efficacy of initiatives or therapies (Becker, 2015). Gain Score analysis is done to evaluate the improvement (or gain) in students' performance or motivation by comparing the two test scores. Analyzed gain scores was applied in determining the magnitude of improvements for independent groups and its statistical significance the data was presented using tables and graphs.

3.13 Ethical and Logistical Considerations

The respondents were instructed not to disclose any information about the schools, teachers, or students for confidentiality. Students used admission numbers on the achievement tests and questionnaires for easy identification and recording. Confidentiality of data was also maintained by guaranteeing the sample school administrator that results obtained from achievement tests were to be used with confidentiality and for data analysis only. Their students or teachers personal information was not to be made public in any way. Any other information obtained from sample schools or respondents remained strictly secret.

CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION, AND DISCUSSION

4.1 Introduction

This chapter discusses statistical analysis and interpretation of data acquired from the two research instruments; student's questionnaires and achievement tests. It outlined the entire data collection process, instruments used, interactions with participants, and results obtained from the fieldwork. The following null hypotheses served as the foundation for the research study's findings:

(a) There is no statistically significant difference in performance between students taught using LEGO-bricks-based instruction and those taught using without LEGO-bricks.

(b) There is no statistically significant difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

(c) There is no statistically correlation between motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

4.2 Demographic information

The demographic data represented outlines the return rate for data collection instruments and proportion of respondents in both Experimental and control group

4.2.1 Research instrument return rate

Both the experimental and control groups comprised 190 students in total who did achievement tests and filled out questionnaires to provide the required data. Data obtained in pre-test for motivation to learn and performance was analyzed followed by data in post-test for motivation and performance. Table 4.1 shows the research instrument return rate.

Table 4.1 Research instrument return rate in percentage

School	students enrolments in pre-tests	students enrolments in post-tests	Percentage return rate
School A	51	51	**100%**
School B	43	43	**100%**
School C	47	46	**97.87%**
School D	49	49	**100%**
Total	**190**	**189**	**99.47%**

The number of learners who did the post-test and filled motivation questionnaire in school C was 46 out of 47. One student was unwell and absent. This translated to a 97.87% percent instruments return rate. A total of 189 students out of 190 students in four schools did the post-test and filled out motivation questionnaires. This translated to an overall return rate of 99.47% percent in four schools.

4.2.2 Proportions of the respondents per Group

The respondents of the study involved two independent groups. Experimental group was made up of ninety eight (98) students from two secondary schools, fifty one (51) boys from school A and forty seven (47) girls from school C. Control group was made up of ninety two (92) students from two secondary schools, fifty three (43) boys from school B and forty nine (49) girls from school D. Frequency and percentage of the respondents in each group were calculated and the results were represented in form of a Pie-chart (Figure 4.1). As a result, there was homogeneous representation because the independent groups had equivalent and similar features in terms of participation rates.

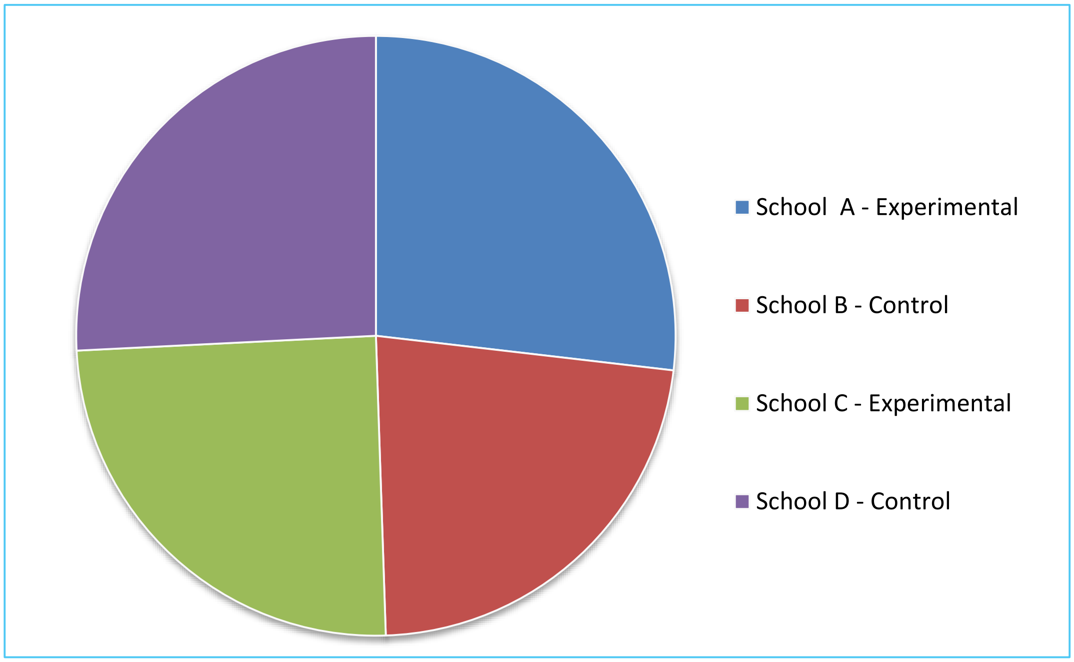


Figure 4.1 Proportions of the Respondents per Group

4.3 Students responses on Questionnaires

During the study, a trend in student's responses on motivation questionnaire was noted. Both Control and Experimental groups of learners were provided with questionnaires before the study began (pre-test) and after the study (post-test).

4.3.1 Student's responses on pre-test questionnaires

The data for motivation to learn was collected using students questionnaires. The total number of respondents was one hundred and ninety (190) students. Experimental group school A and C had ninety eight (98) students while control group school B and D had ninety two (92) students. At the initial stage of the study, learners from both independent groups were given questionnaires to fill in order to determine their initial level of motivation to learn. Questionnaire had negative and positive statement with reverse coding which reduced responses bias and prevented halo effect. Negative statements determined level of demotivation and misunderstanding of chemical reactions. The positive statement assessed their level of motivation and appreciation on learning of chemical reactions. Table 4.2 shows students' response rate on likert scale.

Table 4.2 Pre-test questionnaire responses in percentage

		Responses				
Statement description	**Group**	**SD %**	**D%**	**U%**	**A%**	**SA%**
Positive Motivation to learn chemical reaction *(Enjoyed learning Chemistry)*	Experimental	33.2	45.8	0.9	9.2	10.9
	Control	32.1	31.4	1.7	19.5	15.3
Negative Motivation to learn chemical reaction *(Find difficulties in learning Chemical reaction)*	Experimental	4.5	5.2	2.3	51.1	36.9
	Control	3.3	6.8	1.4	45.2	43.3

From the students responses on the (pre-test) questionnaires (table 4.2), 79% of the learners in experimental group and 63.5% in control group testified that they didn't not enjoy learning of Chemistry. Students who reported that they were motivated in learning chemistry were 20.1% from experimental group and students and from 34.8% control group. On the other hand, 87.7% of the students in experimental group and 88.5% in control group agreed that they were demotivated and hand difficulties in learning chemical reactions. Those who disagreed with their counterpart that they were not demotivated and had no difficulties were 10.1% of learners in control group and 9.7% of learners in experimental group. Student's responses obtained from the pre-test questionnaire clearly indicate that the concept of chemical reaction is abstract to students. Students in both experimental and control group were found to have the same challenges and equal strength at the beginning of the study.

4.3.2 Student's responses on post-test questionnaires

After learning chemical reaction using LEGO-bricks-based instruction in Experimental group and without LEGO-bricks in control group, students from both were given post-test questionnaires to fill in order to determine their level of motivation to learn. Students rated their motivation to learn using on likert scale. Table 4.3 shows students' responses in percentage.

