VEHICLE STRUCTURE DESIGNS AND MATERIALS ON SCHOOL BUS BODY CRASHWORTHINESS: A CASE OF VEHICLE BODY BUILDING INDUSTRY IN NAIROBI COUNTY, KENYA.

BY

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DECLARATION

Declaration by the Student

This study is my original work and has not been submitted for any academic award in any institution; and shall not be reproduced in part or full, or in any format without prior written permission from the author and/or University of Eldoret.

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This study has been submitted with our approval as the University Supervisors.

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DEDICATION

This study is dedicated to above all our Almighty God, for the will and strength, to my immediate family, for their understanding and patience, mentors, friends and the Doctor of Philosophy fellow colleagues for their support and encouragement.

ABSTRACT

Thousands of vehicles are involved in vehicle collisions or crashes every year in Kenya, resulting in fatal accidents and severe injuries to passengers. There is growing concern among the stakeholders that the design of bus vehicle structures and the levels of crashworthiness are quite alarming. According to experts, school bus vehicle structures and minibuses involved in accidents indicate that the design is substandard and therefore rendering pupils/students more vulnerable to fatalities and serious injuries. Even though vehicle crashworthiness in developed countries has been documented, there is limited research done in Kenya in this specific area. This study attempted to fill the gap by focusing on school bus vehicle structure crashworthiness. The purpose of this study was to establish the effect of vehicle structure designs and materials on bus crashworthiness among body industry players in Nairobi City County. The specific objectives were to determine; the influence of locally designed bus vehicle structure, competency skills, engineering materials, equipment, welding technology, vehicle structure inspection tests and customer needs on crashworthiness of school bus. This study adopted Axiomatic theory, Mathematical Framework theory and Taguchi design theory. The pragmatic philosophy informed the study. The explanatory research design was used. The target population was 1500 respondents from bus body building firms and government regulatory institutions. The sample size was 315 respondents. Questionnaires, interview schedules and observation were the data collection instruments. Supervisors served as expert judgment to establish validity of the instruments. Cronbach's Alpha Coefficient of >0.7 was used to determine the reliability of the research instrument. The data collected was analyzed using descriptive and inferential analysis with the aid of SPSS V22 software. The multiple regression model, the coefficient of determination (R squared) of .744 showing that 74.4% of the variation in crashworthiness of a bus can be explained by vehicle structures designs and materials. There was a significant relationship between locally designed bus (β_1= 0.089), competency skills (β_2=0.429) engineering materials (β_3= - 0.725), equipment and tools (β_4=0.127), welding technology (β_5 = 0.575) and inspection test (β_6 = 0.321) and customer needs (β_7=0.094) crashworthiness of a bus. The engineering materials had a negative and significant influence on crashworthiness of a bus. The equipment, locally designed bus, competency skills, welding technology, vehicle inspection tests and customer needs had a positive significant influence on crashworthiness of a school bus. However the engineering materials used in the manufacture of school buses does not guarantee bus body crashworthiness. The ministry of industrialization should provide incentives to the school bus manufacturing company to locally build school buses that have a lower failure rate. The management of school bus manufacturing companies should periodically send their employees to refresher workshops for competence skills upgrades. This study will help improve school bus body construction and materials thereby enhancing school bus body crashworthiness hence ultimately increasing student survival rates in the event of a school bus accident.

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ABBREVIATIONS/ ACRONYMS

ABS Anti-lock braking system

AC Alternating Current

AD Axiomatic Design

ADA Americans with Disabilities Act

AKI Association of Kenya Insurers

ANN Artificial Neural Network

ANNs Artificial Neural Networks

APTA American Public Transportation Association

ATD Anthropomorphic Test Devices

BAC Blood Alcoholic Concentration

CAD Computer Aided Design

CAM Computer Aided Manufacture

CFRP Carbon Fiber Reinforced Polymer

CIAL Crashworthiness and Impact Analysis Laboratory

CIREN Crash Injury Research

COG Center Of Gravity

Cr Chromium

DALYS Disability Adjusted Life Years.

DC Direct Current

DfHS Design for Human Safety

DI Deformation Index

DOE Design Of Experiment

DPs Design Parameters

ECE Economic Commission for Europe

EU European Union

FARS Fatality Analysis Reporting System

FDOT Florida Department of Transportation

FEA Finite Element Analysis

FEM Finite Element method

FMVSS Federal Motor Vehicle Safety Standard

FRs Functional Requirements

FW Friction Welding

GA Genetic Algorithm

GAs Genetic algorithms

GRA Grey Relational Analysis

GVWR Gross Vehicle Weight Rating

HAZ Heat Affected Zone

HCP Hexagonal Closed Packed

HEEDS Hierarchical Evolutionary Engineering Design System

HIC Head injury criterion

HITS Head Impact Test System

HSLA High-Strength Low-Alloy Steel

KABM Kenya Association of Bus Manufacturers

KEBS Kenya Bureau of Standards.

KSI Killed or Seriously Injured

KVM Kenya Vehicle Manufacturers

LBW Laser Beam Welding

MAAS Mobility As A Service

MADMO Mathematical dynamic models

MIG Metal Inert Gas

MIRA Motor Industry Research Association

Mn Manganese

MPV Multi- Purpose Vehicle

NASS National Automotive Sampling System

NBTEB National Business and Technical Examinations Board

NHTSA National Highway Traffic Safety Administration

Ni Nickel

NTSA National Transport and Safety Authority

NVH Noise, Vibration and harshness

OECD Organization for Economic Cooperation and Development

PAW Plasma Arc Welding

PRA Protectable Rollover Accident

PSV Passenger Service Vehicles

R&D Research and Development

RS Residual Space

RSEW Resistance Seam Welding

RSW Resistance Spot Welding

RTA Road Traffic Accidents

SB School Buses

SCS Stop Control System

SID Side Impact Dummies

SMAW Shielded metal arc welding

SPSS Statistical Package for Social Sciences

SUV Sports Utility Vehicle

TIG Tungsten Inert Gas

TRC Traction Control System

TRIP Transformation Induced Plasticity

TRIZ Theory of inventive problem solving

TVET Technical and Vocational Education and Training

UNECE United Nations Economic Commission for Europe

USA United States of America

UVW Unloaded vehicle weight

VCU Viscous Coupling Unit

VDC Vehicle Dynamics and Control

VIN Vehicle Inspection Notification

VSC Vehicle Stability and Control

WHO World Health Organization

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter presented the background of the study, purpose of the study and statement of the problem. It also presented the objectives of the study, research questions, hypothesis of the study, justifications and significance of the study. Further, this chapter discusses assumptions, scope and limitations of the study, theoretical framework, conceptual framework, operational definition of terms and chapter summary.

1.2 Background of the Study

Increasing number of motor vehicles is one of the key reasons leading to global road injury accidents and fatalities. Development in the motor sector has introduced social gains and risks, with traffic injuries making a major contribution to the latter. In the sense of road crashes about 1,2 million people are killed annually and another 20 million to 50 million are hurt and affected by road traffic incidents worldwide according to Peden, Scurfield, Sleet, Mohan, Hyster, Jarawan and Mathers (2004). Path accidents account for 2.1% of global deaths and 23% of all accidents worldwide. The global disease burden from 10th to 8th in 2002 by 2020 is projected for road traffic accidents (Peden et al., 2004).

The U.S. has the largest number of wounded persons in traffic collisions in developing nations. 10,21 of 1,000 individuals were injured in RTA between 2001 and 2003. Simultaneously, in Canada 7,18 out of 1,000 were injured, while in Denmark there were at least 1,59 out of 1,000 injured, closely followed by Finland with 1,64 injured. A total of 4,39 people in road accidents out of 1,000 were wounded (Organization for Economic Cooperation and Development, 2007).

The gross loss of road injuries in the low- and medium-income countries for the whole of the year was measured at about USD 65 billion (Jacobs, et al., 2000). In developing countries traffic deaths more than doubled in 13.4/100,000 and 32.2/100,000 in Europe and Africa respectively (Peden, et al., 2004). Roof Crush Resistance, Federal Motor Vehicle Safety Standard (FMVSS) No. 216, in the USA, described the minimum roof strength requirement to 'diminish death and injury from the passengers' roof squatting during roll-over collisions.' The roof must be sufficiently firm to keep the plate from growing 5 inches when a force equivalent to 1.5 times the vehicle's weight is powered. The exam entered into effect in 1973 and remained untouched until the announcement of the revised regulations in 2009 (National Highway Traffic Safety Administration, 2012). Roof strength and risk of injury in rollover collisions have a strong correlation (Brumbelow, Teoh, Zuby, & McCartt, 2009).

According to the U.S.A. National Highway Safety Administration (2012) Rule, a bus roof was expected to withstand use of force equal to 3 times the weight of the vehicle while retaining adequate headroom for an average adult male. While the roof on both sides was to fulfill the ancient requirements, only one side of the roof was checked on any car. The most recent law demands that the roof of the same car on the other side be secondly tested. Starting in the models 2013 and by the models 2017, 100% of the fleet of each maker must comply with the latest rule (National Highway Traffic Safety Administration, 2012). It contributed to a theory that the crush of the roof of larger cars was closely related to overflow injuries and that the crushing of the roof could cause passenger injury.

According to Worley (2008), road accidents decreased by 27% in the United States of America and 63% in Canada between 1975 and 1988. Crashworthiness and automotive safety research have drawn interest in recent years, with a focus on the investigation of passenger car safety (Prochowski Prochowski, Zielonka and Zuchowski 2011 and Al-Thairy & Wang 2014). However, eighty-eight countries have decreased the rate of traffic accidents, but the overall number of road deaths remains unacceptably high at 1.24 million per year. The average global road fatality rate is 18 per 100 000 inhabitants. Middle-income countries have the highest annual road fatality rate of 20.1 per 100 000, whereas high-income countries have the lowest annual fatality rate of 8.7 per 100 000 (World Health Organization, 2013).

Accident figures from the 2013 Road Safety Facts survey indicate that the number of deaths and accidents per car mile traveled has been promisingly diminished over the last three years (NHTSA's National Centre for Statistics and Research, 2014). Bus transit is known to be the safest medium and long-distance mode of travel by rail. However, the number of bus crashes and fatalities has grown with the number of buses. In the United States, there are 55,000 bus incidents a year, with an average of 250 deaths and up to 14,000 casualties. Popular forms of bus crashes include frontal crash, side-impact, rear-impact and roll-over accidents. Among others, the main proportion of thirty-five per cent of fatal bus accidents is the result of the original frontal effects.

Rollover accidents are known as the most dangerous situations for bus accidents (Matloscy, 2007). And if it is an uncommon occurrence, because only 4-5 per cent of all bus crashes are rollovers, it is the cause of almost 50 per cent of serious accidents and fatal injuries (Gepner, 2014; Martinez *et al.*, 2013). Many countries do not keep track of bus crashes, particularly school busses. That's why many researchers use ordinary bus data to test rollover incidents in their study (Bojanowski, 2010 & Gepner, 2014). One of the most useful methods for collecting statistics on bus crashes in the United States is the Fatality Analysis Monitoring Method (FARS). The FARS database offers annual statistics on fatal casualties sustained in automotive traffic collisions

(NHTAS, 2014). The FARS statistics released for 2012 was that nearly 127 million vehicles registered in the United States were involved in more than 18,000 fatal accidents.

According to the data, only 249 deaths involving bus crashes occurred from almost 765,000 busses registered in the United States in 2012. This causes almost 140 fatal crashes per 1 million vehicles and over 300 fatal crashes per 1 million buses. Out of all 251 fatal collisions involving busses, there were just 11 rollover accidents (which makes it 4.4 percent of all bus crashes). Almost 32 percent of all bus crashes with injuries were involved with the bus rollover. Although the chosen FARS data do not specify the number of deaths in any of the bus incidents, it indicates general figures and the ratio of car to bus accidents which have occurred in the US during the year 2012 (NHTAS, 2014).

Obviously, there is little research on coach and bus defense. For passengers' protection all regulation which is obligatory for large vehicles is enforced. Federal Safety Guidelines for Motor Vehicles (FMVSS) 220 define performance criteria for school bus roll-over safety in the United States. Regulation-66 of the European Community applies to the strength of the super-structure under the Competitive Lateral Rollover Test and ECE R80 questions sit strength and anchors in the United Nations Economic Commission for Europe (UN-ECE).

Regulations and instructions explicitly set down for the frontal collision of the bus system directly dealing with the safety of the driver and crew do not apply. However, passengers are at much higher risk if the driver of the bus is not covered in the case of a crash. The ECE R29 Rule is enforced in order to ensure the safety of the truck cabin and the driver in the event of a frontal collision (Mirzaamiri et al., 2012). ECE R29 was under debate in the UN-ECE Working Group on Passive Protection (GRSP) and a related rule for busses will be implemented in the immediate future (Cerit et al., 2010). Road protection is a major problem all over the world. In over 112,000 traffic collisions a year in Alberta, Canada, almost 400 people are killed and over 27,000 wounded (AT 2006). The social direct liability to Albertans of motor vehicle collisions is 4.68 billion dollars or 2.4 percent of the gross domestic product of Alberta. While the number of injuries in Alberta in the last decade has been 0.4% of the total number of school busses (SB's), these events tend to have been reported excessively by the media and the general public because of high safety requirements for SB and the severity of emotions involved when school kids are just injured.

SB safety has a high priority in the town and parents put the belief that their children should be transported safely to and from school in schools and SB drivers. Around 6,000 SBs in Alberta, Canada, transport about 126,000 students in rural areas and 139,000 students in urban areas (Opus 2008) per year over 76 million kilometres, and are considered to be one of the safest modes. The share of injuries incurred by SB collisions is 13.7%, while the share of total Alberta crashes contributing to injury during the same timeframe is 152%. (Opus 2008). The odds of SB crashes leading to injuries are substantially smaller in comparison with other accidents.

However, SB incidents do occur, often with serious results, and appear to be accompanied by public pressure for action. Each SB collision triggers an alarm, particularly if it injures our most vulnerable population. It is necessary to understand the causes of SB-connected accidents to offer evidence-based recommendations to improve the safety efficiency of these busses and ensure much greater security of SB operation. In the event of the frontal bus crash the driver's safety is related to two opposite effects: the driver's deformation measured by interference and the driver's deceleration measured by the amplitude and length of the crash pulse (Matsumoto et al., 2012).

The use of components capable of buckling in a controlled pattern was a way of enhancing the safety of vehicle occupant protection in passenger cars. Thin-walled steel tubes collapsing under axial crushing as energy absorbers more commonly occur as either square or circular cross-sections (Abramowicz, 2003; Zhang & Zhang, 2012; Nia & Parsapour, 2014). The geometry inefficiency allows the frontal longitudinal tubes to break in bent mode rather than incremental axial crushing. Eren et al., (2009) and Ambati et al. (2012) used the finite element solver ANSYS/LS-DYNA to reliably predict the breakdown of the various configurations of the front rail of the bus vehicle. In the face-to-face bus collision, some researchers used Finite Element Analysis (FEA) to determine the deformation process and structural reaction of the bus vehicle to impact loads based on various principles. Studies on improving the safety of passenger busses are restricted

Road injuries in Tanzania increased by 44 per cent between 1990 and 2000, according to the survey (Museu, Mcharo and Lashabai 2002). The overall number of wounded passengers was 56 per cent led by pedestrians at 25 per cent. Tanzanian police have traced more than 50 per cent of deaths to imprudent driving, while unroad-worthy cars have contributed around 15 per cent to all incidents. The lack of side pavements for pedestrians and pedal bikers on the highways, however, caused some injuries and this was referred to as bad road design. Lack of gadgets to calculate the BAC rate of victims in Tanzania may have contributed to the inference that substance dependence had a slight effect on RTAs. Most possibly, some of the careless drivers that caused more than 50 percent of Tanzanian road deaths may have been under the influence of alcohol. Similar patterns have been recorded across East Africa.

Accidents in Kenya tripled, from 1963, to 1989, from 3578 to 10,106 and 1994, to Muyia, 11,785 (1995). In 2014, there have been 6 6650 killings, 6650 severe injuries and 11094 minor injuries. Unwary drive, non-road vehicles and dangerous road conditions were the causes of accidents. The Kenyan highways kill almost three thousand people a year, Odero, Khayesi and Heda (2003) observed. Injury figures have grown from 10,300 in 1990 to 16,800 in 2000 and 17,400 in 2009. (Odero et al. 2003 & Kenya Roads Board, 2010). The economic cost of road accidents is estimated to be 5% of the world's national gross product (Kenya Roads Board, 2010).

In the last decade, Kenya has seen an increase in road injuries (RTAs), categorized as a zone with low middle-income revenues. This is linked to urbanization and motorisation in the region. As a low-income economy, the development of road connectivity is also behind international safety standards, as is the case in policy problems. In 2014, there also were 2,907 accidents including motor vehicles collisions in Kenya (NTSA, 2015). The causes of such accidents include car speeding and dangerous driving. According to the National Transport and Safety Authority (NTSA), Kenya, the transport authority reported 3 572 deaths, 6938 grave injuries and 5 186 minor injuries in Kenya as from December 2019. (NTSA, 2020).

The numbers mentioned were criticized by particular parties (Kelly, 2018). The general rationale behind this is related to mathematical processing and accident data categorization. NTSA appears to record fatality on the spot, and no hospital follow-ups are carried out to ascertain which injuries caused death. This violates the global reporting trend that acknowledges RTDs in a 30-day cycle (World Health Organization, 2015).

Previous reports described the predominant accident measures as numerous transport and traffic situations. Such IDs include traffic congestion, person and activity factors, road types and sections, motor situations, police, weather (Zheng et al., 2020; Hordofa et al., 2018; Bucksuházy et al., 2020; Sun et al., 2019; Mohammed et al., 2019). This is the only way to classify these identifiers. In this section, we discuss some of the common circumstances in the country which are intended to fuel the RTAs and certain corrective actions and policies taken by the stakeholders involved.

In Kenya, tragic road injuries are now facing unprecedented danger. In contrast, injury mortality rose by 26%, with injuries rising by 46.5% between January 2015 and January 2020. (Muguro, Sasaki, Matsushita & Njeri, 2020). In order to resolve the danger and to curb the actions of the pilot, all stakeholders need immédiate action. According to data tablets from the National Highway Safety Administration (NHTSA), National Center for Statistics and Research, 2017, academic bus-related deaths killed 117 people nationwide in 2018.

NHTSA defines an event involving an accident connected to a school bus that specifically or implicitly affects a vehicle, irrespective of its body configuration, as a school bus. This covers injuries with kids in or out of a car. From 2009 to 2018, about 70% of the fatalities in school bus accidents were non-school vehicle drivers and 17% were footbusses. Any 5% were drivers of school buses, 4% school taxi drivers and 2% pedal bikers. From 2008 to 2018, about 36% of those involved in school bus crashes were school bus drivers, 8% were school bus drivers, and 51% were other vehicle drivers. Many were peaters, pedal bikers, and other or unknown persons (National Center for Statistics and Analysis, 2017).

Millions of kids would go to school every day from home and vice versa. Many children get trapped in a school bus park after going to school, skipping a bus, running an inappropriate bus, or leaving a missed bus station without any sort of supervision (Shaaban et al., 2013). Studies carried out by the Scottish Executive Central Research

Unit in order to raise the share of non-car transport to school show that bus or coach transport is by far the safest mode of travel (Shaaban et al., 2013). The school bus is universally used to bring school children to and from school and is an important part of the educational system. It is a big, painted vehicle that takes children to school and returns them to their homes in many countries around the world. They are commonly painted yellow for visibility, protection and fitted with advanced traffic warning systems (Gangopadhyay, Dev, Ara, Ghoshal & Das, 2011).

1.3 Statement of the Problem

In Kenya, safety in cars is a big concern. Annual total of 3, 000 deaths and 9,000 serious injuries was reported in around 26,000 car accidents. This reflects over 33 crashes and nine deaths every day. The World Street Safety Report of the United Nations points out that road accidents in Kenya represent the third cause of death after malaria and HIV/AIDS, posing a public health risk, morbidity and associated health costs. The overall population is estimated at 1.2 million and is injured worldwide in traffic accidents.

The world's 9th leading causes of disease load in terms of disability-adjusted life years (DALYS) are now the death and injuries related to traffic accidents (United Nations General Assembly, 2010). Although these numbers are multinational, they were adequate to enable the UN to organize international efforts in the fight against road injuries. The UN announced a decade of road safety action from 2011 to 2020 as a result of these dreadful numbers. The goal of a 10-year action plan is to stop the rise of fatalities and injuries and thus halve the trend by 2015 (United Nations General Assembly, 2010).

Over the last few years, many busses have been mobile coffins, as cars on Kenyan roads have fallen short of body building requirements. Busses are not designed to the appropriate specifications and thus crash on impact. In addition, the use of inadequate materials and bad workmanship by welders or suppliers who neglect the necessary spacing of frames that should sustain the bus body has been identified as a major cause for limited survival in the bus crash (Bergeron, 2018). If Kenya is to achieve its goals as set out in the 2030 Poverty Eradication Vision, road safety must be given priority. Poverty mitigation cannot be a fact if billions of shillings are invested on the aftermath of accident.