Table 4.3 Post-test questionnaire responses in percentage

Statement Description	Group	Responses SD %	D%	U%	A%	SA%
Positive Motivation to learn chemical reaction *(Enjoyed learning Chemistry)*	Experimental	6.4	1.0	3.3	49.6	39.7
	Control	12.2	29.7	2.0	32.5	23.6
Negative Motivation to learn chemical reaction *Find difficulties in learning Chemical reaction)*	Experimental	36.6	37.0	3.3	10.5	12.6
	Control	23.2	35.9	4.5	17.5	18.9

From table 4.3 student's responses on the post-test questionnaires, 86.3% of the scholars in experimental and 56.1% in control group reported that they did enjoyed learning of chemical reactions and that they were positively motivated. Response indicated that students in experimental group who learned using LEGO-bricks-based instruction enjoyed and loved chemistry more as compared to students in control group who learned chemical reactions without LEGO-bricks. Learners who said they weren't inspired to learn chemical reactions and found some difficulties in learning chemical reactions were 23.1% in Experimental group and 36.4% in control group. The number of students who experienced difficulties was found to be slightly higher in control group that learnt chemical reactions without LEGO-bricks.

4.4 Data analysis

The data that was obtained from collection instruments was analyzed as per the following objectives;

(a) To determine the difference in performance between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks

(b) To assess the difference in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

(c) To correlate the motivation and performance for students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

4.5 Performance analysis

In order to determine the difference in performance in Chemistry between groups that were experimental and control in order to accomplish the first goal, an accomplishment exam was given to independent groups. Pre-test was administered to determine the entry behavior. Post-tests were used to evaluate students' achievements.

4.5.1 Performance analysis for achievement pre-tests

Students in both groups were tested before the research began. The analysis was done to determine homogeneity in performance for independent groups. Pre-test was given to all students in four secondary schools before the study and scores were recorded. As indicated in Table 4.4, pre-test scores were analyzed using Levine's independent sample t-test.

Table 4.4 Performance analysis for achievement pre-tests by mean score

Learning approach	N	Mean	SD	Df	t-value	ρ-value
Experimental	98	45.08	13.62	188	1.764	.079
Control	92	41.77	12.14			

From Table 4.4, t-calculated (1.764) was less than t-critical (1.962) which indicated that the difference in mean for the experimental group (M =45.08) and control group (M=41.77) was not statistically significant. The disparity in the mean for the two independent groups was also compared using p-value calculated. Since the calculated P-value (.079) was higher than the threshold of significance (α=0.05), the observed difference in means was not statistically significant. From the findings, the experimental and control groups. From the outcomes, the two independent groups were homogeneous and comparable.

4.5.2 Performance analysis for achievement post-tests

Post-test scores obtained from achievement tests were analyzed to determine the difference in the group's performance. The mean for post-test and pre-test for experimental and control groups was compared using an independent t-test (Table 4.5).

Table 4.5 Performance achievement post-tests mean score

Learning approach	N	Mean	SD	df	t-value	ρ-value
Experimental	99	49.57	15.07	189	2.138	.034
Control	92	45.29	12.29			

The findings in Table 4.5 revealed that the t-calculated (2.138) was higher than the t-critical (1.962) which indicated that the difference in the mean was statistically significant for both the control group and the experimental group. The observed difference in mean for Experimental and control group was also compared using p-test. Since the P-value (.034) obtained after calculation was lower than the threshold of significance (α=0.05), the observed difference in means was statistically significant. From the findings, mean for experimental group was greater compared to the control group.

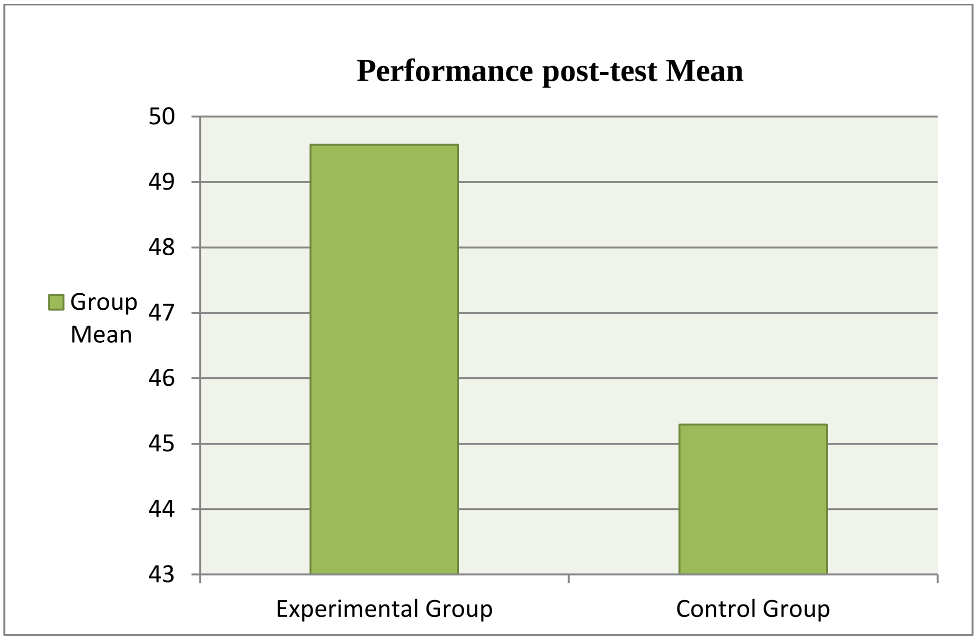


Figure 4.2 Performance post-test mean for the Groups.

Achievement post-test findings (figure 4.2) indicated the mean score of the experimental group (M = 49.57) was higher than the mean score of the control group (M = 45.29). Thus, students from schools A and C who learned chemical reactions using LEGO-bricks-based instruction teaching performed better than those in schools B and D, who learned without LEGO-bricks.

4.5.3 Performance Mean gain scores

To test the first hypothesis, the performance disparity for the experimental and control groups was determined using gain-score. Performance mean gain-score is the change between mean for performance post-test and mean for performance pre-test (table 4.6).

Table 4.6 Groups Performance Mean gain scores

Test	Scale	Group	
		Experiment	**Control**
	N	**98**	**92**
Pre-test	Mean	45.08	41.78
	N	**97**	**92**
Post –test	Mean	49.57	45.29
	Mean gain score	**4.49**	**3.51**

The Performance the mean for investigational group in pre-test mean was (45.08) while performance mean for investigational group in the post-test mean was (49.57). The difference in mean translated to the experimental mean gain-score of (MG =4.49). The pre-test performance mean for the control group was (41.78), while the post-test performance mean for the control group was (45.29). The mean difference translated to mean a gain-score of (MG =3.51) for the control group.

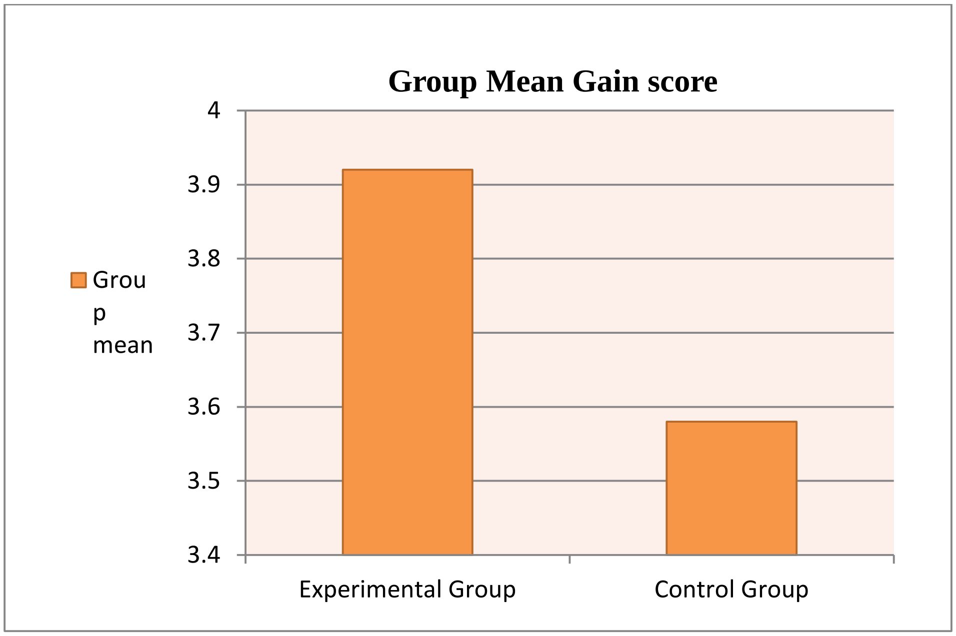


Figure 4.3 Performance Mean gain scores for independent groups

As indicated on bar graph on figure 4.3, learners in the experimental group had a higher mean gain score (MG = 4.49) than those in the control group (MG = 3.51). It was discovered that experimental students who learned chemical reactions using LEGO-bricks-based instruction outperformed control group of students who learned the same concept without LEGO-bricks. Differences in performance was be attributed by difference instructional methods. Those findings did not support the first hypothesis that stated that no statistically significant variation in Chemistry performance between learners learnt chemical reaction using LEGO-bricks-based instruction and those learned without LEGO-bricks. This hypothesis was therefore rejected.

The study conducted by Kahn and Ross (2020) indicated that students who were engaged with LEGO-bricks in constructing physical models showed significant improvement in test scores compared to those taught via lecture-based methods. Their findings support this study because experimental students who learned chemical reactions using LEGO-bricks-based instruction outperformed control group of students who learned without LEGO-bricks. Research study done by Smith and Jones (2010) supported this study in their highlight that learners who learned with LEGO-bricks-based activities confirmed better comprehension of molecular structures compared to those who received traditional instruction. The hands-on nature of LEGO-bricks allowed students to visualize and manipulate models of molecules, leading to improved comprehension and retention.

Experimental group of students (school A and C) were exposed to LEGO-bricks as a teaching and learning tool. They could visualize chemical reactions internalizing reactants and products. They were able to conceptualize the steps involved in chemical reactions, writing and balancing chemical reactions. Control group of students did not have that opportunity and therefore the level of understanding concept of chemical reaction remained low contributing to their low performance in chemistry.

A study conducted by Zendy (2020) supported these findings. The study revealed that LEGO-bricks-based teaching and learning materials effectively support diverse educational needs for conceptual understanding of abstract concepts. These teaching and learning materials are adaptable for illustrating molecular structures, chemical reactions, and principles of periodicity. The study emphasized the importance of aligning LEGO-bricks-based activities with learning objectives to maximize their pedagogical value. Chrissi and Craig (2014) also in their study, they discovered that using the LEGO-bricks model aids students in discovering the creative connections between their educational experiences and the emergence of new ideas. The study explained that students who built models using LEGO-bricks enhanced their reflective thinking through visualization of their ideas. Pazos et al (2019) also supported these studies. They documented that students who participated in LEGO-bricks-based learning outperformed their peers who learned with conventional methods in terms of understanding and retaining key concepts. The study associated this improvement to the active learning environment facilitated by LEGO-bricks, where students could visualize abstract scientific concepts and apply them practically. In a study conducted by Williams and Black (2018) also supported the findings of this study. They conducted comparative studies on LEGO-bricks-based instruction against traditional teaching methods on performance of biology. The study revealed that the learners who used LEGO-bricks-based instructional approach outperformed the control group that learnt without LEGO-bricks.

The research findings for Chemistry Performance indicated that use of LEGO-bricks-based instruction approach enhance active engagement of students with LEGO-bricks and visualization of chemical reactions. The hands-on, interactive nature of LEGO-bricks aligns well with constructivist learning theories, which emphasize on active learning and knowledge construction through tangible experiences. Students were able to create mental pictures of atoms, molecules, reactants and products which improved visualization, conceptualization and understanding of chemical reactions. They understood the abstract concepts that improved their performance. The hands-on and engaging nature of LEGO-bricks activities helps students understand complex concepts and fosters a positive attitude towards learning. The hands-on learning experience provided by LEGO-bricks allows students to develop critical thinking, problem-solving, and conceptual understanding, all of which contribute to improved academic outcomes.

4.6 Motivation analysis

In order to find out the difference between the two instructional methods on motivation to learn Chemistry as per the second objective, Experimental and control groups of learners were given closed-ended questionnaires to collect data for motivation. The experimental group learned using LEGO bricks while their counterpart learned without LEGO-bricks. Thereafter, the data on motivation to learn was evaluated.

4.6.1 Motivation pre-test analysis

Before the start of the research, the mean for pre-test for both independent groups was compared using the t-test to establish the similarity and homogeneity of the independent groups. To begin a study with homogenous groups, a researcher used pre-testing to ensure this. In addition, the findings of the pre-test enabled researcher in drawing reliable and unbiased conclusions at the end of a research study (Lavanya-Kumari, 2013). During the pre-testing phase, learners were required to rate their motivation as per guidelines in questionnaires.

In order to compare the mean for motivation to learn before the study, an independent sample t-test was used to compare the mean for learners in the experimental and control groups (Table 4.7).

Table 4.7 Differences in groups pre-test motivational mean score.

Scale	Group	N	Mean	SD	Df	t-value	ρ-value
Motivation to learn Chemistry	Experimental	98	3.49	0.44	188	1.563	.120
	Control	92	3.39	0.40			

From Table 4.7, t-calculated (1.562) was less than t-critical (1.962) which indicated that the difference in mean for the experimental group (M =3.49) and control group (M =3.39) was not statistically significant. The mean difference for the two groups was also compared using p-test. Given that the computed P-value (.120) exceeded the significance level (α=0.05), it was concluded that the observed difference in means was not statistically significant. From those findings, the motivation to learn chemistry between the experimental and control groups was similar and therefore groups were comparable.

4.6.2 Motivation post-test analysis

When students learned chemical reactions using LEGO-bricks-based instruction and without LEGO-bricks for control group, a post-test analysis was undertaken using group statistics to determine whether there was a positive gain score in motivation to learn. In both groups, the differences in post-test motivation mean are shown in Table 4.8.

Table 4.8 Difference in motivation post-test mean scores

Scale	Group	N	Mean	SD	Df	t-value	ρ-value
Motivation to learn Chemistry	Experiment	97	**3.92**	**0.29**	188	6.010	.000
	Control	92	**3.58**	**0.46**			

The results in Table 4.8 showed that t-calculated (6.010) was higher than t-critical (1.962) which indicated that the difference in the control group's mean and the experimental group's means were statistically significant. The disparity in mean for the Experimental and control group was also compared using p-test. Since the arithmetically computed p-value (.000) was lower than the threshold of significance (α=0.05), the observed difference in means was statistically significant. The experimental group of students with a mean of (3.92) had higher improvement on motivation to learn compared to a control group with a mean of (3.58) figure 4.4

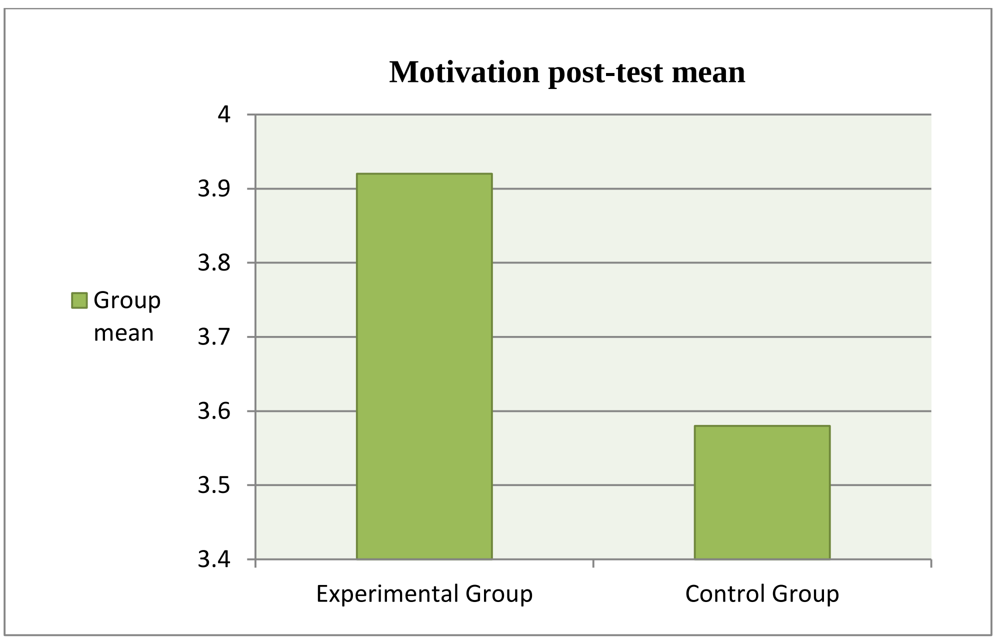


Figure 4.4 Motivation post-test mean for the Groups.