Despite the high social and economic costs, a comparatively limited amount of funding has been made in the production of road safety studies. Deaths and deaths are focused on data on frontal vehicle accidents (Smith, 2012). In addition, consumers and stakeholders are worried about the design of bus buses and the extent of crashworthiness based on previous vehicle injuries. According to researchers, bus vehicles involved in crashes mean that the design and weight of the material is a significant determinant of the safety of the vehicle.

It is also important to make passengers more vulnerable to fatalities and serious injury and vehicles before heading out on a long journey to ensure that they are roadworthy (Mwithimbu, 2014). As in other parts of the world, busses used to transport students tend to be more general-purpose vehicles used as school busses are visually identical to transit buses. In certain circumstances, school busses are contracted to transport ordinary passengers, such as funeral services, and are also often involved in collisions. Tens of children are treated in hospital emergency rooms every year in Kenya for accidents associated with school buses. There are such tragic ones as the ten school children who died in Mwingi after a good Coast Holiday Trip (Moses, 2018).

With parents preferring to live away from their preferred schools, the need for school buses has arisen an unprecedented demand for the service. A high percentage of school-going children rely on the type of school transport for their regular transportation. During extracurricular sports, such as football games and school busses, one of the main mass transport services in the world and more so in urban centres.

Not all school bus transit services comply with the necessary safety requirements. According to NTSA, school busses involved in accidents based on prior observations, school busses on impact, it is apparent that the body construction of the bus is poor and thus not in line with the recommended production vehicle body level (Moses, 2018). The issue under investigation was that, in the case of a bus collision, why would the bus chassis or bus frame collapse after an accident? Because of the safety aspect of the bus vehicle system, it was very important to be researched and learned in order to comply with the specification and the structure.

The number of school bus and van crashes in Kenya has been worrying for parents, relatives and Kenyans, believing that young children are losing their lives (Obuhuma, Ondiek & Ombui, 2013). Failure of bus vehicle construction frames is one of the key factors that has been widely neglected during a crash which causing a high number of deaths in bus crashes. An in-depth investigation can help to provide insight into the causes of failure or crashworthiness in order to provide details about how best to minimize the number of fatalities. It was evident from the wreckage of school bus crashes that the new requirements applied in the manufacturing of school busses in Kenya were troublesome. The study therefore sought to investigate the influence of school bus vehicle designs and materials on school bus crashworthiness among vehicle body construction companies in Nairobi County, Kenya.

1.4 Purpose of the Study

The purpose of this study was to determine the effect of school bus vehicle structure designs and materials on crashworthiness of school bus among vehicle body construction companies in Nairobi County in Kenya.

1.5 Objectives of the Study

1.5.1 Main Objective

The main objective of the study was to establish bus vehicle structure designs and materials used as well as its influence on school bus crashworthiness in Kenya.

1.5.2 Specific Objectives

The following were the specific objectives of the study:

1. To establish the effect of locally designed school bus vehicle structure on crashworthiness.
2. To determine the relationship between competencies skills of vehicle structure builders on crashworthiness of school bus.
3. To establish the effect of engineering materials used to build vehicle structure on crashworthiness of school bus.
4. To identify the influence of equipment used to build school bus vehicle structure on crashworthiness.
5. To determine the effect of welding type on crashworthiness of school bus.
6. To determine the influence of vehicle inspection tests on crashworthiness of school bus.
7. Determine the effect of customer needs of vehicle structure design on crashworthiness of school bus.

1.6 Research Questions of the Study

This study sought to answer the following questions:

1. What is the effect of locally designed school bus vehicle structure on crashworthiness?
2. Is there any relationship between competencies skills of vehicle structure builders on crashworthiness of school bus?
3. What is the effect of engineering materials used to build bus vehicle structure in relation to crashworthiness of school bus?
4. What is the influence of equipment used to build school bus vehicle structure on crashworthiness?
5. What is the effect of welding type in school bus vehicle structure on crashworthiness?
6. What is the influence of school bus vehicle structure inspection tests on crashworthiness?
7. What is the effect of customer needs of school bus vehicle structure design on crashworthiness?

1.7 Hypotheses of the Study

This study sought to address the following hypotheses:

H_{o1}: There is no significant effect of locally designed school bus vehicle structure on crashworthiness.

H_{o2}: There is no significant relationship between competencies skills of vehicle structure builders on crashworthiness of school bus.

H_{o3}: There is no significant influence of engineering materials used to build bus vehicle structure on crashworthiness.

H_{o4}: There is no significant influence of equipment used to build school bus vehicle structure on crashworthiness.

H_{o5}: There is no significant influence of welding type in school bus vehicle structure on crashworthiness.

H_{o6}: There is no significant influence of school bus vehicle structure inspection tests on crashworthiness.

H_{o7}: There is no significant effect of customer needs for school bus vehicle structure on crashworthiness.

1.8 Justification of the Study

Despite steady advances in vehicle safety, crashworthiness and vehicle crash – causing defects are still widespread. Millions of defective vehicles capable of causing severe injuries and death in otherwise unremarkable accidents remain on the roads today, but few realize the nature and scope of the problem. This state of affairs necessitates the need for research to be undertaken. Moreover, there is limited and scarce documented literature concerning vehicle crashworthiness in Kenya and in view of this, the researcher derives great source of motivation to undertake this study in order to fill the gap and add to the body of knowledge.

1.9 Significance of the Study

The significance of this study in the field of education is in view of those charged with protecting the safety of school children/ students to apply the recommendations of the study to select safer method of transportation and to manage the risks associated with it. Evaluating and identifying interventions that are effective and that may be applied widely should help to achieve the complementary goal of safe school transportation. Furthermore, the findings of this study concerning school bus vehicle structures designs and materials on school bus crashworthiness will help inform school management on possible steps to undertake while planning to procure a new school bus as compared to a second hand or any other.

This study may be of great benefit to the National transport and safety Authority of Kenya, Kenya Bureau of Standards, Kenya Association of Bus Manufacturers, among other relevant stakeholders as they seek to address road safety challenges in Kenya. The study also compared and contrasted the effects of all the above noted objectives in regard to severity of an accident and gave recommendation on new findings on enhancing safety of a school bus.

The immediate beneficiaries are mostly the students and teachers who are at a risk of rampant road accidents. Most of the casualties are the productive young adults who contribute enormously to the development of the Kenyan economy. Accidents generates huge burden on the Government's resources (health bill) which would otherwise be used on other important developments like road infrastructure, education, security and many more. It is hoped that the Government, National Transport and Safety Authority and bus vehicle structure builders will make the right decisions when reviewing safety of the school buses in our country after analyzing this study. This study will also serve as a source of additional knowledge to scholars who may need to use this information in future.

1.10 Assumptions of the Study

The study assumed that:

a) It was assumed that all respondents understood the vehicle structures designs and materials used and crashworthiness of school bus.

b) The researcher was given access to the anticipated manufacturing firms and able to secure the relevant information sought.

c) It was also assumed that management of bus body building firms allowed an efficient and effective data collection

1.11 Scope of the Study

The scope of this study concerned school bus vehicle structures designs and materials used and crashworthiness. This was achieved by establishing the locally designed bus vehicle structure, vehicle design tools and equipment as used, competencies and skills of technicians in industry, the engineering materials used in the vehicle structure design, the equipment and tools used in bus manufacturing, the welding type, vehicle inspection tests and customer needs. The context of the study was based in bus vehicle manufacturing companies in Nairobi city of Kenya.

This was done through an investigation of construction process of bus vehicle structure design, standards, fabrication methods used an assessment of material selection used for the frames and sheet metal and studying designs applied by the manufacturing companies by observation method. The scope of this study involved an investigation on school bus vehicle structure design and the material used and the level of vehicle structure crashworthiness in the event of vehicle impact collision. The respondents of the study constituted managers, technicians and supervisors in bus vehicle structure construction companies and relevant regulatory agencies in Kenya, such as NTSA, KEBS and NPS.

1.12 Limitations of the Study

This study was based on vehicle manufacturing companies in Nairobi city and the move to sample out a few and generalize might not be a true representation of the bus vehicle structure construction companies. In order to mitigate such a challenge, the researcher enhanced the sampling frame and incorporated a significant number of sampling units to ensure representation. Considering the fact of vehicle structure crashworthiness, indeed everyone sought to find out the truth behind school buses involved in accidents, some of the respondents may have avoided giving information for the fear of incrimination. In such a case, the researcher had to inform the respondent about the need to find the truth and promise non-disclosure of the identity of respondents and the confidentiality of the information they gave.

Vehicle crashworthiness of school bus occurs countrywide and such a situation requires a long time to visit all vehicle manufacturing companies to find out the truth about what causes the accidents. The researcher mitigated this by sampling the vehicle manufacturing companies in Nairobi County as a representative of other body building companies. The researcher used questionnaires and interviews to collect the information from respondents on vehicle structures designs and materials used and crashworthiness.

1.13 Theoretical Framework

Various methods are widely used to assist designers, though some additional ideas give more analytically robust assistance to engineering designers. To collect knowledge from members in the design procedure, the most realistic technique is used to enhance the design process and other common approaches (the Pugh Method, Quality Function Deployment, Decision Matrix techniques and the Analytical Hierarchy Process). These approaches provide a reasonably high standard of discretionary judgment. Variability, consistence and complexity in the concept process are approached with alternative approaches (Projected Latent Structure, the Taguchi method and Six Sigma).

This procedure is more analytical and is typically paired with the methods employed in the manufacturing of the goods. Alternatives for artists are also used for other approaches (artificial intelligence and TRIZ). In addition to this, there are the less common theories of architecture (Dym, Suh's Axiomatic, Yoshikawa's and Math

Framework) that offer a more solid theoretical foundation. Finally, these methods are primarily used in the fields of management science and the economy and are debated in recent research on the applicability of engineering design decision making. Dym, the Suh axiomatic philosophy, the theory of mathematical form and the Taguchi theory of strong conception accompanied this dissertation.

1.13.1 Axiomatic Design Theory

The Axiomatic Architecture (AD) theory was developed in 1990 by Suh. Its goal is 'to provide the designer with a theoretical framework on which to draw on realistic and rational processes and tools for the improvement of the design activities" (Suh, 1990). It ensures a good approach that meets "what we need" with "How we meet the requirements." Human security understanding has grown in recent decades in the design process. In the design process, the key burden for keeping a device secure lies (Caputo, Pelagagge & Salini, 2013).

In this case, this endeavor to integrate the experience of protection of human beings into the design process is included in the term "Design for Human Safety" (Sadeghi, Mathieu, Tricot, Al Bassit, Ghemraoui, 2013). A significant number of research are used to determine security of architecture theories, approaches, methodologies and/or procedures. The Pahl and Beitz (SA), (2007) and Suh's axiomatic principle (AD) philosophy, are today in their official form (Pahl, Beitz, Feldhusen and Grote) (Suh, 1990 and Suh, 2001). There are some of the architecture theories most widely recognised.

The fundamental axioms of interpretation and decision-making are presented in Suh's AD (1990). The AD theory is more successful as far as DfHS is concerned. In this way, this principle is important because of its ability to present design requirements and corresponding design constraints, including design parameters. Efforts were made in recent years to incorporate the DfHS AD principles. The number of studies using AD principles is rising gradually because the dominance of AD gives definitive advantages in overcoming multi-criteria decision-making challenges. convergence between AD and other architecture philosophies, approaches, tools and/or tactics, including hierarchy, has also emerged in the literature.

In this Suh, (1990) theory, architecture is defined as a diagram of how and what the artists want. The axiomatic model of a domain, the client domain, the logical domain, the physical domain and the method domain, is known for its architecture as a sequence of mappings in 4 domain fields. Different elements describe the specifications of each domain: client properties, functions and method variables, specification parameters (DPs) (PVs). There are also limits (Cs).

The axiomatic theory of programming extends to many different fields and structural forms. In the middle of the 1970s, Suh applied the technique to a research, widespread, codified and standardized design procedure. Four domains are the foundation of the method of axiomatic design: 1) the user domain, 2) the technical domain, 3) the physics domain, 4) the process domain to systematize the thinking process and to create a division between the various design practices (Matt, 2009).

The customer domain includes the properties of the so-called user value (CA) and the feature domain (FRs) is extracted from these. Functional Requirements), the Design Domain includes the Specification Parameters (DPs) for the eventual execution of the FRs, the transition into procedure is governed by the Process Variables (PVs) in the FRs (Suh, 2009). The center of AD theory is defined as the required and adequate requirement of the "good" nature of the product or technique via two axioms, the Independence Axiom (1st axiom) and the Information Axiom (2nd axiom).

(1) uniqueness axiom: retains freedom of FR. Suh (1990) suggested two axioms for effective architecture. Mapping between the FRs and the DPs within a suitable architecture ensures that each FR can be carried out without affecting the other FRs; (2) an information axiom: decreases the contents of concept information to a minimum. If a set of designs complies with the same conditions and the axiom of independence, the minimum information content should be given. A quantitative estimation of the importance of this design is given by the information axiom. Axiomatic Architecture has been used as a method for device design and is mostly used to design increasingly complicated systems.

Axiomatic Simulation is also increasingly used for the design of manufacturing systems in addition to many other diverse issues and decision-making problems. It is appropriate to organize complex challenges into smaller and more functional workplaces because of its organizational nature and its top-down approach. The use of solutions and design parameters (independence and information axioms) can be defined separately, and can also specify the best alternate solution for the system. As AD's dominance gives policymakers considerable benefits in overcoming multi-criteria decision-making challenges, the number of studies using the AD concepts is growing (Kulak Cebi & Kahraman 2010).

Axioms are disadvantaged because the definition approach appears to be not total and maximum. Axiomatic architecture is also used in better practical implementations in combination with other design techniques. An individual axiom can determine which design parameters in the stringent Taguchi methods in order to achieve a solid design. Axiom criteria are also used to test concepts in the TRIZ protocol (Mann, 1999). There is no top classification alternative in the axiomatic structure system. Sadly, a new choice may impact the rating of existing options, which are considered unacceptable in the decision-making stage. The structure of hierarchy study has problems of complexity which can be used only in approximation. The methodology therefore would not have a basis for assessing whether or not ambiguity can be removed.

The biggest advantage of the theoretical hierarchy system is easier interpretation and implementation. Decisions may be useful in the case of a significant failure and a full array of alternatives defined a priori in powerful control variables. The dilemma with the research Hierarchy is not only to solve problems required to gain interest in a choice of alternative, but also the theoretical features listed above. The simplistic way the system can answer complicated questions limits its ability.

1.13.2 Mathematical Framework Theory for Engineering Design

The decision-based engineering design architecture argues that a major part of building requires decision making processes which would provide theological guidelines on the use of decision-making tools in industrial engineering. This is an unmissable prerequisite which enables definitions to conform to the theory of decision-making. And this dissuades paradoxical results by recommending possibly the worst design option during the design process. In the last 300 years, systematic theory of choice has advanced and is embedded in many mathematicians and economists' work, including Daniel Bernoulli, Charles Lutwidge Dodgson (Lewis Carroll), John von Neumann, Oskar Morgenstern and Kenneth Arrow. The results from the mathematicians and economists Hazelrigg (1998, 1999) set up a quantitative policy for designing engineering, while extending previous work of people including Tribus (1969), De Neufville (1990) and Sage (1977).

The Hazelrigg framework seeks to provide an independent method for the classification of possible engineering concept alternatives. The system takes into account certain primary design considerations not known by other approaches within a decision-making theory: (1) all design decisions will be made in significant uncertainty and risk circumstances; (2) Those priorities of critical value in the decision-making process are that of the decision-maker (not those of customers or stakeholders); and (3) the alternatives must be ranked on a transparent and checked real-scale measure. Thus, in line with von Neumann-Morgenstern utility theory, Hazelrigg uses the option by the CEO of the company or other decision-making authority as the basis to guarantee the metric's validity under volatility and risk as a ratio scalar measure (usually the net current value of the design cash flow).

Hazelrigg adds two axioms to von Neumann or Morgenstern, but the first axioms can be picked out from Neumann morning star axioms and are only given for convenience. The two further axioms are as follows: Axiom 1, Axiom of deterministic decision making. The decision-choice maker's is the preferable alternative provided a set of alternatives to choose from each with a known, deterrent effect. Axiom 8, Engineering design axiom of truth: all engineering designs are explicitly chosen from a selection of possible designs.

Von Neumann-axioms Morgenstern's establish a comparison structure with known alternatives. It is not true that a tested solution will be equivalent to an uncertain one, and thus some engineers suggested that the framework of the Hazelrigg is not exact. Axiom 8, in which each design selected is an appropriate alternative in the selection choice, means that Neumann-findings Morgenstern's refer to the engineering design (it should be intuitively obvious since we are not producing things we never dreamed before).

The end of the von Neumann-Morgenstern axioms is two: the theorem on utility expectations is the preferred choice with the highest expected value given two alternatives, each with the necessary potential results. The theorem of the substitution, the decision-maker, is indifferent between a lottery and a certain outcome, whose utility correlates to the forecast value of the lottery and for analysis the two should be replaced.

These engineering concepts were introduced early in Greenberg and Hazelrigg (1974). Thurston & al. (1994) and several other recent papers have expanded engineering architecture decision making theory but largely neglect decision-makers' sophistication and approach to risk. They are the latest developments in utility theory. The axioms of von Neumann and Morgenstern were used by Marston and Mistree (1997) to facilitate the integration of further realms into design theory such as the subjectivity of alternatives and expectations for designers. The aptitude and effectiveness of a decision-making design was measured by Thurston (2001). Of course, the desirability of the design for the consumer is a crucial element in the formulation of the research function, which usually helps the designer's company as a result of the demand to pay.

Kenneth Arrow, the winner of the 1951 Nobel Prize, offered conclusions of extreme value for the architecture of engineering. For example, if alternative A is preferable for alternative B for both conditions and each measure, then the selection protocol does not select B over A. The selection process defines six requirements that must be met through the filtering process. It is then demonstrated that no selection method can be assumed to produce a true outcome for three or more alternatives and three or more selection parameters (e.g. by voters). Arrow's Impossibility hypothesis refers to a number of tools for modeling simplistic multi-criterium decision-making methods.

The early applications for engineering design are found at Dyer and Miles (1976). The recent Allen research (2001) reveals that a deterioration of Arrow's axioms enables risk-adverse group-determination opportunities in uncertain conditions in the context of a decision-making process for von Neumann and Morgenstern. In consideration of the widespread presence of many individuals in a design process, Scott and Antonsson (1999) suggest that engineering design is closer to the requirements of several decision makers than to the principle of social decision-making.

1.13.3 Taguchi Method

Dr. Genichi Taguchi offered new mathematical methodologies at the end of 1940 which were useful instruments for developing and successfully applying the method (Madhav, 2006). In the design and construction of the component, known as the quality control off-line, Taguchi methodology is widely used. The Taguchi method is a methodology used for designing and performing experiments in order to refine the idea of the system or product of which the structure involves control factors, noise factors and interaction factors. Taguchi is a systematic experiment that lets you choose a product or technique to achieve maximum performance, consistency and cost more reliability in the operating environment.

Taguchi is a systemic experiment which enables you to choose a product or technique to achieve maximum efficiency, accuracy and cost-effectiveness. Taguchi architecture attempts to classify controllable influences that reduce the influence of sound factors referred to as sound factors. A device meant to do this would improve reliability, irrespective of the consequences of uncontrollable factors. The Taguchi solution has become well known in recent years as a conductive engineering optimisation strategy because of its high performance and excellent reliability (Khalkhali et al., 2017b). Some assumptions have been made that qualities should be determined by deviation from the target value, rather than by compliance with the preset tolerance cap, a fixed loss function established that provides an indicator of a deception of the client when the product is generated when it varies from the target value.

The durability of products poses external challenges for the consumer, the innovation architecture must have a quality product, which is oriented towards methods and environmental vulnerabilities, while staying oblivious. Taguchi advocates the use of mathematical methods throughout the design process, from conceptual ideas to commercial applications. He was the first to stress that mathematical planning was necessary and the experimental research was carried out to define and quantify the reasons for uncertainty and sensitivity in order to help overcome problems in design engineering. The creation of the Taguchi parameter design is especially interesting where the non-linearity of the reaction is used to decrease the design sensitivity to a given degree of noise variability in production and operation. Taguchi's main contribution to engineering design experience reflects on the need, in performance and environmental variables, to analyze product responses to uncertainty (Ross, 1996).

This research based on Genichi Taguchi's robust design theory in the early fifties. The principle of Taguchi of a sustainable product and service design should be so designed that it is completely faulty and high quality. A solid specification is one where parameter values have been selected in order to execute the product or process efficiently, even in the face of difficult to control variables. Taguchi advocates the use of various experimental designs to determine the optimal parameter settings as shown in Figure 1.1.

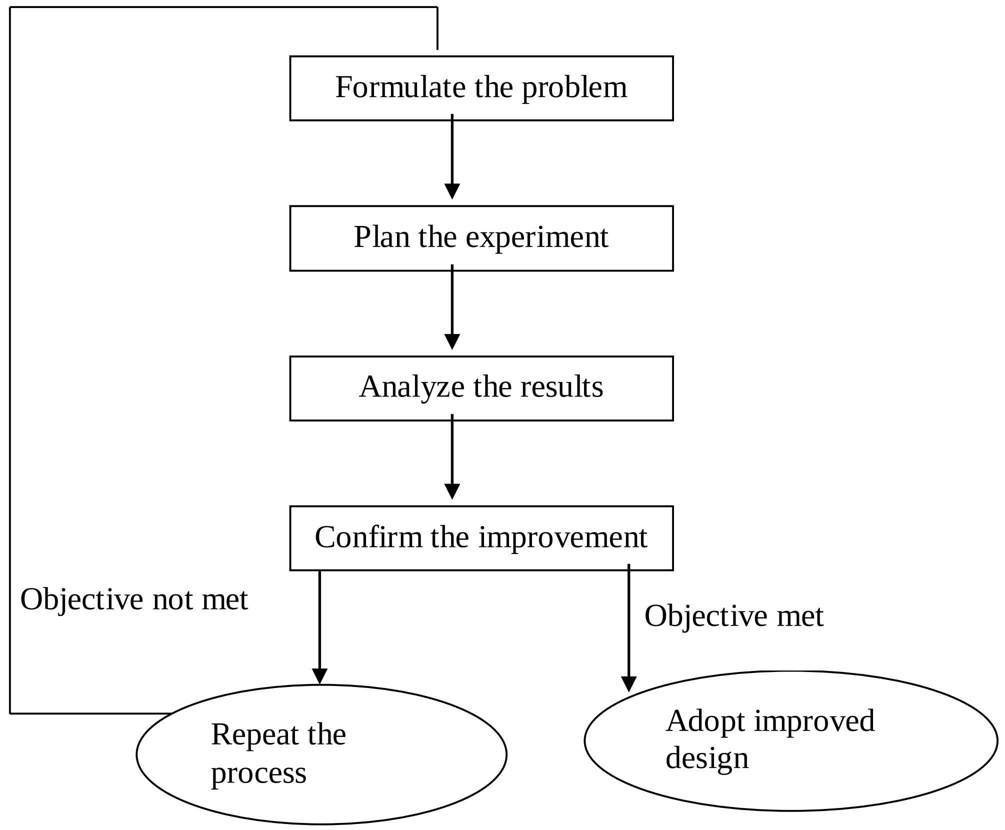

Figure 1.1: The four major steps in the robust design methodology.

(Source: Corbett, Dooner & *et al.*, 2004).

In the architecture of the system, robustness ensures that the product can sustain reliable efficiency with minimum disruption due to changes in uncontrollable conditions in its operating environment. In process design, robustness ensures that the process proceeds to deliver a successful product with limited impact due to uncontrollable changes in its operating environment. The tolerance design process aims to strike a balance between setting broad tolerances to promote production and minimizing tolerances to maximize product efficiency (Groover, 2001).

In device design, robustness requires the use of technical experience and research to create a prototype design that satisfies the needs of the user. At the design stage of the project, the system design refers to the final design stage of the product, the system design refers to the final product setup and specifications, including the starting materials, parts and subassemblies. For example, in the construction of a modern car, the device design involves the size of the vehicle, its styling, the size and strength of the engine and other features that target it for a specific segment of the market (Groover, 2001). From literature reviews Taguchi and axiomatic methods are considered to provide reliable, robust design and development during bus body construction.

1.14 Conceptual Framework

In the diagrammatic view of the conceptual framework, the independent variables are the locally designed bus vehicle structure, vehicle design tools and equipment as used, competencies and skills comprising of the education and skills possessed by technicians in industry and personnel in government agencies and private sector players, the engineering materials used in the vehicle structure design and ultimate bus construction, the equipment and tools used in bus manufacturing, the welding type and vehicle inspection tests. The dependent variable is the vehicle crashworthiness, which according to the diagram depends on, the vehicle design (tools and equipment), the education and skills possessed by the technicians in vehicle construction industry and the customers' needs or tastes.

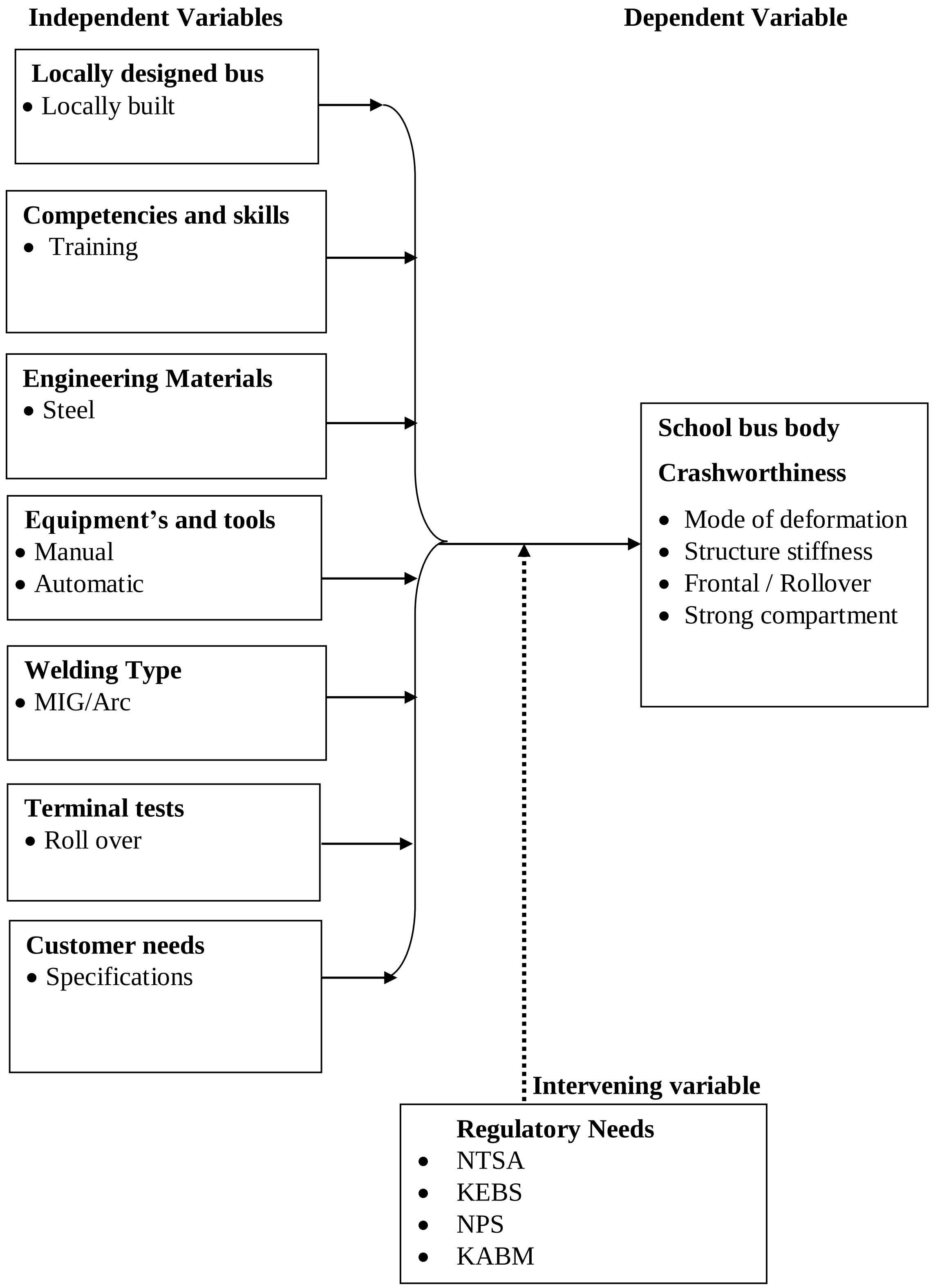

Figure 1.2: Conceptual Framework.

Source : Author, 2017)

The intervening variables include the law enforcement agencies such as the highway National Traffic Police, government of Kenya regulatory agencies such as the NTSA, KEBS and the Motor Vehicle Inspection Unit. Secondly, vehicle crashworthiness depends on how the vehicle was designed, the materials used in the manufacture, the education and skills as used by the school bus body building technicians in vehicle construction industry and the customers' preferences or tastes based on bus vehicle structure safety needs and customers purchasing ability.

1.15 Operational Definition of Terms

Bodywork – means a complete structure of the vehicle in running order, including all structural elements which form the passenger compartment, driver's compartment, baggage compartment and spaces for the mechanical units and components.

Bus Body builders – these are the accredited companies which construct and assemble the vehicle bodies per the customer requirements but adhering to the Government set standards

Crashworthiness – it means the bus ability to provide inert safety for the passengers through dissipation of the vehicle kinetic energy during crash accidents.

Design - the development of an engineering product with considerable features such as dimensional aspects as size, shape, material application for desired end product.

Engineering materials - materials used in the design and manufacture of products such as vehicle bodies.

Roadworthiness – state or condition of a vehicle that is considered generally of good mechanical and overall vehicle body safe to operate on the road in view of road transport safety.

Robust design – consistent quality performance of an engineering product even in the face of difficult uncontrollable factors to the satisfaction of the customers.

Rollover test – means a test on a complete, full- scale vehicle to prove the required strength of the superstructure**.**

School bus – vehicle structure designed and build with the aim of transporting school going pupils or students and teachers although can also be hired by public.

Strength of materials – an examination of engineering materials in terms of impact strengths such as tensile strength, shear strength, compressive, stiff, bending, stress – strain, among others.

Superstructure – vehicle structure with an elaborate use of complex engineering materials.

Vehicle safety – based on the design consideration and the materials used in vehicle body building or manufacture**.**

Vehicle structure – the physical layout of a vehicle body in terms of the chassis, trusses or frames and the general vehicle body panels.

1.16 Chapter Summary

This chapter presented the background of the study on vehicle structure designs and materials on crashworthiness of school bus from global, regional and local perspective. It also gave the purpose, statement of the problem, objectives, research questions and hypothesis of the study. The justifications and significance of the study was given. The assumptions, scope and limitations of the study highlighted. Finally, presented the theoretical, conceptual framework and operational definition of terms.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presented the literature review with respect to the global, regional and local perspective in the following sections; school bus vehicle structure and crashworthiness, crash characteristics of bus vehicle structure, locally designed school bus vehicle structure, equipment and tools used for school bus vehicle structure, competency skills of bus vehicle structure builders, engineering materials used on bus vehicle structure, welding type on bus vehicle structure, bus vehicle structure inspection tests and crashworthiness, customer needs based on school bus vehicle structure and finally the knowledge gap.

2.2 School Bus Vehicle Structure and Crashworthiness

Crashworthiness is an engineering concept used to describe the capacity of the construction of the car to shield the passengers during impact (Jones, 2003). Crashworthiness is not only limited to the structure of bus buses, but is also applicable to other transport vehicles, such as ships, aircraft and trains. In reality, Thomas Andrews applied the first systematic and empirical study of the topic to railway axles between 1879 and 1890 (McQuaid & Jones 1999). In other words, crashworthiness is the method of maximizing a structure's crash efficiency by compromising it under impact to shield passengers from harm (Jones 2003).

Every year more than one million people are injured in traffic crashes (World Health Organization 2009). Guler, Elitok, Bayram and Stelzmann (2007) looked at the efficacy of the use of seatbelts in the rollover of buses. Writers sought to measure the risk of injuries to passengers and to compare the reliability of the use of seatbelts during a rollover collision. In all cases tested, the author uses LSTC for the calculation of passenger casualties to measure the Hybrid III 50th projectile dummy model. A driver without the seat belts, a 2-point lap belt and a 3-point shaulder belt are called passenger restrictions. During the rollover test the use of seat belts resulted in a reduction in the projection and disposal of bus riders and a decrease in injury.

Ko, Shin, Jeon and Cho (2009) have written a report on the crash and rollover features of a low-floor composite sandwich bus. In the vehicle structure was integrated the composite of the aluminum pinewood and fibreglass epoxy face sheets. This article analyzed two collision conditions, a frontal action of 60 km/h and an ECE-R66 rotation. No detailed validation effort was presented while checks for material properties were carried out on composite samples.

Ozcanli and Yilmaz (2014) studied the effect of the application of foam on the bus system in order to enhance their crashability in roll-over incidents. While the use of foam on structural beams reduced bus deformation, there was little effect (0.25 percent).

Iskandar and Li studied the ageing effects of corrasion and the mechanical properties of the rollover (2013). Data for the mechanical aspects of the corroded metals were used by the authors and added to the current model of FE buses. Conclusions suggest that the ageing effect has a major impact on car crash tolerance and lowers the stability of the buses.

During this research the machine and tests obtained in this area have shown that the crashworthiness of buses designed by numerous manufacturers is substantially different. Many structural characteristics which affect these variants, such as: tube favorites for the connection between tubes, wall-to-floor or wall-to-dach joints, external couch (thickness, material, cage link) and other layers (Bojanowski, 2010). In terms of crashworthiness, structural weakening of old busses is a significant problem in the case of an accident. Many factors contributed to the loss of structural integrity, such as operational schedule, environmental and loading impacts, and others. To improve the structure design for crashworthiness, it was required to understand the different factors affecting the crash process.

2.2.1 Crash Characteristics of bus Vehicle Structure.

Accidents are happening in a spontaneous way. The car can be affected at various speeds from either direction. It may also involve a vehicle impacting another vehicle which, in turn, may be the same or different from the first vehicle. This shows how the vehicle is impacted and shaped by injuries (Seiffert & Wech, 2007). A car also can affect a stiff fence, tree, light pylon, etc. that can result in extreme deceleration and high loads, as a stiff structure cannot bow to withstand any force from the effect.

The issues with crash resistance can be characterized by: displacement and energy according to Galganski (1993): Front length is minimized by existing design styles, but at the same time a high volume of energy is absorbed and interference in the compartment is reduced. Crash Pulse: Crash Pulse is a deceleration caused by a human body effect.

The HIC is used to measure a stroke-related brain damage that could be less than a certain limit as defined in the Regulations (Newman, 1980). Collision location: The structure shall be able to monitor the number of casualties in certain crash regions, such as frontal injury, side-collisions, rear trauma, and overturn. Collision location: Auto-compatibility: In the case of different type of vehicle caused by a collision involving two separate cars, the structure should be able to minimize accidents which can vary in size or weight.

Crash resistance naturally measures the ability of the vehicle structure to shield the passengers by collision and the structure itself needs to fulfill these criteria. To mitigate the energy effect, the structure must controllably withstand plastic deformation, to the degree practicable the residual energy impact that can then be controlled by the retention system; the structure must be predeformed. Good design should achieve these objectives at the same time as meet other design objectives, including convenience, usability, weight, fuel consumption, etc (Seiffert & Wech, 2007). The entire design process is very complex and there is good cooperation between the various disciplines. In order to achieve these goals, it is important to maintain a clear knowledge of the structural deformation mechanism and its purpose.

In general, the structure's deformation modes can be categorized into two main modes: the axial collapse mode, which is defined by the usual type of accordion folding; or the irregular folding of the walls. Cold bending mode, in which discreet plastic hinges are shaped, and the frame is folded in a pattern of attachment. The most advantageous form of collapse is pure axial collapse, since it involves the absorption of the most energy. The formation of complete plates along the beam/tube is important for an axial collapse, also called progressive folding. Although it is hardest to achieve and can be accomplished only during front-to-back crashes, front-to-back direct crashes or light off-angles collisions.

2.3 Locally Designed School Bus Vehicle structure

The school bus is universally used to bring school children to and from school and is an important part of the educational system. It is a big, painted vehicle that takes children to school and returns them to their homes in many countries around the world. School busses are known to be the safest mode of transport in urban environments, despite poor ergonomic interior architecture and a prevailing dangerous condition (Gangopadhyay, Dev, Ara, Ghoshal & Das, 2011). In the light of the 2014 Nirupama and Hafezi decisions made by bus drivers, road operators, school departments and parents, the welfare of school children may be specifically affected. School busses use each year on 10 billion unmatched trips to the USA for pupils. 475,000 school busses move 25 million children per day from and to schools and the related activities.

In the last 40 years, several studies on school busses and pupils' welfare have been carried out. The main conclusion of the studies is that a school bus is the best way for children to travel. The number of collisions, fatalities and deaths indicates that more school-aged children die in private vehicles than school buses. According to the 2013 National Transport and Safety Authority (NTSA), Road events are on the rise in Kenya with nearly 3,000 deaths per year. A total of 2,683 deaths had been caused by road collisages as of 8 November 2013, 5,485 serious injuries were recorded and 4,258 since January 2013 had been seriously injured.

The then Transport and Communications Cabinet Minister, Eng. The following is Michael Kamau (2013):

Due to bad carbodies crashing or shaving at the front, side or roller-over results, the number of deaths from a collision with PSVs was growing partly. The Ntulele bus crash, which recorded the largest number of deaths that year, on the May Mahiu-Narok highway on 29 August 2013, would be a clear example of this. The poor condition of the bus displaying the disintegration of the whole roof of the bus was one of the reasons for the loss of many lives (Ngeno, 2013).

The major safety elements in the building of the bus according to Gakuu (2014) are: roll over protection, front impact protection, protection against side impact, cross-member, gangway and seat layout, diagonal lateral walls, passenger door, passenger seat configurations. Gallows are the primary safety features of the Kenyan Kenyans Standards Office (KEBS) and the Kenyans Traffic Act (KVM) upper mound.

Gakou (2014) insists that busses also comply with minimum requirements such as:

protection against roll-over; protection against front impact; and protection against side impacts. The rolling protection of the passenger cabin would include gussets to increase force between side walls and the roof and diagonals. Protection for the front impact calls two options; one is the use of a diagonal column to protect the roof, directing the pulse force to the bottom by making a two-pin column solid bars and keeping a correct angle from the top to the floor, using a zi-zag link between the bar and from the column to the framework of the bus body. On the other hand, designers of bus buses, by reinforcing side pillars, may improve the roof. Side effect protection requires two recommended options: the use of the vertical triangular reinforcement underneath the floor supplying structural stability to survive lateral impact and roll-over; and the longitudinal triangular reinforcement of the floor surface.

The top stairs do not cross a corridor that prevents dangerous interference. If intrusion is present, the passenger seat should be made of circular tubing and the width of the frame should be 400 mm per seat, with neither a sharp curve nor protrusion of the seat. The front grille is lost and almost always locks and places traffic at risk. It should be connected by hinges to the bus body. Although the rear overhang should be up to 60 per cent of the wheel base estimated behind the rear axle to the rear bumper (road stability) (Gakuu, 2014).

After the Ntulele accident, stakeholders in the public transport industry came up with several measures to reduce death during such accidents, the main target being material used to assemble buses. Shatter-proof glass material has since been made a requirement for the windows, but many manufacturers do not adhere to that. Bus manufactures in Kenya now have to follow criteria such as floor heights, gang distance, seating arrangement, hand tracks and handholds, signage and lighting, emergency exits, fire protection and overhead baggage carriage sizes to ensure passenger safety. In order to ensure passenger safety, bus manufacturers in Kenya now have to follow standards such as height of the floor, door width, sitting structure and handrails, lighting and lighting, emergency exits, fire protection, and overhead carry rack dimensions. The new code also forces bus vehicle frame makers to apply best practices, for example good seat fixing and the use of fabrics like fabrics and plastics instead of heavy metals in seat grips (Gakuu, 2014).

According to industry players, it costs a total of KSh.1.5 million and more than Sh2 millions for large buses. It takes 30 days to create a body for smaller busses and 45 days for larger busses. A City-to-City bus rode to Ntulele, which killed 41 in August 2013, was quoted by former NTSA Chief Executive Officer. The roof of the bus had been torn off, the passengers had been tossed out, and the chassis of the bus had been seriously mangled. Until now, there have been no rules regulating body makers, resulting in busses in various sizes and designs, an inconvenient number of passenger seats and inclines, narrow alleys, and rotting windows and roofs (Ngugi, 2018). Concerns over local bus protection prompted Toyota and Isuzu East Africa to nominate international companies to develop their Hino and Isuzu busses, respectively. Toyota Kenya, in mid-2013, dealt a blow to local body makers after the South African company Busmark contracted to supply bus vehicle bodies for its busses under the Hino name due to quality and safety issues.

General Motors, now Isuzu East Africa, followed in October of that year and partnered with GB Polo, the Cairo-based bus body maker, to create buses after local body builders were unable to provide guarantee on existing quality and safety requirements. The bus industry in Kenya is dominated by existing players such as Toyota (Hino), CMC (Man, UD), Isuzu East Africa and Simba Colt (Fuso, Mitsubishi) who need manufacturing services. The race to reach the latest requirements arrives only as Toyota Kenya grapples with litigation alleging to have delivered defective busses and trucks (Moses, 2018).

Accident testing reveals that the impact that passengers may have on the side wall, on the luggage rack, and even on interaction with the occupants may cause damage to the rollover collisions. Without the aforementioned minimum criteria for a bus vehicle or coach rollover, the occupant will have a larger gap from the rotation core than the automotive occupant. That's the rolling crash that causes the high number of deaths in Kenya, especially fatal. Lateral windows being destroyed, there is an increased chance of passenger dismissal and damage. When no ejection happens, the most prominent body regions damaged in a roll-up are the head and spine and the shoulder.

2.4 Equipment and Tools used for School Bus Vehicle structure

The safety within the vehicle category is similar to those found in the Hungarian study in the prediction category, which mostly defined this classification by light injuries. Intrusion, full expulsion and partial exection are three main circumstances leading to serious or fatal injuries to bus riders. Bus protection studies experts agree that the use of protective belts will reduce total and partial eyecasting and projection (Saul, 2007 & Mayrhofer, Steffan and Hoschopf, 2005). European Parliament (EU) Directive 2001/85/EC defining the required passenger seat belts on all new buses all new passenger seat belts is applied (Albertson and Falkmer, 2005).