The difference in motivation for the two groups is also clear on graph in fire 4.4. Learners who were exposed to LEGO-bricks based instruction enjoyed learning and their motivation was higher compared to learners who had no exposure to LEGO-bricks

4.6.3 Comparison of students' Motivational Mean gain scores.

To test the second hypothesis, the mean gain score for motivation to learn for both independent groups was computed. Motivational Mean gain-score is the difference between motivation post-test and pre-test mean. The mean gain score for the two group was determined independently.

Table 4.9 Difference in groups motivation mean gain scores

Test	**Scale**	**Group**	
		Experiment group	**Control group**
	N	**98**	**92**
Pre-test	Mean (max = 5)	3.49	3.39
	N	**97**	**92**
Post –test	Mean (max = 5)	3.92	3.58
Mean gain score		**0.43**	**0.19**

The pre-test mean for the experimental group was (3.49), whereas the post-test mean was (3.92), as indicated in Table 4.9. This translated to a mean gain score of (MG = 0.43). Control group's pre-test mean was (3.39) while control group's post-test mean was (3.58). This translated to a mean gain score of (MG = 0.19). From the analysis, experimental group learners had higher motivational gains compared to those in control group. The difference in the mean gain score for the independent groups is also presented in figure 4.5 below.

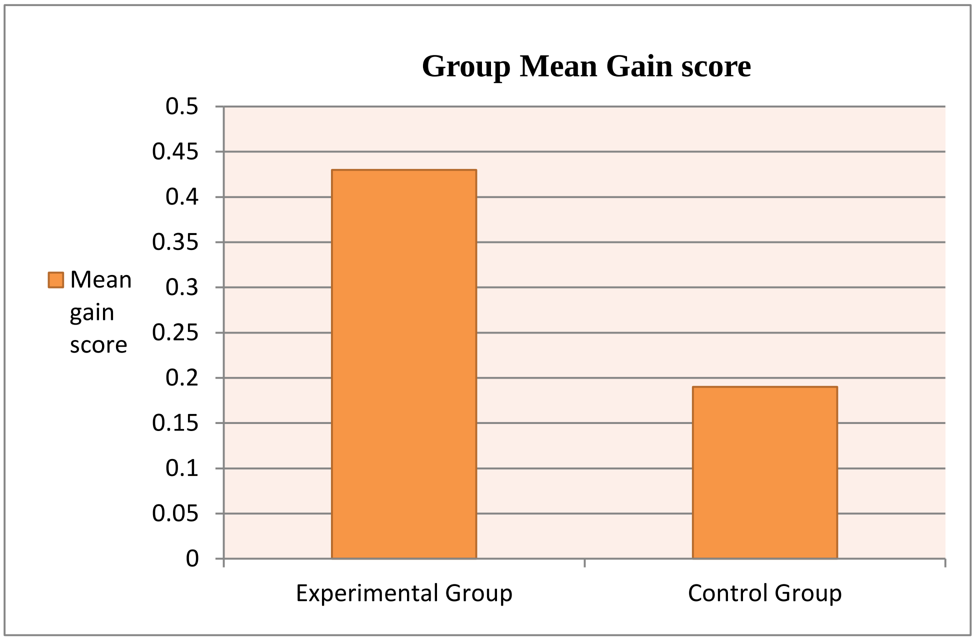


Figure 4.5 Performance Mean gain scores for independent groups

As indicated on bar graph on figure 4.5, the experimental group's mean gain score for students who learned using LEGO-bricks-based instruction was higher in comparison to mean gain score of the control group of students who learned without LEGO-bricks. Students from the experimental group (schools A and C) were highly motivated to learn chemical reactions due to the use of LEGO-bricks-based instruction. Students from the control group (schools B and D) had low motivation due to the use of conventional methods. Those findings lead to the second hypothesis's dismissal, which asserted that there isn't statistically significant correlation in motivation to learn between students taught using LEGO-bricks-based instruction and those taught without LEGO-bricks.

Some studies were found have supported those findings; A study by Kaberman and Dori (2015) highlighted that students who engaged with LEGO-bricks-based learning demonstrated higher levels of motivation to learn compared to those who learned using conventional methods. In their study, they noted that the interactive and playful nature of LEGO-bricks made the learning process enjoyable, thus sustaining students' intrinsic motivation and enthusiasm to learn.

Exposure to LEGO-Bricks-based instruction may have contributed to this higher positive gain in motivation to learn chemical reactions. During the study students from schools A and C were introduced to LEGO-bricks as a teaching and learning tool. So they could see how atoms in chemical reactions generate reactants and products. They were able to better understand the steps involved in chemical reactions when taught using LEGO-bricks than when taught in theoretical situations and students ended up actively engaged in their studies. In another study, Bakar (2014) discovered that students who were motivated learned better and retained more information as compared to those students who were not motivated.

Wang et al (2017) performed a research on impact of LEGO-bricks-based activities on student engagement was also found to support these findings. Their study indicated a positive correlation between use of LEGO-bricks and increased motivation. Students who used LEGO-bricks expressed higher levels of interest in the subject matter. The study concluded that using tangible and manipulable objects like LEGO-bricks helps demystify complex scientific concepts, thereby fostering a more motivating learning environment.

Another study conducted by Garcia and Lee (2020) was found to support the findings that LEGO-bricks-based instruction increases student engagement and learning motivation. Their study highlighted that students who were involved in LEGO-bricks-based projects were more enthusiastic and participated more actively in class discussions. This increased learner’s engagement which is linked to higher academic performance and a deeper interest in learning of science subjects. Learning motivation according to Cavas (2011) study stimulates learning activities and aids in the development of conceptual comprehension of a concept. Conventional methods of learning chemical reactions to students at schools B and D may have diminished their motivation to learn and lowered their interest in the subject matter, which might have affected their performance in the classroom. When students aren't motivated, they learn less and have difficulty comprehending, which makes it harder for them to focus during a lecture (Mayuri, 2021).

Motivation to learn is very essential factor in education process. It was found to stimulate a learner to concentrate and focus on the concept. It was observed that students learn better when they are well involved in learning activities which enable them to enjoy and appreciate learning. The research findings for Motivation to learn indicated that use of LEGO-bricks-based instructional approach stimulated students to visualize and conceptualize chemical reactions improving their Motivation. It was observed that when students are exposed with LEGO-bricks, they are engaged with learning activities and interaction with reactants and products. Improvement in visualization and understanding of chemical reactions promote autonomy in learning and increases self-determination to attainment of learning outcomes.

4.7 Relationship between motivation and performance

To test the third hypothesis, the correlation between students' motivation and performance was determined using gain-score analysis. Group statistics were used to examine motivation gain score and performance gain score in pre post-tests for equivalent groups, and the comparison of findings was tabulated (table 4.10)

Table 4.10 Comparison in Motivation and performance mean gain score

		Motivation		**Performance**	
Test	**Scale**	**Experiment**	**Control**	**Experimental**	**Control**
	N	98	92	98	92
Pre-test	**Mean**	**69**	**67.8**	**45.08**	**41.78**
	N	97	92	97	92
Post test	**Mean**	**78.4**	**71.6**	**49.57**	**45.29**
Mean gain score		**9.4**	**3.8**	**4.49**	**3.51**

The findings in Table 4.10 revealed that experimental group's motivational mean gain score (9.4) was high translating to high performance mean gain score (4.49).