NHTSA declared in November 2013 a similar law for motor coaches (NHTSA 2013). The State of Florida offers passenger seat belts on all paratransit buses purchased by the state. The key component of injuries, both minor and catastrophic, can only be mitigated by the reinforcement of the superstructural system. In the United States, this aim has been achieved by using FMVSS 220, which allows the roof structure to stand against a low deformation of symmetrical static loads. For this reason, UNECE

Regulation 66 (ECE-R66) is the most common international standard adopted by more than 40 countries in the world (UNECE, 2006). In order to give passengers survival space, ECE-R66 specifies the residual space that must remain unchanged in the daily roll over.

The author has evaluated more than 300 bus overflows in one of the studies (Matolcsy, 2007). The author gave a summary of the PRA in which passengers could not be protected, not accepting very serious injuries. Of the results, this group comprises 191 roll-overs. For the crash and death rates associated with joining the bus system in the survival area, the 191 PRAs were analyzed. This resulted in the fatality rate being 15 times higher when the survival room was broken and the serious injury rate was 3.5 times more than when the survival region was maintained. The U.S. administration has published regulations on problems like braking, emergency doors, floor power, seating structures, locks, mirrors, fuel systems and crash tolerance of body and frame. As a result of these rules, school busses are considerably safer than all modes of travel used for school-aged students.

Unlike big buses, cutaway busses are being designed in two different phases (Bojanowski et al., 2011). In the first level, an automobile frame with a driver's cab is designed by a major vehicle maker. Next, a smaller firm attaches a passenger cabin structure to the customer's order. The biggest concern with such a process is that, unlike large automotive producers, smaller firms cannot afford to carry out the same amount of R&D and research. Another aspect that makes these cars special is the lack of applicable safety regulations in the United States.

In order to determine the overall crash tolerance of the cuts, experimental testing methodology and quantitative dynamics studies have been undertaken (Kwasniewski et al., 2009). The UNECE Regulation 66 (ECE-R66) (UNECE 2006) was introduced and established as the main standard for such evaluations in order to evaluate the safety of these cars by more than 40 countries around the world. The ECE-R66 defines a buffer region (rests) which must remain intact during a special inspection of the rollover. The test consists of positioning the bus in an awkward balanced position on a flat basculating surface. The bus then sinks under its own weight into an 800 mm long, smooth concrete ditch and the deformation of the side walls is measured.

Nowadays, there is a strong market for lightweight energy efficient and secure systems for transport applications (SAFEJOINT, 2017). The key factors of great strain are heavy competition, safety standards and consumer requirements for motor cars, and buses and buses. High strength steel, due to its high mechanical properties, is still the most common material used at reasonable cost. Typically, the bus body consists of hollow, rectangular transverse beams that are glued together by a soldering operation. The major advantages of the soldering process are that the welding process is more rapid, longer and quicker, no material for the filler is required and dimensional precision during soldering with local heating better maintained (Ertas, Vardar, Sonmez & Solim 2008 and Dost, Khan & Aziz 2012).

But soldering requires high temperatures that prevent the formation at the joint interface of a brittle coating of an intermetallic compound. There is also a premature lack of corrosion, leading to more regular checks. The bus body undergoes a variety of dynamic loads, especially in some welded joints, causing problems with cracking due to fatigue. from pavement to frame (Perez, Badea & Arribas, 2014). The manufacturers of buses and coaches would develop and implement new designs, components and assembly methods.

Various research work was carried out on the incorporation of different material forms for the manufacture of bus and coach car frame, for example alloys, Aluminum Muttana

Sardar, Mubashir (2011) & Constellium (2017) and LITEBUS composite (2017) & Colombo and Vergani (2010). Although fiber-enhanced composites have shown promise in recent decades for vehicle component, due to numerous pitfalls, including low production, automation rates and significant costs, the implementation remains to be carried out at a mass production stage (Song, Youn & Gutowski, 2009).

Many transport industries not only in aeronautics and aerospace, but also in car manufacturing, are utilizing multi-material construction techniques (Ocana, Arenas, Alia & Narbon 2015). This consists of not only conventional stainless steel parts, but also a mix of components made of different lightweight materials, such as aluminum alloys or composites that greatly minimize vehicle weight. However, the replacement of materials is not an easy job, as mechanical properties of laminates are evolving in particular (Korta & Uhl, 2013). New assembly methods for different materials are now possible due to the use of structural adhesives.

The manufacturing of hybrids gradually uses structural adhesive joints Lauter, Troster and Reuter (2013) & Marques, da Silva, Flaviani (2015) and complex systems for civil, vehicle and aerospace applications (Lamberti, Maurel-Pantel, Ascione & Lebon) (2016). They offer considerable advantages over other types of joints because they are quick and flexible. It is able to attach diverse materials (e.g. metals made of composite), less corrosion (preventing the creation of galvanic corrosion batteries), and doesn't require great inversions, along with the constant application of stress during loading (Kah, Suoranta & Martikainen 2014).

A variety of recent experiments have been carried out on the conduct of structural multi-material adhesives. In Korta, Mlyniec and Uhl, the mechanical efficiency of the adhesive joint was checked for the effects of moisture cycling (2015). In the wet and dry conditions on CFRP single lap joints Agarwal, Foster, Hamed, has investigated the thermo-mechanical load effects (Carbon Fibre Reinforced Polymer). According to Ghosh and Kumar, Preeti and Rajoria, as features of the mechanical and chemical surface treatment of substrates, the dissimilar adhesive joints on mild aluminum sheets and stainless steel are characteristic. Fluid and weighting properties of nano-composite epoxy adhesives containing different TiO2 substratum concentrations were also taken into account. Also measured was the effect on the shear strength of the joints of the adhesive bond line thickness in lap joints of the faying surfaces of the various materials treated with different care. The fatigue crack problem in welded joints of steel bus systems is addressed by a new concept of joint made with CFRP.

The steel CFRP adhesive joint was defined by the curves obtained from shear tests, showing that the proposal was adequate to resolve the issue. In accordance with EN 1465:2009 (UNE-EN 11465) tests are carried out on shear (2009). These checks effectively determine the suitability of the adhesive and surface solution used for the problem under consideration. The shear measurements are performed in a universal 2 mm/min measuring unit. While it is unusual, about 4 to 5 per cent of bus accidents being rollovers, causing almost 50 per cent of serious and deadly casualties, Rollover was known as a most dangerous accident for buses (Matolcsy, 2007; Liang and Le, 2010 & Bojanowski, 2010). The science community is well known for this and bus crash regulations and protection legislation depend on rollover.

There are now worldwide two main protection standards for roof integrity. Busses are subject to Federal Engine Safety Standard 220 (FMVSS220) in the USA and Canada, and are subject to the protection of school bus rolling stock (US DOT, 1998). For the rollover of school busses, FMVSS 220 defines efficience requirements for all other bus types sold in the United States, although it is most common in the United States. Another safety measure used in the unintentional examination of the buses is United

Nations Economic Commission for Europe Regulation 66, 'Uniform technical requirements for recognition by large passenger vehicles of the strength of their superstructure' (ECE-R66). ECE-R66 has now been adopted by over 40 countries as the most common safety standard by busses in the world (Bojanowski, et al., 2011). The ECE-R66 version is also included in the Paratransit Bus Control Standard (FDOT Standards) The State of Florida accident and safety monitoring standard (FDOT, 2007). The ECE-R66 was launched in 1973, owing to an exceptionally bad roll-over accident in Hungary. Hungary also mentioned the lack of regulations to enforce the bus superstructure's requirements in case of a rolled over collision. In the following case, Hungary answered the concern. A reliable and repeatable simple reversal test led to the adoption of a new law was carried out for 12 years (Matolscy, 2003). As a single acceptance protocol, the ECE-R66 uses a total hierarchical roll-over evaluation. Several steps surround a complete dynamic roll over. The energy supplied to the bus in the roll over is proportional to the vehicle's total weight and the center of gravité direction (COG).

The weight of the passengers can be added to the operated bus for busses equipped with passenger limitations, such as seat belts. If there are no seat belts, check the mass of the unloaded car (UNECE, 2006). The ECE-R66 Pass-Fail criterion is based on residual space description (RS). Residual space would be defined as the required space for passengers and drivers to remain intact to provide a survival zone. The remaining space before or after impact cannot be reached by a part or section of the car.

The Federal Motor Vehicle Safety Standard 220 (FMVSS 220) provides efficiency standards on the security of school bus roll-over, but is also used as an obligatory safety standard in the United States on all busses. FMVSS 220 is described as adding a static force of 1,5 times the unloaded vehicle (UVW) weight (US DOT, 1998). The load rate is not exceeding 12.7 mm/s (0.5 in/s) and the force is symmetrically distributed across a smooth, solid rectangular plate. A loading plate of 12 inches less than a roof of the vehicle checked and 36 inches long shall be added to vehicles with a GVWR (Große Vehicle Weight Rating) of more than 10,000 lb.

The FDOT Transit Bureau carefully picked the right vehicles to provide its passengers with the maximum crash tolerance and the best possible climate. The initiative contributed to the creation of the Florida standard for crashworthiness and safety evaluation (FDOT, 2007; Bojanowski, 2010; Bojanowski, Kwasniewski & Wekezer, 2013). The FDOT norm was developed in August 2007 (FDOT, 2007). It is focused on and provides scope to a range of areas under ECE-R66. While ECER66 covers general specifications for computer simulation including code form, content models and mathematical models, no particular methods of validation or verification are specified. The FDOT standard includes a well-defined simulation test program for validation and verification. The computation of the roof integrity on the whole bus, or using a FE simulation in a full scale rollover drill, can be achieved experimentally using the FDOT standard. The national transport and security authority says Wainaina (2016) predicts that passenger cars (PSV), before they can run on the highways, will soon be in accordance with the current body building needs (NTSA).

The norm known as KS472:2014 is applied to ensure the uniformity of all motor vehicles and as a test of road safety. "Bus accidents are fatal because of the poor construction of buses in Kenya," said Gerald Wangai, NTSA Director of Motor Vehicle Inspection. According to Wangai, PSV operators importing vehicles must ensure that they meet with the requirements as they will be tested by the Kenya Bureau of Standards (KEBS) in the port. Body builders will be evaluated by entities certified by the Kenya Accreditation Service. The requirements that PSVs must follow include no roof luggage racks, 400 mm passenger seats, protective belts and safety devices such as fire extinguishers and first aid kits, said Zakaria Lukorito of KEBS.

In order to avoid passagers from being pierced in the case of a collision, all metals inside the bus have to be fluid and do not sharply. There are also anti-rolling bars inside the car, composed of constant rolling bars, meaning the canopy of the bus is very unlikely to fall in the case of an accident. The bus seats should be secured on the chassis and not on the bus body, while the door should be wide enough to allow quick entry and escape (Gakuu, 2014). New and old buses are required to conform with these new rules by 2023, according to the National Transport and Safety Authority (NTSA), 10 years after the Ntulele accident. Body builders are evaluated by institutions certified by the Kenya Accreditation Program. The State has already sounded an alert about vehicle body builders making PSVs without meeting with the requirements set by KEBS.

New regulations also mandate PSVs to remove baggage racks on roofs, have 400 mm passenger seats, protective belts and safety devices such as fire extinguishers and first aid kits. NTSA says it will no longer hesitate while busses begin to destroy innocent lives and will quickly make these new requirements applicable immediately. Many of the busses that run without a booking office and whose businesses can only afford to hire one driver per ride are said to be flouting the rules including evading inspection. Following the crash in Kericho, it remains to be seen if the relevant authorities will now be keen to ensure that the latest Bus Building Rules are enforced and action is taken against anyone who want to disregard them (Gakuu, 2014).

According to NTSA Director-General Francis Meja, the seats should be anchored on the chassis and the bodies made of continuous roll. The use of fiberglass and plastics rather than metals on seat handles can be improved." Toyota's safety issues have led Isuzu to hire foreign companies to design their cars. Local Bus Body Builders are racing to meet with revised production requirements that came into force last week and are intended to increase passenger safety and comfort. The National Transport and Safety Authority (NTSA) had set May 22, 2017, as the deadline for coach makers to comply with the new code, informed by rising fatalities on Kenyan roads blamed on poor workmanship, which exposes travellers to harm (Moses, 2018).

2.5 Competency skills and School Bus vehicle structure.

A vehicle mechanic has been identified by Hiller and Coombes (2004) as a qualified staff in the fields of operation, repairs und, frequently, vehicle shift. Penn (2009) has identified an auto mechanic to be a professional personnel in all automobile mechanics, which includes: auto body repair and spray paint, auto electric work, auto body work and car body construction. Mechanical automobile manufacturers are educated on any component of a variety of types of vehicles or are only certified in a certain area or in a particular form or brand of a car. His task involves correct detection and repair of vehicle issues (US Occupational handbook, 2011-2012).

The workshop is listed as a small business, since it has the characteristics described. Automobile is a self-propelled vehicle mainly used on public roads, according to Fetherston (2009). The vehicle was described by Abwage (2007) as a self-driven, four-wheeled and internal combustion engine vehicle used for both public transport and personal transport. It has different styles based on design, number of doors and function. There are therefore four-wheeled buses, which can accommodate up to six drivers; coaches, minivans, and busses equipped to transport more passengers; pick-ups or trucks, based on their size and set-up, to carry freight; sports utility vehicles, used for driving in mud or snow (Fertherson 2009). When these vehicles have found a fault, they are however looked for by a competent mechanic at the car garage and a motor truck.

The site, area, room or building of machinery, machines, hand tools, workbenches and materials used in the manufacture or repair of goods is a workshop according to jubril 2011. The workshops on cars are also a site where simple vehicle repair is carried out by car mechanics and/or car mechanics. Certain skills are required to be possessed by the individual to build and survive a car workshop. According to Osuala (2004), competition is a significant driving force for industry to be more competitive and to employ techniques to increase production, operation and product quality. The car mechanic must also possess both employability and professional expertise for the activity of the car workshop.

Osuala (2004) summarizes human competences: communication competencies, comprising, programming and history, personal efficiency competences: personal administration, ethics and technical sophistication, economic capacity to adapt: solve challenges, employer preparation and job growth, and community and organisational competences: interpersonal competences, corporate competences. Professional skills are the work-related skills required to do a specific job (Robinson, 2000). In addition, Arul & Kavi (2002) observed that technical competence includes: advanced experience, expertise in research and the use of tools and techniques in a particular area.

Sadly, the position of these skills as employability and technological abilities in the establishment and progress of their organization such as an automotive factory is not taken into account. This is why it is important to research employability and technical skills required to develop car workshops to enhance the development of jobs, entrepreneurship and wealth generation. Technical experience in various fields of automobile mechanics is required including engine operation, servicing, construction of car frame, automatic electrical/electronics, vulcanisation, steering and suspension, braking and auto air conditioning. Nwoji and Osinem (2010) have the following competencies: protection and health, basic and specialized computer operating skills, professional writing skills and bulletins and skills in drawing/sketching. The technological expertise used in the construction and manipulation of processing and manufacturing equipment, machinery and techniques may be defined as the technical expertise.

Osinem (2008) notes that technical skills are a kind of competence that require a strong understanding and expertise in a specific operation, in particular with respect to approaches, procedures or techniques and processes. Medina (2010) described technological capacity, whether engineering or technical, as the skill or technical competence in this area. Technological skills are hard skills connected to the use of machines, work-related equipment and all technological problems.

The 2007 curriculum is a program designed to establish a master technician in vehicles as mandated by the National Commercial and Technical Review Board (NBTEB) in the design, production and repairs of vehicle body. In its curriculum and module requirements (CNT, 1985), the National Board of Technical Education (NBTE) described it as a program intended to provide instruction for trainee trainees in the construction of car body structures to allow them to create, paint and adapt to commercial and public service designations upon completion of the course. Technical Colleges provide full professional training in Kenya, however, to allow technicians to learn specific skills in vehicle designs for the construction of body buildings.

2.6 Engineering Materials and School Bus Vehicle Structure

The key raw materials are now steel, for instance in the industries which produce collective transport vehicles (e.g. buses and trains) and agricultural vehicles (e.g. harvesters and tractors). With a view to reducing the weight of such vehicles, plants are engaging in designing structural components using modern steel forms that allow for the implementation of more thinning materials (thinner sheets) and frameworks with welded joints of various metals (Mvola, Kah, Martikainen, Suoranta, 2015, Urbikain, Perez, López de Lacalle & Andueza, 2018). In order to develop high strength, easy to soften and high levels of ductility and toughness, this industry needs steel mills.

The role of material is important for accident resilience. The weight of cars for the reduction of costs is being built using lightweight materials. Simultaneously these lighter materials should keep the car safe under rules. Substantial research has been carried out to achieve both goals. This material was classified into four categories: (1) steel, (2) composite materials, (3) aluminum and (4) magnesium according to the material type.

About a century ago, stoneware was invented. Their use has since grown up to 30 million metric tons annually. They are suitable for HVAC, sanitary, structure and transport applications with high corrosion resistance, a strong toweight ratio and aesthetic appearance (Claes, 2008). "Stainless steel" is a stone resistant to corrosion (also called inox, rustfree or rostfrei). They form a chromium content self-healing protective layer that gives a high resistance to corrosion, shiny finish and esthetic look. Comprising higher strength, ductility, hardness, cryogens, corrosion resistance and more attractive looks than carbon steels, lower maintenance (Placidi & Fraschetti 2005).

In lightweight manufacturing, innovative stains also play an important role. Although lightweight alloys such as magnesium, aluminum and titanium are often used as non ferrous alloys, they are nearly equal to their specific stiffness (Elastic modulus / density) in stainless steels (Snelgrove, 2001). There are many other reasons than specific rigidity in many applications. These include formability, softening capability, hardness of work and costs. All in all, stainless steels provide a viable reduction in weight (Placidi &

Fraschetti, 2005). Training and traction resistance of current rust-resistant steels are comparable to other metal alloys and the EU 2030 target. Some other advantages of stainless steels, like recyclability, fire resistance and crash resistance, can be summarized.

Brearley in the United Kingdom and Maurer & Strauss in Germany first used the industrial use of stainless steel in 1912-1913. The worldwide use of stainless steels has since its invention dramatically increased to almost 30 million tonnes, reaching an annual production of (Claes, 2008). The high strength to weight, corrosion resistance, the esthetic appearance, ductility, toughness, weldability, innovative stone is a common feature in the householder, food industry, chemical industry, fasteners, hygiénicoactive and medical devices and high levels of availability all over the world (Peckner, 1977; Altan, 1998).

The manufacturers of cars must construct lightweight vehicles. In the past, so-called light metals were the only alternative to conventional materials. These are costly, however, and are not suitable for sweating. The mechanical properties of inox steels are exceptional. Combining outstanding weldability and formability, designers can produce steel components as light as their counterparts in "light metals." Often the number of components can be reduced and montage complexity optimised. This allows innovative steel to benefit economically from competing materials (Snelgrove, 2001). In vehicle structural applications Stainless Steel is an excellent candidate.

In this area, the rivalry between different materials is intense. Mass saved option centres, formability, softness, resistance to corrosion, tiredness, expenditure and environmental considerations. Specific emphasis should be given to protection and crash resilience. The ability of the car system to protect passengers is a crash. It also ensures that minor accidents without trauma can be survived. Today, automotive manufactures are looking for the best in rigidity, weight reduction and safety (Snelgrove, 2001). In structural frames and body paneling of buses and coaches, stainless steel is now widely accepted for use. The steels used range from stainless steel to austinite types such as AISI 301, 304 and 430. In Europe, for example, Spain's factories are heading towards completely using stainless steel in buses. A number of variations of stainless steel are offered by Volvo and other European producers.

The lifetime cost of the substance is substantially reduced by its easy-to-maintain and corrosion-resistant properties. For operators in damp regions or areas where roads are salted, this latter factor is important. The absence of weak points shows in the event of a crash the lack of corrosion. This and its robust mechanical properties guarantee optimum protection for the rider. Further essential advantages include fast processing, higher passenger capacity, saving in weight and self-handling of stainless steel when injured. The traditional passenger car uses between 15 and 22 kilos of steel. Particularly the system of exhaust. In long-haul and local trains since the 1930s, indoor steel has been used. Today US or Sweden's X2000 high-speed trains are a good example of rail transport of stainless steel. Bus carriers are more and more made of steel and some street carriers are now coated in stainless steel. Big new applications for vehicles are ongoing, and transport use is expected to take root (Snelgrove, 2001).

The production of lightweight vehicles is planned by vehicles manufacturers. In the past, the only alternative to conventional materials is so-called light metals. However, they are expensive, and they take care of the soldering. The mechanical properties of Stainless steels are superior. With the combination of outstanding softening and formability, manufacturers can make stainless steel components as light as their "light metal" equivalents. The number of components can also be limited and the size of the assembly simplified. The comparative advantage of Stainless steel is also possible products (Snelgrove, 2001).

AISI 301L is of particular significance (EN 1.4318). This steel is particularly good for working hardness and high resistance, which confer exceptional "crashability" (resistant behaviour of the material in an accident). It is also possible to locate it in thin gauges. These advantages include exceptional formability and corrosion resistance. This is now the grade picked for the rail freight structural service. In this way, expertise obtained in the vehicle construction field will easily be added. Metallurgists continued to focus on ferrous chromium alloy around the turn of the 20th century. In 1908 German chrome containing steels (FeCr) was studied by Monnartz.

Ferrous alloys with more than 12 percent Cr are known as stainless steel (Peckner, 1977; Davis, 1994; Gardner, 2005). Stainless steels are categorized into five classes according to their microstructure: (1) austenitic, (2) ferritic, (3) martensitic, (4) duplex (ferritic-austenitic) and (5) precipitation-hardening (PH) (Totten, 2007). According to the figures of the American Iron and Steel Institute, austenitic stainless steel is the largest category in the world, responsible for 65-70 per cent of annual demand. Alloys are also referred to as numbers and chemical compositions.

Chromium is one of the most critical parameters in stainless steel with high corrosion resistance. This property is dependent on the composition of the alloy. Chromium in the alloy produces a passive surface film. This film provides a high resistance to corrosion and a strong surface finish. The consistency of this coating is influenced by ambient conditions and by the percentage of Cr in the alloy. 10.5 per cent of the Cr content of stainless steel would be produced in unpolluted rural areas; however, it may not be adequate in contaminated or aquatic atmospheres (Dean, 1988; Davison, 1992).

Nickel is used to improve tolerance to mineral acids and is effective in minimizing the environment. 304 has the highest nickel content in alloys in this sample and 201 the lowest. However, the influence of nickel content is more significant in the cracking of stress corrosion (Davison, 1992). Manganese in moderate concentrations and with some nickel, Mn can substitute some Ni. High content of Mn can result in resistance to galling (Davison, 1992). In this analysis, 201 has a substitution of Mn over Ni. 301 and 304 have just 2% Mn and a higher Ni content relative to 201.

For over a century, steel sheets were used in car frames. It is a commodity of choice for car manufacturers because of its low manufacturing expense, its predictable qualities and its considerable expertise in its production processes. Several investigators have investigated the effectiveness of the collision resistance. The capacity to crash high strength steels is discussed in Van Slycken, Verleysen, Degrieck, Bouquerel and De Cooman (2006). They have also shown that high strength stones under volatile loads are experiencing greater energy absorption, which is increased as the stress intensity increases, which is helpful for applications that consume crash energy.

Peixinho and Pinho (2007) studied the behavior of the effect of thin wall tubes made of dual step and TRIP steels. TRIP steels are austenite metallic steels which become martensites during plastic deformation so that the strength and ductility can be improved (Callister, 2007). Tensile inspections have been conducted for different stress thresholds as well as for applications for axial accident dignity. The LS-DYNA used for modeling experiments was highly compatible with numerical and experimental results. By inserting ring grooves, Hosseinipour and Daneshi (2003) examined improvements in the crash actions of steel rods. They showed also that this could lead to a controllable incremental deformation, which increases tube energy absorption potential.

For their possible use as energy absorbing components of effect, composite materials have been studied. In the event of a collision several of the composites studied are randomly cut, strengthened composites with fiber. The quality of randomly cut epoxy refined carbon fiber composites was studied by George, Starbuck, Fellers, Simunovic and Boeman (2006). They performed quasi-static experiments and considered them to be used as shock absorbers. ABAQUS is used in the imitation of corrugated steel tubes with fibers of cotton stuck in polyprosylate by Mahdi, Mokhtar, Asari, and Elfaki, Abdullah. They find that the absorption potential increases as the number of corrugations increases and the ratio of diameter to thickness (D/t) decreases.

Thanks to its low mass, aluminum is used in some automotive structures. In 1993 the Aluminum Space Frame Sedan was introduced and in 1999 the first all worked Aluminum Crib was adopted by GM (Taub, Krajewski, Luo & Owens 2007). The effect behaviour of the frontal system of the 2005 aluminum frame Ford GT was studied by Caliskan, Jeryan, Mees and Iregbu (2005). The assessment was done at the front and the material properties of the different samples were used as data input for the LS-DYNA model. They further investigated the potential for energy consumption of rails of aluminum alloy 6063-T6 and found that the properties of the HAZ affect rail crash performance and their role in future models.

Recently, Magnesium was given much attention by the automotive industry due to its enticing low density. It is the lightest structure of all metals (78 percent lighter than steel and 35 percent lighter than aluminum). It is also one of the most important structural elements in the crust and seawater of the earth (Krauskopf, 2003). Thanks to the excellent casting properties it is used for a variety of parts in automobiles including engine block, engine cage, transmission cabinet and instrument panel. It was also used as internal door and sitting frames (Das, 2008). The following challenges did not completely substitute steel on vehicle structures: Magnesium has a Hexagonal Closed Packed (HCP) crystal structure and has limited guts, especially on cellar aircraft, making it difficult to shape especially at low temperatures.

Magnesium has a high affinity to react with oxygen, which induces corrosion, so costly treatments are required (Kainer, 2003). A lot of research is being conducted to solve the problems that preclude the complete use of magnesium alloys in automotive systems. A cross beam instrument panel made of magnesium alloy AM60B was proposed by Nehan and Maloney (1996). Magnesium increased protection in the car and decreased vehicle weight at the same time. Newland and Murray (1996) have researched magnesium alloys' strain rate behavior and concluded that declining aluminum content in the alloys raises their pressure rate sensitivity and, finally, enhances the absorption power.

The magnesium alloys AM60, AS21 and AZ91 were analyzed in Abbott, Easton and Schmidt (2003), and concluded that in crashing circumstances they would perform exceptionally well. A new alloy AM-EX1 has recently been developed by Easton, Beer, Barnett, Davies, Dunlop, Durandet, Blacket, Hilditch and Beggs (2008). Magnesium alloys, in particular AZ31 alloys, can absorb more energy than alume or steel alloys, they were also mentioned. They concluded that material models could be strengthened by providing microstructural features and non-uniformity defects. Despite this initiative, more study is needed to understand the efficiency of magnesium crash structures alloys.

Steel's CO2 content is increasingly lowered, with the addition of alloying agents including titreanium, molybdenum, chromium, niobium, aluminum and vanadium to improve strength and strength (Koo, Luton, Bangaru, Petkovic, Fairchild, Petersen, Asahi, Hara, Terada & Sugiyama, 2004). Niobial alloys, for example, provide grinding of grain and precipitation, which contributes to sluggish movement of discord. Additional micro-alloys such as vanadium and titanium can also be applied to achieve optimum mechanical properties (Lee, Lee, Sohn, Kim, Um, Kim & Lee, 2017).

High-strength low alloy steel (HSLA) has been produced in this connection, allowing vehicle weight to be minimized. This improves the efficiency of internal combustion motors and thus saves fuel and provides passengers with greater protection. In the airspace industries such as Sharma and Maheshwari (2016) and Schafrik (2016), Boyer and Hermenegildo, Torres, Afonso, Ramirez (2015); Gao, Ding, Yang, Li, Zhu, Liu (2016), Gao bridges, offshore structures and civil engineering (2015). Such steel types have also been used for other applications such as oil and gas pipelins; Gao, Cotton, Mohaghegh, and Ramirez (2017).

In many structural applications ASTM A36 steels were replaced by ARBL Din EN 10149 S700MC Steels in the metalworking industry in the regions of Rio Grande do Sul, Brazil, with the introduction of HSLA steel. LNE 700 steels are still unused in welding assemblies, especially as regards the validity of the rules laid down for this type of steel in various standards and codes. This raises the risk for the phenomena of instability (Machado, 2013). This material has certain characteristics which, because of its lower ductility, prevent use of regulatory principles in popular structural steels.

Usually, the mechanical properties of steels created by controlled rolling cannot be recovered, so it is not unusual that the strength of HAZ can be decreased during soldering, depending on the manufacturing and/or the chemical composition of steel (Andia, de Souza & Bott, 2014). The HAZ regions with low hardness are created by shifts in the microstructure during the welding of LNE 700 steels (because of the temperatures and the length of time to which welded joints are exposed to these).

In addition, the diameter of the HAZ increases and the hardness decreases as higher soldering energy is soldered; therefore, these factors must be controlled during welding (Hochhauser, Ernst, Rauch, Vallant & Enzinger, 2012 and Górka, 2013). Usually, as welded, the joints break apart in the lowest HAZ hardness regions when they are less mechanical than those of a base metal. The use of relative low soldering energy, namely less than approx. 1 kJ/mm Gliner (2011), is advised to ensure the mechanical properties of the joints sold on such steels are not damaged.

The use of unique consumables for this purpose is needed in soldered HSLA steels (Haupt, Riffel, Israel, Silva & Reguly, 2018). The welding parameters must also be tested so that regulated thermal inputs are not adversely impacted by mechanical properties. Production of consumables in terms of the mechanical strength of high-fast steels must complement the increasing development. The propensity to build an area of hardness less than that of the base metal in the HAZ is a fundamental point for melting welding. Iron, a small alloy and a small volume of carbon, is the most important raw material used to build school buses. Steel along with different other materials is used for the construction of the frame and the body. Steel consists of iron ear, coke (a rich carbon material formed in the absence of air by burning coal) and calestone.

There is laminated glass on the windshield of a school bus. Laminated glass is composed of two glass layers overlapping a plastic sheet. If the window has cracked, the plastic keeps the glass in place, adding protection. A school bus tire consists of a combination of natural or synthetic rubber, black tar, sulfur, and other additives to determine the tire characteristics. Different metals and plastics are other raw materials used in the construction of school buses. The several small pieces are made to form the completes car and are assembled in combination with the frame and body.

2.7 Bus Vehicle structure Inspection tests and Crashworthiness

According to the APTA, the number of passengers riding on order answering systems grew from 68 million in1990 to 190 million in 2010, according to the American Public Transportation Association (Dickens, Neff and Grisby, 2012). ADA highlights the need for a modern model of vehicle, allowing riders more versatility in wheelchairs and the opportunity to travel on regular routes. They are in great contrast to the assembly process. In comparison to uniform broad buses the transit buses are constructed in two stages. The first phase produces a chassis for a major vehicle maker with a driver's seat. The architecture and production processes therefore differ greatly.

The total car weight (GVWR) of transport busses sadly amounts to around 10,000 lb. They are not subject to design restrictions unless a special bidding process is requested. Customers also attempt to bridge this void by trying to conform with new laws on bus safety. For the evaluation of the roof integrity of paratransit buses the Federal Auto Vehicle Safety Standard 220 (FMVSS 220) "School Bus Rollover Protection" As of 2005 in the United States (US), the paratransit firms in Pennsylvania, Minnesota, Wisconsin, Tennessee, Michigan, US, Alabama and California were included in the requirement (NHTSA, 2005).

The alternative approach for crashworthiness and safety assessment (FDOT Standard) for transit buses is laid down in the Florida Standard (FDOT, 2007; Bojanowski, 2010; Bojanowski, Kwasniewski and Wekezer, 2013). The FDOT Standard, adopted by FDOT and implemented in 2007, is based on the UN Economic Commission for Europe (ECE-R66) Regulation 66. (UN ECE, 2006). As a single acceptance protocol, the ECE-R66 uses the full scale hierarchical roll-over assessment. The criteria Pass Fail is based on the residual space theory (RS). Residual space is defined as a required room for passengers and drivers to remain intact after a roll-over.

The State of Florida leased over 300 commuter buses from seven separate providers in 2010. Busses that year had over 40 different configurations of floor/wheelbase and frame (CIAL, 2011). Such an ordered selection of vehicles enables the Buying Agent to order vehicles tailor-made for the intended purpose, but it often forms a hurdle for the approval process. Compared to the rest of the automotive industry, bus vendors are comparatively small. They cannot make themselves or donate any model produced for roll-over research to set up and finance their own R&D departments.

In the other side it is a very necessary project for a testing institution like The Crashworthiness and Impact Analysis Laboratory to formulate, test and check FE models for all automobiles purchased (CIAL). It was clear that full-scale experimental roll-up projects and the computer simulation FE model design process were too expensive and time intensive to effectively implement in today's environment. Figures on bus accidents in Paratransit are not available readily. In the past, those buses were known as general busses or "other busses." Until 2010, Fatality Analysis Reporting System (FARS), established by National Highway Traffic Safety Administration (NHTSA), did not contain a specific category for paratransit buses (NHTSA, 2012).

The new "Van-Based Bus (GVWR > 10,000 lb.)" type (GVWR > 10,000 lb.) was created for paratransit bus operations beginning with the 2011 Traffic Safety Facts Report (NHTSA, 2013). There are only valid figures for two years (2011, 2012) and only a small number of such vehicles on the way are insatisfactory to completely display fatal accidents involving paratransit buses. The Accidents Injury Study (CIREN) and the National Automotive Sampling System (NASS), which have been developed by NHTSA, are also a possible source of knowledge for transport bus statistics. There are many significant injuries recorded in the CIREN database, including repair accidents and injury trend info. CIREN includes data from 1996 which can be accessed by the public (NHTSA, 2014).

In the other hand, NASS collects national police surveys of all kinds of traffic collisions. The data is randomly sampled and coded in detail according to NASS standards from available injury data (NHTSA, 2014). Regrettably, no bus collisions were reported in the CIREN database and no information for bus roll-over in the NASS database have been identified. The overall reports on bus crashes are more useful in the inference on injuries for riders on the bus due to the absence of long-term crash data on paratransit busses.

The UNECE has collected data since 1973 on bus accidents, when Hungary raised the problem of the lack of specification for bus overhead systems.. The Economic Commission for Europe (Matolcsy, 2003). More than 570 bus rollover cases have been registered up to 2008. (UNECE, 2008). Unfortunately, there is no unified bus roll-over system in Europe and the data are scattered and country dependent. Statistical statistics forced to refer to public reports of these cases, which are questionable in terms of incident nature, injury severity (UNECE, 2008).

Looking at the country-by-country details available, you can get a more accurate picture of bus rotation figures (UNECE, 2008). Norway has reported 28,783 busses in 2005. Over 4 years there have been 42 rollover collisions, 5 accidents, 13 seriously wounded and 166 passengers with minor injuries (2002-2005). In 2004, 19,948 busses registered in Germany were recorded by German experts. There was no concrete detail on the roll-over but there were 16 vehicle casualties and 460 serious injuries as a result of bus accidents. In Belgium, the total number of busses and minibusses registered in 2004 was 34,075, and accident details is unreleased. Six confirmed deaths in the bus and a total of 157 killed or seriously injured (KSI) deaths were reported (UNECE, 2008).

10,396 busses in the Netherlands were reported in 2004; the 10-year results indicate that 26 passengers died and 353 were seriously injured (1997-2006). No comprehensive details were presented on the roll-over. Spanish busses and coaches had reported 58.248 National fleet in 2005. This year, a total of 177 bus transfers were recorded with 26 deaths among passengers and 153 serious injuries. KSI value was 62 for rollovers (UNECE, 2008). In January 2008, a comprehensive introduction of the French roll-over data was presented at the IG/R.66 community of experts meeting in Madrid (UNECE, 2008).

Other nations, such as the Czech Republic, the United Kingdom, Italy and Poland, represented at the meeting of the IG/R.66 Expectancies Community in Madrid in January 2008 included only the specifics of the fleet and did not provide bus accidents information in their regions. Another study of the 1995-1999 Spanish bus data shows that the roll-over constituted 4% of bus accidents, but the risk of death was five times higher than some other kind of bus accident (Martinez, et al., 2003). A important tool for gathering information on bus accidents in the US is the fatality analysis tracking scheme (FARS). FARS is a national website of annual information on casualties in motor vehicle collisions the media and policy makers (NHTAS, 2014).

Spain's data records distributions of events with bus collisions relative to all types of bus crashes (Martinez, et al., 2003). In the basis of these observations, the risk of fatal injuries has been considered five times higher than any other kind of collision, and the risk of serious injury is four times the risk of a rollover incident. Sometimes, roll-over crashes leave few people uninjured because of the other types of collisions (2.6 percent for rollover compared to 46.5 percent for other accidents). It is important to study the mechanisms of bus occupant injuries in order to learn how passengers can cover themselves. Unfortunately, FARS database does not provide information about accidents and casualties (NTSB, 1999).

NASS and NHTSA data are the best resources available in the U.S., but both database do not include bus roll-over incidents. The compilation of data on bus collision operation accidents and incidents showed correlations in Europe. For the US market, the European information is awesome. During the 1980-2005 period, the injury mechanics of passengers in bus crashes were critically seen in a similar study carried out in France. This research involved 45% frontal collisions, 42% roll-out and 13% of other forms of damage in 94 serious injuries by bus (UNECE, 2008).

Interface and fan (2011) in a broad and well checked FE model made the bus body configuration structure multifunctionally optimized. Authors use sensitivity analysis to select essential structural variables for the optimization process. The authors used the authors' response as bus weight, torsional rigidity, residual interference and voltage. An boost in torsional rigidity of 0,4% and a 13,8% reduction in maximal stress resulted in a 2.7% weight reduction during the optimisation process. Authors used LSDYNA as a FE solver and LS-OPT optimizer. A compare with experimental and FE roof, breast, and floor pillar knots was conducted for the FE model. The optimization approach led to a 40% and 50% decrease in deformation and a 1.6% rise in weight. Tech & Iturrioz (2009) used the genetic algorithm under rollover to perform a structural optimization of a bus. The authors have developed and implement additional plastic hinges for the purposes of deformation, the streamlined rigid beam model FE with a bus frame. The objective functions of this study were vehicle mass and mechanical responses for the rollover experiment.

In a separate study, Bojanowski and Kulak multi-target programmed the transit bus system subjected to side effects and roll-over experiments (2011). Optimization objectives included: cage mass structure, overhead deformation, lateral impact test penetration gap. The writers concluded that the lateral walls and front cap structures were the 63% changes in objective function, which are the key components of bus construction.

According to Kamau (2018), the KEBS has developed new regulations for car body construction to tackle the problems of constructing NTSA quality bus systems. In case of a collision, KEBS enforcement will increase the survival rate. NTSA has now been set to ensure that car body suppliers conform to the use of specified content failures that they can deregister. Since then, NTSA has also suggested that carriers be banned from mounting on the roof tops of public vehicles. This is critical if buses with upload carriers are likely to tipple over when crowded, as in the case of a Ntulele accident. Improved bus body construction technology saves lives, generates opportunities and we will not only have to jeopardize safety design.

Kenya introduced the latest rules on 22 May 2017, according to Ngugi (2018). The move towards implementing the criteria was told by the increasing number of deaths on bus cars due to inadequate manufacturing. The Updated Code will include best practices for vehicle body builders, such as good seat mooring, the use of materials like fibre-glass and plastics rather than the use of heavy metals on seat handles. The Network of Bus Manufacturers, Kenya Bureau for Standards (KEBS) and Kenya Association for Bus Manufacturers (KENAS) have established the new Body Building Standards (KS 372) jointly (KABM). Majority of motor-vehicle-related fatalities could be avoided by universal adoption of the most basic preventive technologies.

Road safety operators and customer lobbies have consistently cautioned that, while the laws and regulations require car body builders to take best safety practices, the NTSA and KEBS regulatory authorities frequently turn around and open the door to crooked school buses, public bus owners and bus builders, to violate the rules (Gakuu, 2014). The collision at Fort Ternan, was all over with bits of glass. They were once window lenses, but the glass bits quickly turned into weapons after the bus rolled down.

The bus' roof lay a few meters from the bus body, a further indication of the metal condition used for connecting the canopy to the bus. The bus seats remained intact, suggesting possibly that they were protected correctly, but concerns were asked about the material used to make the seats, as over 50 individuals were murdered by rolling busses. The driver was allegedly faulty, however several concerns arising from the nature of the material used to assemble the bus (Moses, 2018).

In order to ensure faults are free, the school bus manufacturer reviews all the prefabricated materials. In order to protect against rust, the sheet metal from steel is often tested for storage. Once bits of steel have been taken out of the metal board, they are checked for the right type and scale to make sure. When the frame is complete, the motor components are shortly powered to ensure proper running. After the body is attached, a complete road examination is carried out to identify any operational defects. To detect any leakage, the school bus is sprayed with water. A thorough final inspection is carried out for the whole vehicle. For school bus manufactures, safety is the main quality control issue. All the items on a long, written list must be individually inspected and approved before the school bus is ready to be shipped.

2.8 Welding technology and School Bus Vehicle Structure.

The welding is primarily used for localizing the required combination of the temperature, the pressure and metallurgical conditions to create a lasting join of two metals. The various combinations of temperature and pressure produced a wide range of welding methods. Welding is the primary way to manufacture and restore metal goods in both sectors (Hayashi, Ishiwata, Minakawa & Funahashi, 1995). Welding is commonly used in the automobile industry among the most important fields of use.

The most widely used welding methods for automobile applications include resistance spot welding (RSW), resistant seam welding (RSEW), inert metal gas (MIG) solding, tungsten inert gas (TIG) (PAW). Advanced welding techniques were developed to decrease vehicles weight and improve fuel consumption for automotive applications (Durand, 2001). In traditional welding techniques, the solder joint that flows into the joined materials to create an exceptionally strong bond is often complemented by an extra material. The metal applied to each solder raises the weight of the vehicle, which lowers fuel economy in turn. Welding is commonly used by manufacturing and technical workers to set up production systems for new goods rapidly and reliably.