Control group's motivational mean gain score (3.8) was lower which translated to a lower performance mean gain score of (4.49). The relationship between motivation and performance is explained in figure 4.5.

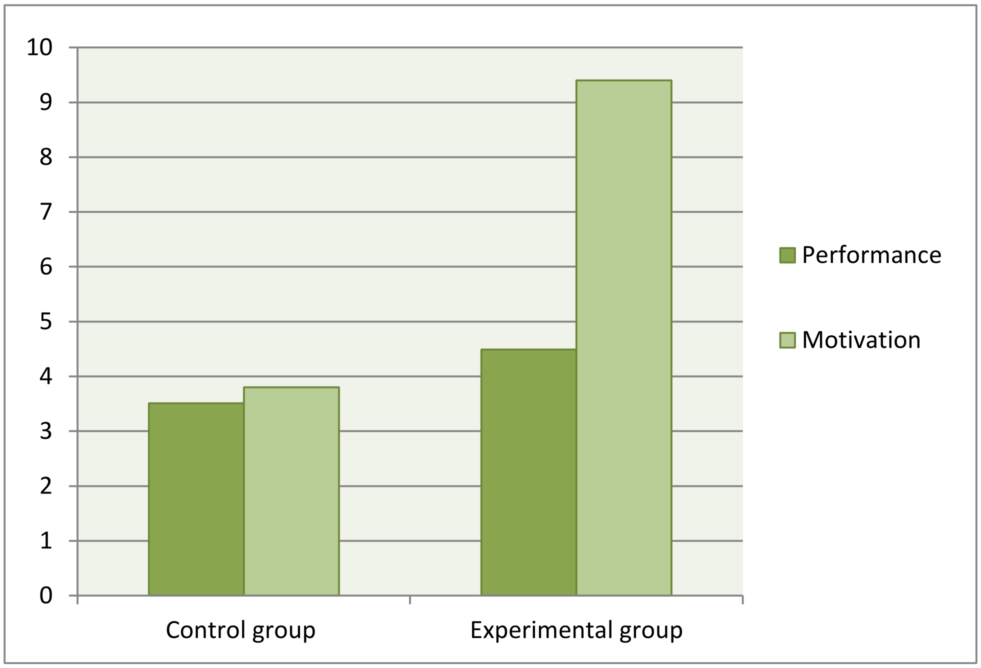


Figure 4.5 Relationship between motivation and performance

As shown on graphs in figure 4.5, experimental group of students (schools A and C) who learned chemical reactions with LEGO-bricks based instruction had higher motivation to learn which resulted to higher performance. On the other hand, control group of students group of students (schools B and D) who learned chemical reactions without LEGO-bricks bricks had lower motivation to learn which resulted to lower performance. Those results exposed a positive relationship between performance in chemistry and motivation. Those findings made the third hypothesis to be rejected which that stated that there is no statistically significant correlation between motivation and performance in Chemistry.

The discoveries of this exploration were found to agree with findings from Lindgren and Foreman (2022) who postulated that students who were highly motivated by the interactive and exploratory nature of LEGO-bricks-based learning exhibited higher performance in physics and chemistry. In their study, they noted that motivation and performance were mutually reinforcing, as students who were engaged actively with LEGO-bricks activities were more motivated and they performed better compared with students who were not exposed to LEGO-bricks activities.

Studies conducted by García et al (2023) were also found to support these findings. They found a strong positive correlation between motivation fostered through LEGO-bricks-based instruction and improved academic performance in STEM-based subjects. Their study emphasized that LEGO-bricks allowed students to build confidence in their abilities by providing a playful and low risk environment for experimentation, which in turn led to enhanced performance outcomes. As documented by Glynn and Koballa (2007) also postulated that scholars who are motivated in sciences had higher chances to achieve their set target goals. In their study, they emphasized those learners who are motivated to study actively involved in process of learning and have a deeper comprehension of their subject matter.

According to Otieno and Serem (2019) motivation showed a significant facilitating role in establishing connection between use of LEGO-bricks in learning and performance in science subjects. They postulated that students who were more motivated by LEGO-bricks instruction not only participated more actively in class but also achieved higher grades in science assessments. The finding of their study also relate well with research conducted by Cavas (2011) who highlighted that motivation plays a key role in studying science, which allows students to build conceptual understandings of the subject matter. Motivation is increased by using LEGO-bricks teaching which involves students in learning activities, encourages the conceptualization of abstract concepts, and improved performance.

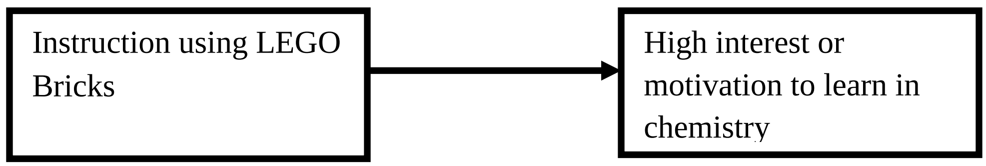
Comparing the experimental group of learners from schools A and C who learned chemical reactions using LEGO-bricks-based instruction to their counterparts in (schools B and D) demonstrated higher improvement in motivation and higher improvement in performance. Students were motivated to study chemical reactions when LEGO-bricks-based learning activities were used which allowed learners to create conceptual knowledge, which in turn helps them to improve their performance in chemistry. When LEGO bricks as instructional tools are used in learning, they promote visualization of abstract concepts of chemical reactions where learner create a mental picture the chemical reaction process, which resulted in greater conceptual comprehension and, ultimately, higher academic achievements.

4.5.1 Motivation-performance instructional model

The positive relationship between motivation and performance enabled the researcher to construct a motivation-performance instructional model based on the study outcomes.

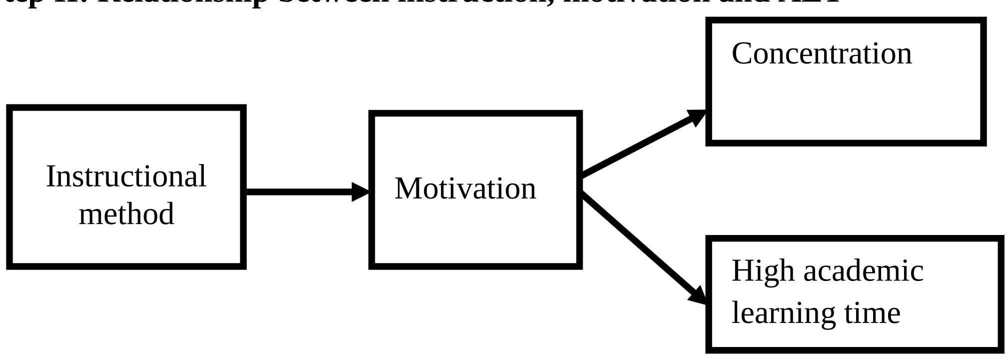
According to the discoveries of this research, a favorable association between motivation to learn and academic success was witnessed. Various studies have also shown that an increase in motivation to learn increases academic performance. The findings from this study and literature that support this relationship by enabled the researcher to construct a motivation-performance instructional model. The study's two dependent variables were performance and motivation. The study's primary emphasis was on the manipulation of LEGO-bricks to learn chemical reactions. This involves learners handling LEGO-bricks and interlocking pieces to present atoms and molecules. This is what can be referred to as hands-on experience which is very different from other instructional methods that teachers use in teaching and learning chemical equations. The LEGO-bricks-based instruction allows students to visualize and conceptualize the chemical reaction process thus creating a mental picture of how atoms or molecules of reactants combine to form products. As the results of this, the LEGO-bricks-based instructional approach improved learning interest and motivated learners toward the content. The relationship between good instructional methods such as LEGO-bricks-based instruction, learning interest, and motivation to learn can be summarized in three steps;