MIG is an arc welding process in which the job is heated in coalescence with an electric arc created continuously between the working piece and the electron supplies. The most important factors influencing efficiency, competitiveness and cost of welding are MIG welding parameters. Metal inert gas (MIG) welding mechanism consists of a temporary heat supply forms a joint in which parent metals are heated, melted or solidified and the filling material is located in the fusion field. The arc welding of gas metal is a protected gas operation, which can be used easily in all positions. Continuous wire soldering facilitates high rate of metal dumping and high rate of welding. The filler wire is usually aligned to one electrode from DC sources with its positive polarity. The piece is synonymous with negative polarity.

The power source may be an electrode-positive continuous DC voltage that provides a stable arc and a smooth transition of metal with a lower distribution over all current spectrum. Arc soldering is a type of welding process which uses a power supply for soldering the metals to shape the electrical arc from an electrode to a base material at the welding stage. They can use current, consumable or inexpensive electrodes either directly (DC) or alternating (AC). Due to its low capital and maintenance costs, the arc welding process is commonly used. Shielded arc welding system (SMAW) is a process of fusion welding that achieves metal coalescence by electrical heat between an electrode and the work (Groover, 2007; Soy, 2011). This procedure is one of the most commonly used metal parts processing methods. Basically, by applying heat and occasionally friction, a fusion of two or more metal fragments is involved.

Sweat encompasses a broad variety of scientific factors, such as time, temperature, electrode, input power and welding speed (Jariyabon et al., 2007; Lothongkum et al., 2001 & Karadeniz et al., 2007). The most significant factors influencing efficiency, competitiveness and cost of welding joints are solding parameters in this process (Karadeniz et al., 2007). These parameters which affect the arc and the welding bath must therefore be calculated and their changing conditions understood during the phase in order to obtain optimum results (Uslu *et al*., 2010).

The solding quality is calculated by the welding parameters including the slot formats, electrode diameter, solding current, soldering speed, arc length, electric forward angle, electron oscillation angle and movement, soldering path and positions. The welding quality is determined by the solding parameters (Afolabi, 2008). Selection of ideal parameters should be carried out according to engineering facts in order to achieve high-quality welds in the shielded metal Arc weld process. The soldering parameters are typically calculated by trial and error depending on the manual values and suggestions of the manufacturers. This choice, however, can't achieve optimum welding output or in the immediate vicinity (Karaoglu & Secgin, 2008). The electrodes are covered with a protective flux of an appropriate composition in a shielded metal arch soldering method.

An experiment was carried out on Ates (2007). Under 180 A and 28 V were welded low carbon steel sheets (15 x 150 x 450 mm). A welding machine MIG and MAG was used, while mixes of CO2, Ar and O2 were used as blinding media. The shielding gas flow rate was 15 l/min and the experiment was carried out by placed the contact tip at 15 mm. The mechanical properties of this experiment were tested.

Achebo (2011) demonstrated that optimization of the input parameters including welding force, tensile power, speed and time was achieved using the Taguchi method to react to the ultimate tensile strength of steel. The Taguchi Device analysis suggested that 240A solder current, 2.0 minutes of soiling time, 0.0062m/s of soiling speed and 33 V of solder voltage are ideal operating process parameters. This article clarifies a step-by-step guide to the Taguchi method.

Nagesh and Datta (2002) predict the geometry and penetration of the weld percolator with input parameters for perforation height, perforation width, penets, penetration area and travel rates. Arc-current, arc volume, and using ANN method for optimizing output parameters. The experimental studies have shown that either preheated plate or low arc travel or high arc fusion results. The perch height and width all fall as arc travel is slower, although the height is lower on a flatter perch with a higher rate of arc travel. With the growth in electrical feed speeds, penetration and HAZ increase continuously.

Correia et al. (2004) introduced the Genetic Algorithm for optimisation of MIG welding parameters (GAs). The search for near-optimal was performed step by step, with the GA predicting the next experiment based on the previous modeling equations of the inputs and outputs of the MIG solding process, and without knowledge. The GA has been able to establish almost optimal environments for a relatively small number of experiments. But optimizing GA technology must establish good parameters, such as the number of generations and population size.

Wahab and Khuder (2011) investigated the effect of welding process parameters in solder joints of different metal using MIG spot soldering. AISI 316L austenitic steel and carbon steel are the base material used for the sweating of this research. E80S-G is the filler metal and CO2 was used to market this unlike metal as a safety gas. The experiment was done by the wire feed, feed time and welding current input parameters. The effect of these parameters on the spot diameter and the shear intensity was the outcome of the experiments. The findings resulted in improved soldering current and shear power, while shear strength decreased with an improvement in welding times. The improvements in the soldering current and soldering time also increased solder diameter and reduced shear strength.

The Artificial Neural Networks (ANN) and genetic algarithms refine MIG welding parameters have been experimented by Kumar, Jadoun and Singh (2012) (GA). The ANN method for soldering parameter prediction, including soldering voltage, used in the mathematical model, for these studies, welding speed and welding current on ultimate tensile stress during the welding of dissimilar material such as stainless-steel grade 304 and grade 316Argon gas was taken as a safety gas and a complete factory test was conducted. To maximize the performance parameter value, the Genetic Algorithm (GA) was used. The study reveals that at 110A soldering current, 18V solder voltage and 43.362 cm/min travel speed the ultimate optimum tensile strength is met. They also showed that the Artificial Neuronal Network (ANN) is successfully integrated into another regression model.

Hooda, Dhingra and Sharma developed a surface reaction model for the predictions of tensile strength of inert gas arc welding AISI 1040. (2012). In this analysis, soldering stress, current, wire velocity and gas flow rate are the input parameter. The experiment was designed using a composite face-based modeling matrix. The experiment shows the optimum method parameter values of both the cross-sectional and the longitudinal arc are soldering voltage 22,5 V, wire velocity is 2,4 m per minute and gas flow speeds 12 l/min with maximum power.

BalaSubramanian (2008), with its high strength aluminium alloy joints constructed by gas metal arc welding and gaseous tungsten arc welding, has been studied with the continuous current and pulse current technologies. Used as a plain argon protective gas. The pulsed gas metal arc solder joints provided high strength values and high joint performance as opposed to other welded joints. The areas affected by base metal and heat provided high hardness values than the metal sold due to fine kernels. The high hardness values of the new pulse gas tungsten arc welded joint were developed and existing gas metal arc welding joints were badly tough. The new pulsed gas metal arc welding created a very fine grain in the welded field.

In order to examine its effect on the welding bead hardening hardness of TIG welding and soldering by Taguchis process and Grey Relational Analysis (2013), the parameters were evaluated by Patel and Chaudhary (2012). Patel and Chaudhary (GRA). The study concluded that MIG and TIG welding had the most important welding current parameter. The optimum parameter configurations of soldering current of 100 Amp; wire diameter 1.2 mm and wire feed rate, 3 m/min for MIG soldering were identified with the application of GRA optimization technology.

Robotic MIG soldering AA6002 Robot AA6005 was analyzed in the Ghazvinloo, Honarbakhsh-Raouf and Shadfar (2010), and the impact and bead penetration characteristics were analyzed by using 1mm of ER5356 filler content with the impacts of soldering velocity, voltaglion and current of 2.35 mm and 10 mm thickness. During the process, soldering parameters of welding differ, stress and current. The increase in voltage and current decreased tiredness, but the solder speed increased tiredness. The energy effect was enhanced by reduced welding speed and increased current voltage. Bead penetration was affected primarily by the welding current and depends on it.

Many researchers have been using diverse types of experimental modeling methods such as Taguchi, the Reaction Surface technique, factory-wide design and Box Behnken design, to work on various types of materials with diverse types of laser. The results of a number of process parameters including electrode size, soldering current, Arc voltage, Arc travel speed, Welding location, Gas flow rate and shielding gas composition were also investigated in a range of materials.

Three various materials, including carbon steel, alloy steel and stainless steel, have been used to apply the welding. For shielded metal arc welding, aluminum has not been recommended and has thus been removed. The welding methods can be broken into four distinct groups: ass, inner angle, outside angle and superposition. The welding slot must be ready in welded sections in order to increase the performance of the joint. In reference to these criteria, the types of slots are defined. The international standard for EN ISO 9692-1:2003 is available in Europe and descriptions of the forms of welding slots. This analysis of the literature reveals that reliable outputs of high efficiency can be achieved with proper optimisation of MIG welding process parameters.

2.9 Customer needs on school bus vehicle structure design

Every part of our life, including the way we buy goods, has change in technology. Online tools for compare and assess complicated items such as vehicles provide fast and simple ways to comparison. Customers looking to buy a new car no longer rely just on a dealer's details. They carry out experiments on their own and attempt to forecast the extent and danger of the real product (Cui, Lui, and Guo, 2012). It has also modified the way consumers buy cars. The chosen mechanisms for most new car owners are personal leasing plans (Whichcouk, 2016). This consumers never become shareholders, however. Likewise, the buying of a car cannot be desirable for people living in urban environments where traffic, demand for parking space and ownership are high.

Companies such as Zipcar, Car2Go, City Car Club and Uber offer a wide range of car payment options (Rogowsky, 2016). These patterns together suggest a change from buying a mobility device to buying Mobility As A Service (MAAS) (Godlevskaja et al., 2011 & Vassilakou, 2014). However, it remains for consumers to determine which vehicle to use, and as a result of such changes the relative value of vehicle characteristics will change. With the recent developments in the car industry, consumer wants, such as needs, motivations and principles (Desmet, 2003) to be captured and appreciated more and more, in order to make the car industry relevant.

However, consumer comprehension is difficult because their decisions are subjective (Reid, Frischknecht, & Papalambros, 2012). Previous investigations proposed process structures in which designers would focus their products on the key aspects of their product design (Noble & Kumar, 2010) and turn customer responses into actionable aspects of engineering (Yadav and Goel 2008). The Quality House is an example of this approach in order to target consumers' subjective responses to measurable engineering characteristics that may influence those responses (Hauser & Clausing 1988). This approach categorizes the reaction or properties of the consumer according to the level of information: primary (for example: good looked), secondary (inside trim), tertiary (e.g. attractive non-plastic appearance), etc (Hauser & Clausing 1988). However, it is vital to consider which characteristics are relevant for which consumers and what to be effective.

Cap Gemini (2011) claimed that brand reliability is accompanied by safety and the price of the car. On the other hand, KPMG (2011), the three most significant considerations were fuel efficiency, safety advancement and vehicle construction. For 2015 there might be similar inconsistencies. Auto Trader (2015), color, size and brand, ranked Harris- Interactive (2015) among the main purchasing considerations, has ranked purchase cost, fuel economy and overall efficiency. Terms of attribute, such as 'safety' (Cap Gemini 2011) and 'protection creativity' (KMPG 2011), generate confusion about the same attributes.

Usually, these characteristics are not identified or specified to make their definition unclear. Assessing characteristics at varying levels of depth often establishes comparative barriers. A car attribute as the key attribute type (KPMG 2011) (Hauser & Clausing 1988). The color attribute (Auto Trader 2015), however, is a third-party attribute, so it can be set in the car type (primary), external (secondary), color (tertiary).

The evaluation of vehicle characteristics at various levels of detail will decide how important other elements of vehicle styling are, in addition to color, for buyers. A comprehensive analysis of Cap Gemini (2011) and KPMG (2011) characteristics provides an impression that not all features of the vehicle have been tested. Cap Gemini took into account vehicle price, emissions and brand names, although the value of these attributes was not stated by KPMG. KPMG also acknowledged the importance of ergonomics, convenience and telematic features not found in the study by Cap Gemini.

Different sample sizes and sample features such as type of consumers will result in the difference in value of the attribute presented in these studies. It can also be due to inadequate assessment of the attributes,, as observed in Cap Gemini and KPMG reports or be related to selective reporting of attributes (top 9 most important attributes (KPMG 2011). The inability to compare studies is complemented additionally by the various terms used, which may or may not differ from the allegedly equivalent attribute ("safety" and "security innovation." Comparisons could not be true in these cases.

Collectively, associations between experiments are troublesome on all the topics discussed.

The academic literature available does not describe the characteristics that are relevant to vehicle customers either. In fact, it has been considered much more difficult to equate academic studies and business ties. This is partially because research studies concentrate on such issues like assessment of the qualities of a particular brand (Stylidis, Hoffenson, Wickman, & Söderman, 2014; Waligóra & Waligóra, 2007), one specific attribute evaluated in depth –product aesthetics (Yadav, Jain, Shukla, Avikal, & Mishra, 2013), sound quality (Cerrato, 2009) or target specific part of the automotive product as interior dashboard (Ahmed & Yannou, 2013; Huertas-Leyva, 2011), or vehicle seats (Erol, Diels, Shippen, Richards, & Johnson, 2014).

The impact of time is a further complication. In academics, the year of publishing is always different from year of publication, due to the long period needed for publication or because previously collected answers were evaluated by researchers (Baltas & Siridfakis 2013, Choo & Mokhtarian 2004). As patterns, economic condition, regulatory concerns and technical truths show the value of vehicle characteristics when attention comes to light, they have already been dated. Moreover, the characteristics of automobiles used for academic studies had the same problems in reports from industry.

To properly understand what is relevant for consumers, a detailed and well-defined list of vehicle characteristics is required. Importance of attribute is evaluated in order to determine the characteristics of the vehicle are important to consumers, to affect their buying decision (Pre-Purchasing Attribute Importance) (Harris Interactive 2015) and/or to assess vehicle satisfaction during ownership (JD Power customer satisfaction studies). The usual model for the pre- and the post-customer journey, used to examine how the meaning of the assignments changes with time, could no longer be enough (Mittal, Katrichis & Kumar, 2001).

While the pre-purchase stage in the past had primarily a link with a shopper visit, individual study is now followed by mostly online expenditures (Syncapse, 2013). The consumer travel thus could be split into three phases – analysis, visits to dealers and ownership. Consumers will have the opportunity to sample the selected commodity individually during a dealer tour. However, the consumer will foresee whether the commodity can fulfill the different requirements comparatively shortly in time.

In view of the sophistication of modern cars, it can be impossible to foresee, for example, innate insight in the longer term of the information system. Furthermore, a vehicle can be experienced in a static mode (in the showroom) and in dynamic mode (a test drive) (Abbott, 2009). In a distributor with a wealth of knowledge, customers may build the feeling of too much information from all senses through various facets of the car in a relatively short period which results in minor details or main attributes being remembered.

By purchasing consumer partnerships in a long-term manner with the product selected by the product maker and the retailer. During this process clients communicate more often with the commodity, carry out routing operations, get to know more about the vehicle they are purchasing and create memories. Over time, the owner will become affectionate and even hooked to the car (Dant, 2004; Sheller, 2004). Key attachments were found to be correlated with the exceptional functionality of the product or to create memories over the lifecycle of the product (Mugge, Schifferstein, & Schoormans, 2010).

Good tools to improve the customer-brand partnership (Ghosh, Kumar, Preeti, Rajoria, Misra 2016; Mugge, Schifferstein, & Schoormans 2010) and affect the re-buying of goods can be used (Baltas and Saridakis, 2013). The way buyers now look for their next car, backed by analysis from both academia and industry, produces indirect and direct quality assessments during internet research and dealer visits.

Customer travel can be split into 3 phases – study, visiting the dealer and ownership. To date, the scholarly and industrial research studies examined have not accepted this customer journey division into the 3 stage customer voyages suggested. It has thus not discussed how the meaning of attributes will change across the various stages of the consumer voyage. If this disparity in consumer travel is true, up-to-date characteristics of the vehicle are required.

2.10 Knowledge Gap

The effect of bus skin on the product of rollover simulation crash was investigated by Li, Shen, Yu, Zhu, and Han (2012). The authors concluded the outcome of FE ECE-R66 roll-over simulation was significantly affected by the skin. There was no validation of this paper and no school bus was involved. Li, Lan and Chen (2012), who subjected to the roll-over of ECE-R66, conducted a numerical analysis into how the superstructural structure affect the coach results. The authors derived seven different versions of the FE coach model, including closed rings, board wall to board ties, column layout and the position of the waist rail, which called the frameworks of structural configuration. Conclusions point out that all the designs tested had a major impact on the rollover results, with the exception of the position of the waist rail. The research was focused on coaches without school buses.

The experimental and numerical analysis on the roll-over of buses is discussed in Zhang and Zhang (2012). The numeric analysis is carried out with LS-DYNA and during the numerical rounding, the authors provide an energy absorption distribution. This paper introduces experimental roll-over, but no comparison is made to the numerical model.

This study was a bus and not school bus experiment. This study was. The crash and safety program initiated by the State of Florida for paratransit busses was defined by Kwasniewski, Bojanowski, Siervogel, Wekezer and Cichocki (2009). Authors defined the Florida Standard for the Assessment of Paratransit Buses for crashworthiness and protection (FDOT Standard). Two examples, rollover, and side effect are at the core of FDOT Norm. The roll-out phase complies with ECE-R66 criteria and is approved to take two approval routes; experimental, including total vehicle testing and numerical paths that are based on FE approval review.

In car exhaust systems and parts of cars, including tights and protective belts, Stainless steel is commonly used springs. The frame, suspension, body and fuel tank would quickly become standard in applications of catalytic converters. Stainless is now a structural application nominee. It can also be recycled with savings in weight, improved crashability and corrosion resistance. The substance combines solid mechanical and fireproof properties with outstanding manufacturability. Under effect, stainless-high strength provides excellent energy absorption relative to stress. It is perfect for the groundbreaking definition of "space frame" (Snelgrove, 2001).

A detailed rolled-up research study for paratransit buses was proposed by Bojanowski, Kwasniewski and Wekezer (2013). For designing the FE model bus, the authors demonstrated a comprehensively tested and verified process. Checking was carried out by experiments on the energy balance. A variety of bus component validation studies have contributed to hierarchic validation. A new rollover bus deformation measure was developed and used (Deformation Index, DI), a bus deformation quantifier. Many scientists have benefited from the growing computing resources in recent years and have become a popular focus of research by optimizing the bus structure. Customers also greatly valued the importance of car safety, which has played a significant role in vehicle sales. Competition in the automotive industry most also makes any corporation build safer vehicles.

In this light, security is of utmost importance in modern vehicle design, and crash tolerance is the first study to be done in modern vehicle design, according to Khalil and Du Bois (2004). Dynamic effect loads can be evaluated for the compliance with vehicle systems made of stainless-steel alloys. Few experiments were carried out on the crash resilience of structural vehicle components made of steel alloys and more so of stainless steels. From the debris of crashes in school buses, it was clear that current requirements were the issue when producing school buses in Kenya. This thesis was therefore aimed at investigating the influence of the designs of school bus structures and materials on the crash resistance of school buses among car building companies in the county of Nairobi, in Kenya.

2.11 Chapter summary

This chapter presented the literature review on crashworthiness, crash characteristics of bus vehicle structure, locally designed school bus vehicle structure, equipment and tools used for school bus vehicle structure, competency skills of bus vehicle structure builders, engineering materials used on bus vehicle structure, welding type on bus vehicle structure, bus vehicle structure inspection tests, customer needs based on school bus vehicle structure and finally the knowledge gap.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

This chapter highlights the research philosophy and design as used in this study. This chapter also examines the rationale or justification for the methodology used, the study area, research population, sample design, data collection instruments used, validity and reliability of the questionnaires and data collection and analysis procedures that were observed. Study variables and model specifications were also studied in this chapter. Finally, looked at the ethical considerations that were observed in this study

3.2 Research Philosophy

This study followed pragmatism as the methodological basis of the study. Pragmatism is not devoted to any particular system of philosophy or truth. Pragmatist scholars are focusing on the 'what' and 'how' of the study issue (Creswell, 2009). Early pragmatists "rejected the scientific notion that the "reality" of the real world could only be accessed by a single scientific method" (Mertens, 2005). In reality, a proactive approach would allow researchers to focus on common definitions and behave together using various approaches to different paradigms (Morgan, 2007).

In other words, popular knowledge is based on creating mutual behavior patterns. A practical science approach does not deny any contact between scientists in different ways (Morgan, 2007). The literature in mixed process analysis has introduced pragmatism as the "best paradigm" of this study by Teddlie and Tashakkori (2009). A realistic perspective has no influence on the metaphysical assumptions about the actions of experimental methodology, as opposed to a critical realist approach to mixed method study. Researchers are less limited as far as analyzes are concerned.

Pragmatism explores what functions rather than deciding between positivist/ postpositive or constructivist paradigms, to answer the issue of analysis (Johnson, and Onwuegbuzie, 2004; Onwuegbuzie and Johnson, 2006). But this does not mean the haphazard implementation of mixed methods, such that "anything goes" (Denscombe, 2008). They can be implemented thoughtfully (Bryman, 2006; Freshwater, 2007; Denscombe, 2008) by selecting and combining the findings of the required approaches for addressing research questions. In comparison, as paradigms are defined as universal beliefs among specialty participants, the emphasis is less on ontology and epistemology and is more likely to find consensus on the approaches used to function and to be decided by the field.

Morgan (2007) discusses a fundamental context to understand how the functional approach differs in terms of the relation between theory and proof, in terms of both quantitative (positivist/positivist) and qualitative (constructive) contexts. Although quantitative and qualitative research blends hypotheses of inference and induction, the rational approach relies, for example on critical realism (Modell 2009). While analytical and qualitative analyzes are contextual, a realistic analysis approach undermines the traditional distinction between the two in performing research.