Step I: The teacher noted an improvement in learning interest during the lesson



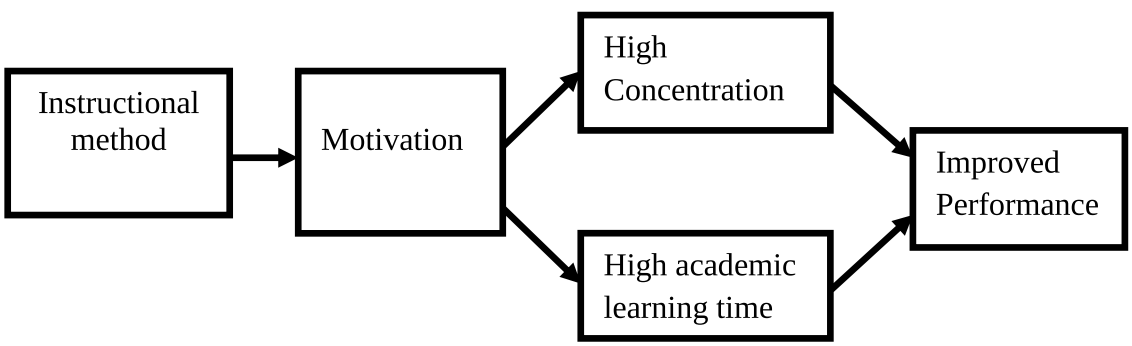
Motivation is considered to stimulate a learner to concentrate and focus on the subject thus investing a lot of time in learning. Students learn better when they are well involved in learning activities which enable them to increase their learning interest (Koballa and Glynn, 2007). Classroom activities enable them to invest more time in learning. This time invested during instruction is often referred to as academic learning time (ALT). As explained by Fisher (1981) Academic learning time is the active time spent in a learning situation when learners are actively engaged in classroom activities. Such learning situations can be classroom activities, practical, projects, homework, etc

Step II: Relationship between instruction, motivation and ALT



This study has shown that instructional method can motivate learners and as a result of motivation, learners likely were kept attentive and active at high concentration (step II). It is also possible that those learners follow up on lessons with revision and practice to consolidate the content. It can be expected that where a learner has a high interest or concentration rate, he or she invests more academic learning time through revision, assignments or research. The combining effect of concentration and academic learning time to leads to improved academic performance (step III).

Step III Relationship between instruction, motivation, ALT and performance



The model in step III illustrates the power of suitable instructional methods in teaching and learning of abstract concepts in Chemistry. It also involves hands-on skills such as manipulation skills. It is now considered that a modern curriculum or content should emphasize on skills enhancing courses. Knowledge and skills lead to innovativeness and wider production of items required for improvement in society

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter gives a summary of the research findings, conclusions and recommendations for further research and actions.

5.2 Summary of the Research Findings

5.2.1 Chemistry Performance

In the determination of the first objective, it was found that learners who learned chemical reactions using LEGO-bricks-based instruction had higher improvement for Chemistry performance compared to learners who learned the same concepts without LEGO-bricks. The findings for Chemistry Performance on pre-test analysis revealed that the learners grouped as experimental (school A and C) and those grouped as control (school B and D) were homogenous and of the same ability. Therefore Learners in independent groups were comparable at the beginning of the Study. The findings for Chemistry Performance on post-test analysis indicated a higher enhancement in the Experimental group relative to the Control group. The use of LEGO-bricks-based instruction was found to have a positive influence on Chemistry Performance.

5.2.2 Motivation to Learn Chemistry

Determination for motivation to learn Chemistry was the second objective of the study. Experimental groups of Learners learned Chemical reactions on LEGO-bricks-based instruction while learner in control group learned without LEGO-bricks. The findings for Motivation to learn on pre-test analysis revealed that the learners in experimental group (schools A and C) and their counterparts (school B and D) had similar and equal entry in terms of ability. Therefore Learners in independent groups were comparable at the stage of the Study. The findings for Motivation to learn on post-test analysis indicated a higher improvement motivation for Learners in Experimental group. Learners in Control group had lower improvement for Motivation to learn Chemical reactions. The use of LEGO-bricks-based instruction was found to have a positive influence on Motivation to Learn. The use of LEGO-bricks-based instruction in the learning of chemical reactions motivated students by involving them in learning activities and interaction with reactants and products. It improves their visualization and understanding of chemical reactions enhancing autonomy in learning and raising their learning interest.

5.2.3 Influence of Motivation on Performance

In the determination of 3rd objective that sort to determine the association between motivation to learn and Chemistry performance. The research findings revealed a positive relationship between motivation to learn and performance in Chemistry. Experimental groups of Learners which had higher improvement on Motivation to learn showed higher improvement on Chemistry performance. Control groups of learners with lower motivation to learn ended up with lower improvement in performance. Scholars were highly inspired to learn when exposed to LEGO-bricks-based instruction. They visualized the reactants and products, which promoted their understanding and improved their Chemistry performance.

5.3 Conclusion

Use of LEGO-bricks-based instruction was found to improve motivation to learn through active engagement of students with LEGO-bricks. Students who learned Chemical Reactions with LEGO-bricks-based instruction were able to visualize and conceptualize reacting particles. They understood the abstract concepts that improved their performance in Chemistry. Motivated learners improved academic performance indicating a high positive association between motivation and performance in Chemistry.

5.4 Recommendations

5.4.1 Recommendations for further research

(a) Research should be carried out in other countries to find out whether LEGO-bricks instruction will have a similar influence on motivation and performance in Chemistry

(b) Research should be done to examine the influence of LEGO-bricks instruction on motivation and performance in mathematics.

5.4.2 Recommendations for Action

(a) Ministry of Education should provide schools with LEGO-bricks to enhance learning of abstract concepts in Chemistry.

(b) The Ministry of Education should conduct a workshop for Chemistry teachers in order to provide guidelines on the use of LEGO-bricks in enhancing the learning of chemical reactions.

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APPENDIX A: CHEMISTRY ACHIEVEMENT TEST (PRE-TEST)

School code…..………

Admission number………………

Instructions

- Please do not provide any personal information about your institution. Instead write your admission number and school code.

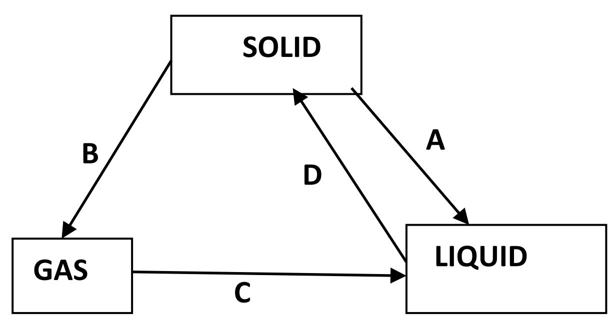
- Before writing the answers, read the questions carefully and attempt to understand them.

- Complete all of the questions.

- Fill in the blanks with your response.

Questions

1. Study the diagram below and answer questions that follow.



Identify process; **(2 marks)**

A - ………………………………………………………………………

B - ……………………………………………………………………..

C - …………………………………………………………………..

D - …………………………………………………………………..

2. Write the symbols of the following elements. **(2 marks)**

(a) Oxygen ………………….

(b) Potassium ………………….

(c) Copper………………….

(d) Nitrogen ………………….

3. Write the names of elements given the symbols as shown. **(2 marks)**

(a) Mg …………………………………………………….

(b) Pb …………………………………………………….

(c) Ca …………………………………………………….

(d) S …………………………………………………….