Pragmatists believe that an analytical approach would be taken from an epistemological point of view at some point in the analysis without the use of topics, in order to create truth (Teddlie and Tashakkori, 2009). Here, a realistic approach helps researchers to be agile enough to take the most feasible approach to solving research problems. This will result in single and multiple realities from quantitative and qualitative research (Creswell and Plano Clark, 2011). By communicating and common sense between researchers, the emphasis would also be on cross-subjectivity, by working together with the objective quantitative approach and the subjective qualitative method. Morgan

(2007) pointed out that the inter-subjectivity dilemma is also a practical solution. Studies may say, using a rational approach, that there is only one reality and that people have their own different viewpoints.

In different phases of the research process, this study used the pragmatic paradigm, which combines qualitative and quantitative approaches (Tashakkori & Teddlie, 2003). The formulation of research problems to be discussed by the integration of evidence from quantitative and qualitative analysis is central to the application of mixed pragmatism methods of study (Creswell and Plano Clark, 2011). The emphasis is on a value system where researchers use the right methods instead of methodology itself to fix study problems (Teddlie and Tashakkori, 2009; Creswell and Plano Clark, 2011).

Consequently, research is mainly associated with the research project, but it is not concerned with the use of analysis to seek abstract expertise (Morgan, 2007). It is an effort to develop awareness through the achievement of specified study objectives (Morgan, 2007). This means that the justified claims originate from a guided examination, which means that no original assertions are made regarding the social world (Scott and Briggs, 2009).

Pragmatism is seen as a theory that provides the underlying methodological basis for mixed-method analysis (Tashakkori & Teddlie, 2003). As this thesis has used quantitative and qualitative methods, this paradigm is considered fitting for this analysis. The mixed approaches used with each paradigm, though. However, each paradigm uses the mixed methods. The practical paradigm focuses on the "the research problem" and introduces all approaches to explain the problem (Creswell, 2009). The "key" research subject selects approaches to data collection and analysis that most likely provide an insight into the issue without philosophically pursuing any alternative paradigm. The study adopted a technique with a hybrid methodology based on a functional paradigm, helping researchers follow better than the single approach designs to assess the precision of the answers (Tashakkori & Teddlie, 2003). Mixed analysis is a research methodology that incorporates both qualitative and quantitative forms. It includes the incorporation of philosophic assumptions, the use of both quantitative and qualitative methods and the combining of both approaches in a review.

Pragmatism is generally used in the approach to hybrid methods as a methodological companion. It points out a variety of knowledge and survey hypotheses that justify the mixed approach. Mixed approach analyzes are an analysis technique, mixing qualitative and quantitative forms by merging them. It comprises theory of philosophy, the implementation of qualitative and quantity methods and the combination of approaches in a review. This means that the average intensity of the survey is higher than the qualitative or quantitative analysis; it therefore covers all of the approaches in combination (Creswell, 2009).

3.3 Research Design

This study adopted explanatory research design to explain the phenomena under study by testing hypotheses and by measuring relationships between variables. According to Saunders, Lewis and Thornhill (2011), studies that establish causal relationships between variables use explanatory design. The design is also deemed appropriate for the study as it allowed the study to be carried out in the natural settings and allow the researcher to employ probability samples. This allowed for statistical inferences to be made to the broader populations and permit generalizations of findings to real-life situations, (Frankfort-Nachmias & Nachmias, 2008).

According to Hair, Black, Babin. Anderson and Tatham (2006) explanatory design allowed the use of questionnaires and thus use of inferential statistics in establishing the significance of the relationship between independent and dependent variables. This was quantitative in nature and hypotheses tested by measuring the relationships between variables. It included quantitative research such as multiple regressions which attempt to identify the effects and interactions among the variables (Maxwell & Mittapalli 2008). The use of terminology such as power, impact and consequence is typical in qualitative analysis, and these terms suggest a causal association.

The analysis explanatory design was acceptable because the main objective of the analysis was to measure an interaction or compare groups in order to create a connection between causes and results. The key advantage of using the explanatory test design was that it allowed the researcher to concurrently address confirmatory questions about the relationship between vehicle design and materials and the crashworthiness of the school bus, both by questionnaires and interviews. The thesis demanded both qualitative and quantitative data, which were descriptively analyzed and inferentially.

The Explanatory Analysis is intended to clarify and account for the descriptive details. So, while descriptive studies which ask 'what' kind of questions, explanatory studies aim to ask 'why' and 'how' questions (Grey, 2014). It is focused on exploratory and descriptive analysis and continues to describe the actual causes for the emergence of a phenomenon (Kumar, 2014). Explanatory analysis searches for causes and factors, offers facts to endorse or contradict hypotheses or predictions, and is undertaken to define and reflect on the interactions between various facets of the phenomena under review (Cooper & Schindler, 2014). This research design was used to explain how vehicle structure, design and materials (independent variable) influenced the vehicle crashworthiness (dependent variable) of the bus body manufacturing companies in Nairobi – Kenya.

3.4. Study Location

The study area was Nairobi City County. Nairobi City, the capital of Kenya is situated, in the highlands at an elevation of about 5500 feet above sea level. The city lies 480 km northwest of Mombasa. Nairobi was declared a municipality in 1919 and was granted city status in 1954. When Kenya gained independence in 1963, Nairobi remained the capital city.

Nairobi is the country's largest commercial hub. The packaging companies manufacture beverages, cigarettes and frozen food. Tourism is also important for the bustling metropolitan with several protected nature reserves throughout the city. The city is situated near the agricultural heartland of East Africa and a range of primary products are routed via Nairobi before being exported through Mombasa. Nairobi still plays an important part in the Eastern African culture. It is the headquarters of large regional railway groups, ports and airway firms. The area is well served by the highways and the rail network. Jomo Kenyatta International Airport 15km to the South West is one of the chief international airports in Africa.

Nairobi is home to several educational Institutions, Including the University of Nairobi, Kenyatta University, Technical University of Kenya, Other Institutions are Kenya National Archives. Dubbed the Green City in the Sun, the city of Nairobi is surrounded by a number of expanding suburban villas in the suburbs, and the city center is home to thousands of Kenyan companies and headquarters. Nairobi is a big industry center where several aid organisations are also headquartered.

Nairobi has a new city center, several lovely suburbs, as well as the biggest slum in Africa. The city is built on a hill, and it remains pretty cool all year round. Nairobi is the economic and cultural hub of Kenya. Nairobi is home to Africa's 4th biggest stock exchange, the Nairobi Stock Exchange (NSE).Based on the foregoing facts about Nairobi city, the researcher found the location conducive for the study since most of the organizations for the intended research are situated right in the city and County of Nairobi. According to recent update by NTSA (National Transport and Safety

Authority) in reference to vehicle road accident fatalities, Nairobi County remained the county with the most fatal crashes in 2015. Nairobi county contributed 22% of all the national fatalities in the year 2015.The update report also indicated that Nairobi County contributed the highest number of fatalities in the previous year that is 2014.

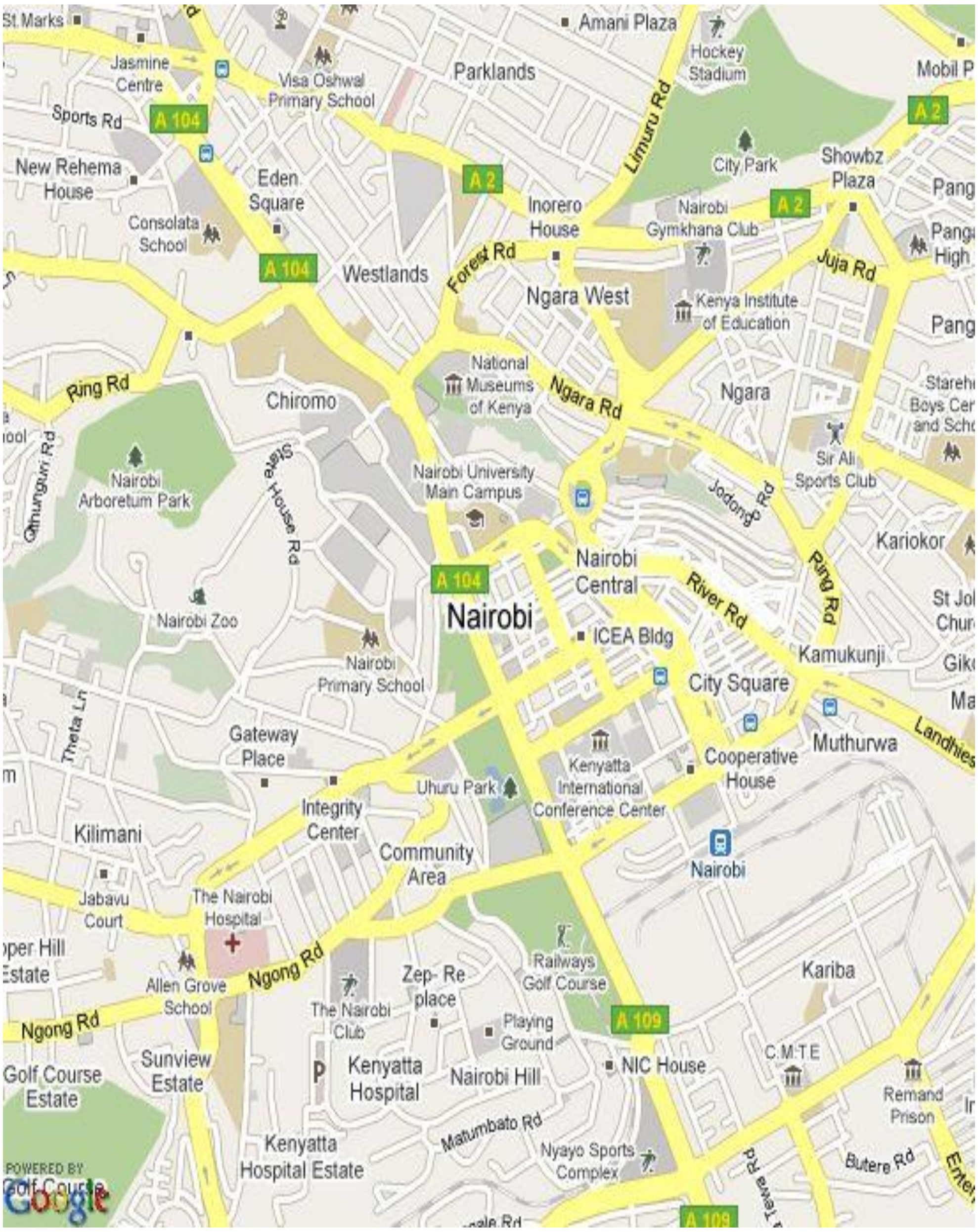

Figure 3.1 Map of Study Area Nairobi City (Source : Google Map)

3.5. Target Population

The target population was fifteen (15) registered bus vehicle body design and manufacturing companies with a total of 1500 employees comprising of technicians, supervisors and managers. Based on information from KABM (Kenya Association of Bus Manufacturers), it was established that there are almost twenty (20) bus vehicle body manufacturers operating in Kenya.

Out of the twenty bus vehicle body manufacturers, only fifteen companies were legally registered to operate as at December, 2018. Bus Vehicle Body Manufacturers in Kenya include Labh Singh and Harman Singh, Dodi Auto Tech, Banbros, CFG (Central Farmers Garage), Master Fabricators, KCI (Kenya Coach Industries), Truck World, Malva, Choda, Highlands, Kenya Vehicle Manufacturers, Toyota (Hino), CMC (Man, UD), Simba Colt (Fuso, Mitsubishi) and Isuzu. Representative from the following organizations were also considered namely: National Transport and Safety Authority (NTSA), Motor Vehicle Inspection Unit, Kenya Bureau of Standards (KEBS), National Police Service (National Traffic Police Headquarters) and Ministry of education staff (Public Schools) were also involved in this study.

3.6. Sample size and Sampling Procedures

Sampling means drawing a target group for observation. It was important because it was not possible to include the whole community in the study. Polit and Hungler (2005) say that it is impossible to set down comprehensive guidelines on the size of the study. The main issue in sampling is the determination of samples that best represent the population in order to allow accurate generalization of the data. Using the Yamane (1973) sample size formula at 95% confidence level, P = 0.05, sample size for workers was computed as below:

$$\mathbf{n} = \frac{N}{1 + N(e)^2}$$

Where;

n = the sample size; **N** = the population size; **e** = the acceptance sampling error

= 1500/1+ 1500(.05)^2 = 315 employees

From the target population of 1500 employees, a sample size of 315 respondents was selected.

For the purpose of ensuring accuracy and validity of findings, this study firstly used stratified sampling where various sampling units are selected based on nature of work and the roles played by each in the body building sector. The stratified sampling methodology was used to categorize the respondents into administrators, subordinates and technicians/servicemen, each of whom formed a stratum. According to Saunders et al., (2007) the stratified sampling methodology also offers a clearer contrast across strata. Stratified random sampling was appropriate as it allowed the researcher to represent not only the population as a whole, but also significant subgroups of the population. The benefit of using the stratified sampling method was that it was not a bias because it provided the sampling units with a fair probability of entering the sample.

The study used objective sampling to select fifteen operational managers out of twenty-six subordinates on the day-to-day operation of the school bus vehicle building in the bus construction business. According to Muijs (2006), the objective sampling method may be very successful if the researcher's intuition or judgment is sound and subjective to some degree. The researcher used objective sampling where sampling units claimed to have in-depth knowledge on vehicle body building players were permitted to engage in the analysis. While the sampling method sounds like bias, it aimed to increase the precision of the data gathered. Sampling units is made up of unique and non-overlapping items in the sampling frame, which represent the whole population. The study used purposive sampling because they are in charge of vehicle body building players in the industry.

Simple random sampling was used to pick 240 technicians to participate which was acceptable as it offered a fair opportunity for all respondents to be included in the survey. Simple random sampling was a big sampling method so each respondent had a fair probability of being included in the survey. It was acceptable since the population as a whole was relatively large, complex and sparsely dispersed, so the random sampling method would help to accomplish the desired goal. The sampling procedure gave and respondent the same chance of being in the sample in the population.

Table 3.1 Sample Size of Respondents

Organizations	Managers	Supervisors	Technicians / servicemen	Sample size
Vehicle Body manufacturers	15	36	240	291
KEBS	-	-	-	2
NTSA	-	-	-	2
Motor vehicle Inspection Unit	-	-	-	2
Kenya Traffic Police HQs	-	-	-	4
Ministry of education(schools)	-	-	-	14
Total	**15**	**36**	**240**	**315**

3.7. Study Variables (Dependent and Independent)

In this study, the independent variables were the locally designed bus vehicle structure, vehicle design tools and equipment as used, competencies and skills comprising of the education and skills possessed by technicians in industry and personnel in government agencies and private sector players, the engineering materials used in the vehicle structure design and ultimate bus construction, the equipment and tools used in bus manufacturing, the welding type, vehicle inspection tests and customers' needs. The dependent variable was school bus crashworthiness. The intervening variables were the state regulatory agencies such as the NTSA, KEBS, KENAS and KABM.

3.8. Data Collection Instruments

Data collection is a method of collecting and evaluating information on variables of interest in a structured manner that helps one to respond to specified study goals, test theories and analyze findings (Sekaran & Bougie, 2013). The data collection component of science is common to all fields of research, and while methods vary by discipline, the value of maintaining accurate and truthful collection remains the same (Cooper & Schindler, 2014). The purpose of all data collection is to capture the accuracy of the information that is then translated into a rich data analysis and to provide a convincing and reliable answer to the questions that have been asked (Kumar, 2014). To this end, the study relied on primary evidence for its observations and conclusions. These data were obtained using structured and self-directed questionnaires. Research tools help researchers to collect information that is used to respond to research questions in a study. The methods used in this research are questionnaires, interview guides and observation plans. It included the incorporation of both quantitative (questionnaire) and qualitative (interview) methods into the study, and both forms of data collection were carried out simultaneously. These are discussed in the following sections:

3.8.1 Questionnaires

A questionnaire comprises a collection of questions that can be answered by test subjects in a set of ways According to Kothari (2008), the questionnaire is a study tool used to collect data from a large sample. Most questionnaires are designed to collect already structured data and therefore provide a list of responses that the respondent can select from, however others can have more open-ended questions that allow the respondent to address the question in their own way, while others include a provision that asks all participants the same questions, in the same order, using the same wording and providing t (Matthews & Ross 2010). In the basis of this claim, the researcher was able to obtain knowledge from different organisations within a brief span of time. Data collection is a method of gathering data from the target population in a defined systematic manner. This allows us to have valid answers to the study issue. Key data used for the study. Cooper and Schindler (2014) outline the critical facts as facts found or gathered through first-hand experience. The questionnaire was seen as a valuable method for collecting statistics from respondents because it provides a way of collecting data in a transparent, simple, analytical and cost-effective manner.

Kothari (2008) points out that questionnaires are usually free from interview bias, since the answers are in the respondent's own language. Matthews and Ross (2010) concluded that the questionnaire was an important review tool used by the researcher to extract personal suggestions from the respondent.

Second, it was considered to have the advantage of receiving reliable responses to items, making it easier to compare data sets. Third, it encouraged participants to share their own point of view on the subject at hand, such as the Likert scale questions (Matthews & Ross 2010). The questionnaire consisted of two parts: the first section covered the background details of the respondents; the second part requested responses to the study questions. The questionnaires were administered to managers, supervisors and technicians within bus body building firms.

3.8.2 Interview Schedules

Interview is a basic form of interaction involving two or more people. Typically the interview is monitored by a person who asks questions. Orodho (2008) argued that more people would be able to communicate orally rather than in writing, and would include information more easily and thoroughly than on a questionnaire. Based on Kumar (2012), the advantage of using a structured interview is that; the interviewer was able to explain certain concerns related to the questions. This meant that the answers were reliably aggregated and distinctions could be made. In addition, the interviewer should become more adept at interviewing with respect to the methods that are effective for answering questions (Tight, Hughes & Blaxter, 2006). A structured interview guide was used to gather information from NTSA, KEBS, MOE, Motor vehicle inspection unit and Kenya police traffic headquarters.

3.8.3 Observation

Observation is perhaps the most basic (not the simplest) method of gathering data. The researcher usually reports what he or she finds in this instrument. Observation is often used in social science as correlated with qualitative data. According to Tashakkori and Teddlie (2010), results as a guide are meant to augment information or facts from questionnaires and interview schedules. At the simplest point, counting is merely a form of observation which is most definitely related to the essence of quantitative analysis (Matthews & Ross, 2010).

3.9. Validity and Reliability of the Instrument

Before the actual data collection exercise was carried out, the researcher carried out a pilot study in Nakuru County between two bus vehicle construction companies. A sample of 20 respondents, including administrators, subordinates and technicians, was used for the pilot analysis. Piloting of the instruments was conducted using respondents from Nakuru City with similar characteristics to the study area. The goal of the pilot study was to allow the researcher to determine

the reliability and validity of the instruments and to familiarize himself with the administration of questionnaires and other tools for data collection.

3.9.1 Validity

According to Matthews and Ross (2010), consistency is assigned to a proposal or calculation of the degree to which it conforms to the determination of information or fact. Validity in an empirical study refers to the degree to which the definition is precisely measured (Heale and Twycross, 2015). Validity should have a meaning, either to ensure that the instrument decides what it needs to calculate. A type of confirmatory test, either a qualitative test (face and content) or a quantitative test, should also be used (criterion and construct validity). The validation test is then divided into four groups, face validity; substance validity; criterion validity; and construct validity. The validity of the instrument was assessed through examination, meetings with supervisors, departmental lecturers and colleagues on the problems of the instrument. In order to assess the validity of the instruments, the scope and elements of the study have been established that constituted adequate coverage as per the objectives.

Face Validity refers to the specialist appraisal of the testing instrument, in particular with respect to language use and comprehensibility (n). Face Validity was developed by deciding whether, by means of a pilot analysis, the questions seem to be testing the design as per the test objectives set out in that report. Basically, this means that the validity is taken at face value through skimming over the processes. As a face-to-face check, research tools have been presented to experts to obtain suggestions for modifications. This was observed by the researcher to ensure that the instruments had adequate coverage of the sample versions. The recommendations included ideas, clarifications and other feedback. Ses recommendations were used to make the necessary adjustments to promote the efficiency of the instruments.

3.9.3 Reliability

According to Orodho (2008), reliability is the degree to which the findings remain stable over time if the results of the analysis can be repeated using a similar technique than was deemed accurate by the test instrument. Reliability means the mathematical accuracy of the calculation of a given construct (Heale and Twycross, 2015). Two of the most common building durability tests exist; Cronbach's alpha and composite reliability (Peterson and Kim, 2013). The questionnaires were evaluated for their reliability by means of a pilot study which helped the researcher to evaluate the clarity of the questionnaire items. Things that were insufficient or ambiguous have been updated to improve the efficiency of the test instrument and thereby increase its reliability.

In order to assess the reliability of the instrument to be used in the analysis, the test-retest approach was used, which required the administration of the same instruments to the same respondents twice over a certain period of time. Questionnaires were administered, collected data was analyzed using SPSS to determine the Cronbach’s Coefficient Alpha. After two weeks, same respondents were given the same questionnaires, collected responses were also analyzed.