4. Name the elements presents in each of the following compound **(6 marks)**

(a) Magnesium oxide

………………………………………………………………………

(b) Zinc (II) suphate

………………………………………………………………………

(c) Lead (II) nitrite

………………………………………………………………………

(d) Sodium hydrogen carbonate

…………………………………………………………………………

(e) Calcium chloride

…………………………………………………………………………

(f) iron (II) sulphide

…………………………………………………………………………

5. Identify **two** conditions necessary for iron to rust. **(2 marks)**

………………………………………………………………………………

………………………………………………………………………………

6. State **one** condition which speed up the rate of rusting. **(1 mark)**

………………………………………………………………………………

………………………………………………………………………………

7. Complete the following equations. **(4 marks)**

(a) Lead (II) oxide + nitric (V) acid $\longrightarrow$

(b) Sodium carbonate + sulphuric (VI) acid $\longrightarrow$

(c) Magnesium + Sulphuric (VI) acid $\longrightarrow$

(d) Sodium hydroxide + hydrochloric acid $\longrightarrow$

8. Complete the table below. **(3 marks)**

Species	Neutrons	Electrons	Protons
${}^{55}_{25}Mn^{4+}$			

9. Write down the valencies and oxidation number of the following. **(3 marks)**

Species	Valance (s)	Oxidation number
Mn^{7+}		
Cu^{+}		
N^{3-}		

10. An element K has the following isotopic composition:

${}^{20}_{10}K$ (10%) And ${}^{18}_{10}K$ (90%)

Calculate the R.A.M of K. **(2mrks)**

11.A student tested the pH of five solutions using universal indicator and obtained the following results.

Solution	**A**	**B**	**C**	**D**	**E**
Ph	14	1	7	5	10

Which of the solutions is likely to be

(i) Sodium chloride solution.. **(1mark)**

(ii) Lactic acid... **(1mark)**

(iii) Dilute Sulphuric (VI) acid……............................ **(1mark)**

APPENDIX B: CHEMISTRY ACHIEVEMENT TEST (POST-TEST)

School code...................................

Admission Number............................

For the sake of secrecy, please do not put your name or the name of the school on the question paper; instead, write your admission number and school code.

- Before submitting responses, read the questions carefully and attempt to comprehend them.

- Answer all of the questions - Write your answers in the places given

1. Distinguish between elements and compounds **(2 marks)**

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

2. Write balanced chemical equations for the reaction that would occur if the following substances react **(4 marks)**

a) Hydrogen gas and oxygen gases

…………………………………………………………………………………………

b) Aluminium and oxygen gas

…………………………………………………………………………………………

c) Magnesium ribbon and chlorine gas

…………………………………………………………………………………………

d) Sodium metal and oxygen gas

………………………………………………………………………………………….

3. Write the chemical formula for each of the following substances **(10 marks)**

a) Calcium fluoride

…………………………………………………………………………………………..

(b)Magnesium hydrogen Sulphate

…………………………………………………………………………………………….

c) Sodium carbonate

…………………………………………………………………………………………….

d) Potassium Nitrate

…………………………………………………………………………………………….

e) Sodium chloride

…………………………………………………………………………………………….

f) Manganese (IV) Bromide

…………………………………………………………………………………………….

(g) Potassium Sulphite

…………………………………………………………………………………………….

h) Ammonium Phosphate

…………………………………………………………………………………………….

I) Chloride of divalent metal R

…………………………………………………………………………………………...

j) Nitrate of monovalent metal X

…………………………………………………………………………………………

4. Complete the table below **(14 marks)**

Name of the Reactants	**Name of the Product**	**Chemical formulae of the product**
Barium, oxygen		
	Magnesium Floride	
	Iron(III)chloride	
Calcium, water		
	Aluminum oxide	
Iron, oxygen, water		
		ZnO

Thank You

APPENDIX C: STUDENTS' MOTIVATION QUESTIONNAIRE

School code…………………..

Adm no Number ……………..

Dear Student,

I am Samwel Wachira, a Masters student at Kenyatta University currently conducting a research study as part of the course work. The research is titled "*LEGO-Bricks-Based Instruction and its influence on students' Motivation and Performance in Chemistry"*. I am respectfully asking you to take part in this study by filling out this questionnaire. I can promise you that any information/data you provide will be handled with the strictest secrecy and used only for the objectives of this research.

Instructions

- Do not write your personal Names or Name of your institution. Write your admission number and school code on the questionnaire for easy identification

-Before selecting an answer, carefully read statement and understand it clearly.

-Put a checkmark (√) or cross (x) on the scale of your choice.

Section B: Motivation to Learn Chemistry

The items on the table below are on motivation to learn chemistry. Indicate your agreement with each using the given scale.

S*cale: Strongly Agree (SA), Agree (A), Un-decided (UD), Disagree (D), Strongly Disagree (SD).*

		Response				
Learning Chemical Reactions topic has:		**SD**	**D**	**U**	**A**	**SA**
Made me love Chemistry	+					
Made balancing equations difficult	–					
Enable me to master chemical reactions topic	+					
Made learning Chemistry boring	–					
Helped me to balance chemical equations correctly	+					
Made learning the topic frustrating	-					
Equipped me with the ability to give names of products given reactants	+					
I still find difficulties in giving names of products given the reactants.	–					
I am now able to do chemical reactions assignments given by the teacher.	+					
I do not feel confident balancing chemical equations.	–					
I am able to work independently when handling chemical reaction problems	+					
I do not expect to apply skills acquired when learning chemical reactions in other situations in life.	–					
I now feel confident learn other topics in Chemistry	+					
I still have difficulties in writing chemical formulae of compounds	–					
I no longer feel uneasy during chemistry lessons.	+					
I enjoy learning Chemistry	+					

I would not like to have such lessons again as they are not interesting	–					
I am satisfied with the way chemistry is taught	+					
I am not satisfied with my performance in chemical reaction assignments and tests.	–					
I would like to have more of such lessons in chemical reaction	+					

APPENDIX D: (ACHIEVEMENT TEST) PRE-TEST MARKING SCHEME

1. A - Melting
   B - Sublimation
   C - Condensation
   D - Freezing

2. (a) O
   (b) K
   (c) Cu
   (d) N

3. (a) Magnesium
   (b) Lead
   (c) Calcium
   (d) Sulphur

4. (a) Magnesium, oxygen
   (b) Zinc, Sulphur, Oxygen
   (c) Lead, Nitrogen, Oxygen
   (d) Sodium, Hydrogen, Carbon. Oxygen
   (e) Calcium, Chlorine
   (f) Iron, Sulphur,

5. Oxygen gas and Moisture/Water
6. Salinity/acidity
7. (a) Lead (II) oxide + nitric (v) acid $\longrightarrow$ Lead (II) nitrate + Water
   (b) Sodium carbonate + sulphuric (vi) acid $\longrightarrow$ Sodium sulphate + carbon (iv) oxide + water

(c) Magnesium + Sulphuric (VI) acid ⟶ Magnesium Sulphate + Hydrogen gas

(d) Sodium hydroxide + hydrochloric acid ⟶ Sodium chloride + Water

8.

Species	Neutrons	Electrons	Protons
$^{55}_{25}Mn^{4+}$	**30**	**21**	**25**

9.

Species	Valance (s)	Oxidation number
Mn^{7+}	**7**	**+7**
Cu^{+}	**1**	**+1**
N^{3-}	**3**	**-3**

10. R.A.M = $\frac{(20 \text{ x } 10)}{100} + \frac{(18 \text{ x } 90)}{100}$

2 + 16.2 = **18.2**

11. (i) Solution **C**

(ii) Solution **D**

(iii) Solution **B**

APPENDIX E: ACHIEVEMENT TEST (POST-TEST)

MARKING SCHEME

1. An **Element** is a pure substance which cannot be split into simpler substances by chemical means.

   A **compound** is a pure substance which is made up of two or more elements chemically combined.

2. (a) $2H_{2\,(g)} + O_{2\,(g)} \longrightarrow 2H_2O_{\,(l)}$

   (b) $4Al_{\,(s)} + 3O_{2\,(g)} \longrightarrow 2Al_2O_{3\,(s)}$

   (c) $2Mg_{\,(s)} + Cl_{2\,(g)} \longrightarrow MgCl_{2\,(s)}$

   (d) $4Na_{\,(s)} + O_{2\,(g)} \longrightarrow 2Na_2O_{\,(s)}$

3. (a) CaF_2

   (b) $Mg(HSO_4)_2$

   (c) Na_2CO_3

   (d) KNO_3

   (e) NaCl

   (f) $MnBr_4$

   (g) K_2SO_4

   (h) $(NH_4)_3PO_4$

   (i) RCl_2

   (j) XNO_3

4.

Name of the Reactants	Name of the Product	Chemical formulae of the product
Barium, oxygen	**Barium oxide**	**BaO**
Magnesium and Fluorine gas	Magnesium Fluoride	**MgF2**
Iron and Chlorine	Iron(III)chloride	**FeCl3**
Calcium, water	**Calcium hydroxide and hydrogen gas**	**Ca(OH)2 and H_2**
Aluminum and oxygen gas	Aluminum oxide	**Al_2O_3**
Iron, oxygen, water	**Hydrated Iron (III) oxide**	**$Fe_2O_3.2H_2O$**
Zinc and Oxygen	**Zinc (II) oxide**	ZnO

APPENDIX F: CHEMISTRY TEACHERS TRAINING MODULE

Introduction

This training module was used by the researcher to guide during induction process for chemistry teachers on LEGO-bricks-based instructional approach in teaching and learning chemical reactions.

LEGO-bricks are colorful inter-lockable plastic bricks. LEGO-bricks-based instruction is the use of LEGO-bricks as resources to facilitate teaching and learning of chemical reactions.

Identification of LEGO-bricks as atoms and modelling of molecules

Activity 1

You are provided with LEGO-bricks. In pairs, follow the procedure below to identify the LEGO-bricks as atoms and use them to model molecules of different compounds.

(i) Indentify LEGO-bricks as atoms of elements using element color codes.

(ii) Assign different LEGO-bricks to represent elements from the periodic table

(iii) Classify LEGO-bricks of the same atoms and put them together e.g. Sodium, Chlorine, Carbon, Magnesium, Nitrogen, Sulphur and other

(iv) Using Labels write the chemical symbol of specific elements and stick them on separated bricks.

(v) Interconnect atoms to make molecules of different compounds e.g. Chlorine gas (**Cl_2**), oxygen gas (**O_2**), Nitrogen gas (**N_2**) and carbon (IV) oxide (**CO_2**)

Modelling of simple chemical reactions

Following the activity 1, LEGO-bricks were identified as atoms and sample molecules were presented. LEGO-bricks can be used to demonstrate chemical reactions. Example, a reaction of sodium and chlorine produce sodium chloride. Sodium and chlorine gas are reactants while sodium chloride is product.

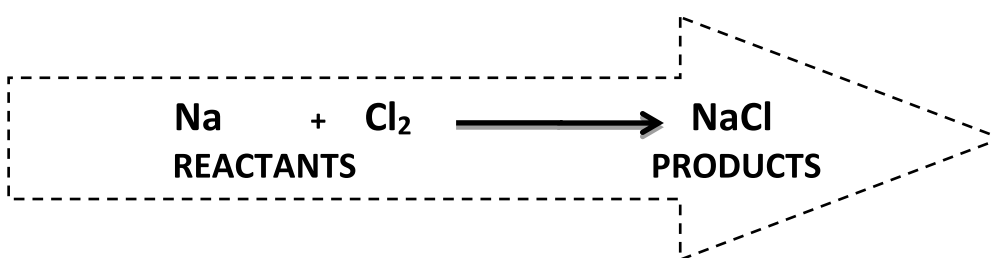
The law of Conservation of mass which state that: Atoms cannot be created or destroyed during a chemical reaction. Therefore atoms used to make the reactants are the same atoms used to create the products.

Activity 2

In pair, demonstrate chemical reactions using LEGO-bricks

(i) Present a chemical equation for reaction between sodium and chlorine gas.

(ii) Put one sodium brick and two chlorine bricks then disconnect them to make a brick of sodium chloride.



(iii) Break and reconnect LEGO bricks to represent how bonds break and form during a chemical reaction.

(iv) Write down that chemical reaction you have presented with LEGO-bricks.

(v) Present any other chemical reaction using the LEGO-bricks classified in activity 1 and write it down.

Balancing Chemical Equations using LEGO

Activity 3

In pair, balance the chemical equations using LEGO-bricks.

(i) Take an example of chemical reaction between sodium and chlorine gas, note the number of atoms appearing on the reactant side and product side.

(ii) Only one LEGO-bricks of chlorine was used to make product sodium chloride while two LEGO-bricks were appeared on the chlorine molecule. One brick was left out.

(iii) Balance the remaining Chlorine by ensuring that no chlorine Brick that was left out

(iv) Write down a balanced chemical reaction for reaction between sodium and chlorine.

(v) Use LEGO-bricks to balancing other chemical equations written in activity 2.

Record those balanced chemical reactions.

Lesson Plans

Teachers to prepare a sample lesson plan for LEGO-bricks-based instructional approach in teaching and learning chemical reactions.

Activity 4

Prepare a lesson plan you will use in your lesson to enhance learning chemical reactions using LEGO-bricks as reaching and learning resources and present your lesson plan to other peer teachers

APPENDIX G: MAP OF LAIKIPIA WEST SUB-COUNTY

LAIKIPIA WEST SUB COUNTY

Source: Google map for Laikipia West Sub-county (2021

APPENDIX H: UNIVERSITY AUTHORIZATION LETTER

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kubps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: E55/CE/25750/14

Date: 3rd March, 2020

The Director General,
National Commission for Science, Technology & Innovation,
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MR.SAMUEL WACHIRA-REG. NO. E55/CE/25750/14

I write to introduce Mr. Wachira who is a Postgraduate Student of this University. He is registered for a M.Ed. degree programme in the **Department of Educational Communication & Technology in the School of Education.**

Mr. Wachira intends to conduct research for M.Ed. thesis entitled, **"Effect of using Lego-Bricks Instruction on the Performance of Chemistry in Secondary Schools in Laikipia County, Kenya".**

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

JG/cao

APPENDIX I: RESEARCH PERMIST FORM NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 660435

Date of Issue: 28/March/2020

RESEARCH LICENSE

This is to Certify that Mr.. SAMUEL WAITHAKA WACHIRA of Kenyatta University, has been licensed to conduct research in Laikipia on the topic: EFFECT OF USING LEGO-BRICKS INSTRUCTION ON THE PERFORMANCE OF CHEMISTRY IN SECONDARY SCHOOLS IN LAIKIPIA COUNTY, KENYA for the period ending : 28/March/2021.

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APPENDIX J: SAMPLE SECONDARY SCHOOLS

School A – Experimental Group

School B – Control Group

School C –Experimental Group

School D –Control Group

School	**CODE**	**Representation**
School A	**AEB01**	Boys School, Experimental group – **Pre-test**
	AEB02	Boys School, Experimental group – **Post-test**
School B	***BCG01***	*Girls School, Control group* ***– Pre-test***
	BCG02	*Girls School, Control group –* ***Post-test***
School C	**CEB01**	Boys School, Experimental group – **Pre-test**
	CEB02	Boys School, Experimental group – **Post-test**
School D	***DCG01***	*Girls School, Control group –* ***Pre-test***
	DCG02	*Girls School, Control group –* ***Post-test***

APPENDIX K: WORK PLAN

ACTIVTITY	TIMELINE
Masters course work	**April 2015 – April 2016**
Identification of the research problem and writing of concept paper	**May – December 2016**
Proposal writing and corrections	**January 2017 – June 2019**
Proposal presentation at Department	**November 2019**
Research licence and Research permits	**December 2019 - March 2020**
Pilot study	**April 2020 – December 2021**
Collection of data and data analysis	**Jan 2022 – May 2022**
Thesis submission to the graduate school	**June 2022**
Thesis Defence	**September 2024**
Collection of thesis and final Submission	**Sept 2024 - Dec 2024**