The researcher used the Statistical Package for Social Sciences (SPSS) tool to examine the reliability and consistency of the research questionnaire using the Cronbach alpha test. Cronbach's Coefficient Alpha was used to assess the efficacy of the testing instrument by correlating the findings from both ratings. Salda (2012) notes that Cronbach's alpha is a coefficient widely used to assess the efficacy and accuracy of standardized questionnaires. According to Kumar (2014), the criterion for Cronbach alpha is set at ≥ 0.7 and the analysis thus followed the same test for a reliable and effective instrument. This showed that there was a relationship between the first and second scores obtained after the instruments had been administered. It was therefore assumed that the data collection instruments were reliable.

3.10 Data Collection Procedures

A research procedure according to Cooper and Schindler (2014) is a clear and concise depiction of all the steps assumed in the study for the basis of explicability. Before the actual data collection exercise takes place, permission was sought from the Ministry of Higher Education, Science and Technology through the National commission for Science and Technology Innovation (NACOSTI) for a research permit. The permit was then presented to the bus body building firms who then gave a go ahead. Data was collected using both questionnaires and interview schedules. The interview schedule were administered to regulatory bodies, while data was collected from technicians using questionnaires using the drop and pick method under close supervision of the researcher. A period of two weeks was given to fill the questionnaire after which the filled questionnaires were picked.

3.11 Data Analysis

Data analysis is a research technique for the objective, systematic and qualitative description of the manifest (Cooper & Schindler, 2014). Data analysis is a method of putting facts and figures to solve the research problem. It is vital to finding the answers to the research objectives. For research quality to be ensured, the study used both quantitative and qualitative methods of data analyses. After all data was gathered, the researcher carried out a data-cleaning procedure requiring the detection of missing responses to increase the accuracy of the responses. The exhaustiveness, coding and accumulation of missing data were checked and edited. The data were categorized, encoded and entered into the research machine using the Social Sciences Statistical Package (SPSS

V. 22). The interview schedule data was thematically represented using themes that complemented the questionnaires. The questionnaire data were analyzed using both descriptive and inferential statistical approaches. Descriptive numbers are mean and standard deviations, frequencies and percent. Inferential statistics consist of Pearson Product Correlation coefficient, multiple regression analysis and hierarchical regression. With the aid of the Social Science Statistical Pack, the results is subjected to correlation and regression analyses. Multiple regressions are parametric statistics used where they satisfy the following assumptions (Field, 2009): interval data, linear connections, regular distributions, outliers detected and omitted.. Data should be at interval stage. Tables and graphs are used to view the results. The theories were evaluated using multiple regression analyzes.

3.11.1 Model Specification

To determine the influence of the independent variables on the dependent variable as captured by the null hypotheses H_{01}, H_{02}, H_{03}, H_{04}, H_{05} and H_{06} a multiple regression equation was applied as follows:

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6e + \beta_7X_7 + e$ ………...Model 1

Where:

Y: Crashworthiness

X: Vehicle design structure and materials

X_1: Locally designed bus vehicle structure

X_2: Competency

X_3: Engineering materials

X_4: Equipment and tools

X_5: Welding technology

X_6: Vehicle inspection tests

X_7: Customer needs

β_0: Constant

$\beta_1 - \beta_7$: Regression coefficients

e: Error term

3.11.2 Assumptions of Multiple Regressions

The key concern of the study involved hypotheses of multiple regression: linearity, homoscedasticity, normality and neckliness. The presumption of normality is based on the normal distribution form and provides scientists knowledge of what values to assume (Keith, 2006). This statement was checked by the researcher using visual analysis of data plots, skews, curtosis and plots (Osborne & Waters, 2002). Normality of uniform residues was further tracked by histograms.

Linearity is calculated by the use of multiple regressions to approx. where the relation is linear in nature between dependent and independent variables. (Osborne & Waters, 2002). Examination of residual plots displaying uniform residuals vs. expected values is useful for detecting violations of linearity (Stevens, 2009). Residual plots showing the uniform residues and the expected values were used to determine linearity.

For all types of independent variables, the assumption of homoscedasticity shall be the same error variance (Osborne & Waters, 2002). This implies that errors were distributed evenly by variables in the analysis (Keith, 2006). Visual study of the uniform residual plot with the predicted normalized return value has checked homoscedasticity (Osborne & Waters, 2002).

A uniform residual dispersion map has been used to assess homoscedasticity. Multi-linearity exists when many indépendant variables correlate at high levels, or when an indie variable is an almost linear combination of other independent variables (Keith, 2006). Statistical analysis packages such as SPSS provide collinearity diagnoses that calculate the degree to which each variable is independent of other independent variables. Tolerance and VIF figures have been used for medical purposes (Keith, 2006).

3.12 Ethical Considerations of the Study

The researcher requested for an introduction letter from Board of Postgraduate Studies, University of Eldoret for onward delivery to National Council for Science Technology and Innovation (NACOSTI) addressed to the Director General. On approval, The National Council for Science and Technology and Innovation (NACOSTI) granted a permission (Research Permit and Letter of Authorization) which enabled the researcher to have the mandate to carry out research work. For ethical concerns, the respondents were assured of confidentiality with regard to their responses and identity. In addition, the respondents were assured of their anonymity thereby not disclosing their names but rather coding their responses in questionnaires. This was done in order to get more honest responses and also get rid of certain fears (Mugenda and Mugenda 2004). The researcher further encouraged the respondents to consent voluntarily to the study while explaining to the respondents, the basics of the research. In addition, the researcher emphasized the importance of the study with a view to disseminate the research findings upon request for the benefit of the respondents (Mugenda & Mugenda, 2008).

3.12 Chapter Summary

This chapter presented the research design and methodology that the study adopted. The pragmatic paradigm and explanatory research design were adopted. It also presented the target population, sample size, data collection instruments to be used. The validity and reliability of the instruments and data collection and analysis procedures were given. The model specifications and ethical considerations were also presented.

CHAPTER FOUR

DATA PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the findings in terms of demographic characteristics of the study sample, descriptive analysis of independent and dependent variables, reliability and validity results, inferential analysis of the relationships and discussions thereof.

4.2 Background Characteristics of Respondents

Employees' background characteristics were measured in terms of gender, category of employee, educational level and working experience.

4.2.1 Respondents Gender

Results from the gender study provided in Table 4.1 showed that the sample was made up of the majority of 215 men(94.7%) and 12(5.3%) women. This suggests that workers working in car building firms in Kenya have separate sexes. Gender was selected as a backdrop to the research, based on studies that indicate strong associations between gender diversity and organization success (Julizaerma & Zulkarnain, 2012).

Table 4.1: Gender of Respondent

	Frequency	Percent	Cumulative Percent
Male	215	94.7	94.7
Female	12	5.3	100
Total	**227**	**100**	

4.2.2 Duration of working with the school bus vehicle structure building company.

The study sought to establish the duration the respondents had been working in the bus vehicle structure building company. Results of the descriptive analysis presented in Table 4.2 revealed that 124(54.7%) of the respondents had been working for between 6-10 years, with 48 (21.1%) had worked for 11 and 15 years, while 42(18.5%) for less than 6 years and the least 5.7% for more than 15 years. The findings indicated that most of the respondents had worked in the bus vehicle structure building company for more than 6 years. This implies that the respondent had enough experience to give relevant information on the relationship between bus vehicle design and crashworthiness of a school bus.

Table 4.2 Duration working in the bus vehicle structure building company

	Frequency	Percent	Cumulative Percent
<5 years	42	18.5	18.5
6-10 years	124	54.6	73.1
11-15 years	48	21.1	94.3
>15 years	13	5.7	100
Total	**227**	**100**	

4.2.3 Job Category of Respondents

Results on the job category of respondents as presented in Table 4.3, reveal that majority 157 (94.7%) of them were technicians, with 56(24.7%) supervisors and 14 (6.2%) managers. This implies that various categories of employees work in bus vehicle structure construction companies in Kenya.

Table 4.3 Job Category of Respondents

	Frequency	Percent	Cumulative Percent
Technicians	157	69.2	69.2
Supervisors	56	24.7	93.8
Managers	14	6.2	100
Total	**227**	**100**	

4.2.4 Highest Level of education attained

From the analysis of respondents' level of education shown in Table 4.4, 83(36.6%) of the respondents were diploma holders, with 65 (28.6%) having diploma certificate of education, while 39(17.2%) had secondary and undergraduate education.

Table 4.4 Highest Level of education attained

	Frequency	Percent	Cumulative Percent
Primary	1	.4	.4
Secondary	39	17.2	17.6
Certificate	83	36.6	54.2
Diploma	65	28.6	82.8
Degree	39	17.2	100
Total	**227**	**100**	

It can be concluded that the employees had the relevant education necessary to proactively participate in issues regarding relationship between bus vehicle structure designs and materials on crashworthiness of a school bus. The result indicates that the bulk of staff of car building workers were graduates of art and graduation qualifications. That is why the Kenyan Government is gradually focused on improving medium-sized skills and on rapidly growing the number of tertiary colleges. Education is a catalyst for deeper understanding of mechanisms and control systems that enable workers to be imaginative, inventive and able to take teamwork measures, quality and productivity improvement (Chimwani et al., 2014).

4.2.5 Working Experience of Respondents

It is clear from the research results in Table 4.5 that, while a good portion of 64 (28,2%) had experience between 5 and 10 years, the remainder of 119 (52,4%) had between 11 and 20 years' job experience, 42(18,5%) was in the current place between 20 and 30 years. Most respondents have spent a comparatively long time in their respective departments and thus could rely on them to understand the link between vehicle structural designs and materials and the crash-resistance of a bus.

Table 4.5 Working experience of Respondents

	Frequency	Percent	Cumulative Percent
5-10 years	64	28.2	28.2
11-20 years	119	52.4	80.6
20-30 years	42	18.5	99.1
>45 years	2	.9	100
Total	**227**	**100**	

4.3 Descriptive Results of study variables

A meaningful overview of the quantitative variables analyzed was rendered using objective statistics to satisfy study design standards. The following alternatives were used for 5-point Likert responses; 1 to extreme disagreements; 2 to diverge; 3 to moderation; 4 to agree; 5 to strong consensus. The continued review of the mean sensitive scores < 1.5 is rather divided; with 1.5-2.5 divisions; while 2.5-3.5

modest divisions; with 3.5-4.5 divisions and ultimate acceptance, >4.5 is fully decided.

4.3.1 Locally designed structure of School Bus

In the current research, the first goal aimed to determine the effects on the crash tolerance of school buses of a local bus structure. In order to classify the consciences of the respondent on the locally built bus car layout, a quantitative study was performed prior to the evaluation of the effect. A total of 4 statements were used to describe the configuration of local bus vehicles and the reactions obtained on the 5-point likert scale shown in Table 4.6. It is evident that many of the respondents 84(37%) moderately agreed that school bus vehicles in their organization are constructed and can readily face the harsh Kenyan environment, with 80 (35.2%) disagreed and 27.8% agreed (*M=3.02; SD=0.96*). This implies that school bus vehicles structures in their organization are constructed and can readily face the harsh Kenyan rough, rugged and meandering roads.

Most of the respondents 100 (44.1%) moderately agreed that locally built school bus vehicles structures have a lower failure rate compared to an imported manufactured product, with 31.7% disagreed and 24.3% agreed (*M=3.01; SD=0.92*). This indicates that the locally build school bus vehicles structures have a lower failure rate compared to an imported manufactured bus. Most of the respondents 93(41%) moderately agreed that school bus vehicle manufacturing companies often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials, with 30.4% disagreed and 28.6% agreed (*M=3.08; SD=0.92*). This indicates that school bus vehicle structure manufacturing companies often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials.

Table 4.6 Locally Designed Structure of School bus.

Statements	SA		A		MA		D		SD		Mean	SD
	F	%	F	%	F	%	F	%	F	%		
School bus vehicles in our organization are constructed and can readily face the harsh Kenyan environment.	22	9.7	41	18.1	84	37.0	80	35.2			3.02	0.96
Our locally build school bus vehicle structures have a lower failure rate compared to an imported manufactured product.	21	9.3	34	15.0	100	44.1	71	31.3	1	.4	3.01	0.92
Locally produced school bus vehicles structures have a quality reputation and enjoy a competitive advantage.	22	9.7	39	17.2	85	37.4	78	34.4	3	1.3	3.00	0.98
School bus vehicle manufacturing companies often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials.	23	10.1	42	18.5	93	41.0	69	30.4			3.08	0.94
Overall											**3.03**	**0.69**

KEY: SA= **Strongly agree; A=Agree; MA=Moderately agree; D=Disagree and SD=Strongly disagree**

On the basis of the results of the report, the answers to the four claims for a local bus structure showed an overall average of 3.03. This suggests that most respondents agreed moderately with the claims used to assess the layout of the local bus car. This was evident with school bus vehicle structures in their organization are constructed and can readily face the harsh Kenyan terrain, locally build school bus vehicles have a lower failure rate compared to an imported manufactured buses, locally produced school bus vehicles have a quality reputation and enjoy a competitive advantage and school bus vehicle manufacturing companies often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials.

From the interview with bus vehicle body construction firms, it was established that there was no difference between a school bus vehicle structure and a general public bus vehicle structure in the design, construction and materials used. On the bus vehicle structure construction firms, the interviews indicated that there was a challenge in the school bus vehicle structure designs. There are many or numerous shapes (designs) developed by industry and that no guiding policy to regulate which presents a chaotic scene. A case in point is for example a 51-bus seater developed by many players having diverse shapes and therefore lacking a model. The respondents further reported that the manufacture of the bus vehicle chassis is given the freedom to produce many shapes (lengths) and therefore presenting a challenge of lack of uniformity in body shape. There should be a professional approach to shape (design) of bus body so as to border on a bus model type just like in small cars as argued by an interviewee.

From the interview with bus vehicle structure construction firms, indicated that the locally assembled and imported buses should comply with standardized parameters of the floor levels, gangways, dimension of footsteps, seats, seat belts installations, seating layout, handrails and hand holds according to KS 372 code.

From the interview, it was established that the government of Kenya has made it mandatory for the bus body building companies to adhere to KS 372 code in a bid to reduce severity of injuries and prevent fatalities in the event of a crash. The standard requires vehicle manufacturers to prepare vehicle designs and submit them to KABM for approval before building the school bus body and seats. No new school buses are registered to operate by NTSA before going through the vigorous process by KABM, KS 372 inspection engineers and issued with the Vehicle Inspection Notification chip known as (VIN) plate. The plate serves as a compliance certificate to allow NTSA pre-registration inspections.

From the interview, it was established that in the KS 372- 2014 code, there is the introduction of the anti-roll bars as a mandatory in school bus body construction and that will go a long way to increase production costs. Even so, it should make buses structurally stable and to some extent safe. Notably, the standard painting colour for all Kenyan school buses is yellow. The school buses according to the KS 372 – 2014 code/standard, identify school buses as a special category.

From the interview, it was established that, in view of KS 372 – 2014 standard, approvals for vehicle designs and or modifications shall be authorized by relevant registered engineer(s) to specific vehicle type and shall ensure that vehicle bodies are constructed in compliance with the manufacturer's specifications. Further to the above, all the safety requirements are prescribed in the KS 372 – 2014 standard in view of vehicle designs (structures).

From the study findings it was established that school bus vehicle body construction takes an average of 45 days to build bus vehicle structure . The notable engine makes in the market are as follows: Isuzu, Scania, Mitsubishi, Hino, Nissan Diesel, UD and Mercedes Benz. Isuzu is the major supplier of engines and chassis for school bus vehicle bodies in most bus vehicle structure building companies. At the Isuzu bus body technology centre, the vehicles are assembled of the chassis and the engine and thereafter taken to various bus vehicle structure construction companies. It was established that 80% of the bus body building in Nairobi is controlled by Isuzu East Africa. Due to the prevailing application of manual work in bus vehicle body construction, it is difficult to achieve quality workmanship, consistency of welds and general operations due to hand held manual operations.

From the interview carried out, it was established that due to manual bus vehicle structure construction, work operations are hampered or reduced since the organizations are not able to meet customer targets. For example, 300 units are expected target against only 20 or less that are actually build and finished per month. There is critical need to automate some of the operations in the school bus vehicle structure industry. There is a challenge of price wars and monopoly occasioned by giant player such as "Isuzu East Africa" and customer prevalence for reduced purchasing price of the completed unit upon ordering.

From the interview done, it was noted that during the school bus vehicle structure construction process, there is no difference between the general public bus transit and the school bus in terms of the designs, layout of structures and the ultimate bus body finishing. Even the materials used are the same. The only difference between a school bus and the general public bus is the final application of colour for which school buses are painted (yellow) and the special needs application. The special needs are for example physically challenged, guard rails around the window panes and seat belts.

From the observation made, it was established that it is impossible to find any school bus wreckage in any of Nairobi Police traffic stations. The reason is that bus vehicle chassis is believed to be the cornerstone of the bus body vehicle. Owners often demand for any wreckage so as to salvage the chassis thereby having a new bus body build and fitted to the chassis wreckage, this normally takes place at some back-street garages that are unorganized bus vehicle body builders with questionable skills and materials.

4.3.2 Competency skills of Vehicle structure technicians.

The second objective sought to establish the relationship between competency skills of bus vehicle builders and crashworthiness of a bus. A total of 11 statements were used to determine the Competency skills and responses elicited on a 5-point likert scale with as shown in table 4.7. Majority of the respondents 93(41%) moderately agreed that organization takes a keen interest in technical skills and knowledge in electronic component sensitivity, with 64(28.2%) disagreed and 30.8% agreed (*M=3.15; SD=0.98*). This implies that bus vehicle construction organization takes a keen interest in technical skills and knowledge in electronic component sensitivity due to bus body structure wiring. Most of the respondents 86(37.9%) moderately agreed that organization values innovation in employees, with 27.3% disagreed and 34.8% agreed (*M=3.20; SD=0.99*). This indicates that organization values innovation in employees. Majority of the respondents 101(44.5%) moderately agreed that welding during bus vehicle manufacture, I/we use MIG welding in fastening / joining of specific metals, with 31.3% disagreed and 24.2% agreed (*M=2.93; SD=0.94*). This implies that during bus vehicle construction, MIG welding is used in joining of specific metals. Most of the respondents 104(45.8%) moderately agreed that MIG welding is a popular welding method used in their organization, with 27.3% disagreed and 26.9% agreed (*M=3.08; SD=0.93*). This indicates that MIG welding is a popular welding method used in their organization.

Table 4.7 Competency skills of technicians

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	%	F	%	F	%	F	%	F	%		
This organization takes a keen interest in technical skills and knowledge in electronic component sensitivity.	28	12.3	42	18.5	93	41.0	63	27.8	1	.4	3.15	0.98
The organization values innovation in employees.	29	12.8	50	22.0	86	37.9	61	26.9	1	.4	3.20	0.99
Welding during bus vehicle manufacture, I/we use MIG welding in fastening / joining of specific metals.	13	5.7	42	18.5	101	44.5	59	26.0	12	5.3	2.93	0.94
MIG welding is a popular welding method used in our organization.	22	9.7	39	17.2	104	45.8	60	26.4	2	.9	3.08	0.93
The organization emphasizes foundation skills, for adapting to dynamic industry changes.	35	15.4	121	53.3	23	10.1	40	17.6	8	3.5	3.59	1.06
During recruitment of new employees, the organization is mostly keen to take note of language, literacy, numeracy and digital skills.	17	7.5	61	26.9	34	15.0	99	43.6	16	7.0	2.84	1.13
The company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades.	29	12.8	109	48.0	62	27.3	27	11.9			3.62	0.86
This company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training.	45	19.8	100	44.1	49	21.6	32	14.1	1	.4	3.69	0.96
Our company promotes the development of management skills for those who have progressed through the ranks of automotive fabrication into management role.	28	12.3	95	41.9	68	30.0	36	15.9			3.51	0.90
The company motivates its staff through sector specific skill expansion.	72	31.7	92	40.5	48	21.1	14	6.2	1	.4	3.97	0.90
The apprenticeship system remains our company's preferred way of complementing skills formation.	90	39.6	109	48.0	15	6.6	13	5.7			4.22	0.80
Overall											**3.44**	**0.55**

Majority of the respondents 104(45.8%) moderately agreed that organization emphasizes foundation skills, for adapting to dynamic industry changes, with 27.3% disagreed and 26.9% agreed (*M=3.59; SD*=1.06). This implies that organization emphasizes foundation skills, for adapting to dynamic industry changes. Most of the respondents 115(50.6%) disagreed that during recruitment of new employees, the organization is mostly keen to take note of language, literacy, numeracy and digital skills, with 15% moderately agreed and 34.4% agreed (*M*=2.84*; SD*=1.13). This indicates that in the recruitment of new employees, the organization is mostly keen to take note of language, literacy, numeracy and digital skills.

Majority of the respondents 138(60.8%) agreed that company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades, with 11.9% disagreed and 27.3% moderately agreed (*M=3.62; SD*=0.86). This implies that company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades. Most of the respondents 145(63.9%) agreed that company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training, with 21.6% moderately agreed and 14.5% disagreed (*M*=3.69*; SD*=0.96). This indicates that company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training.

Majority of the respondents 123(54.2%) agreed that their company promotes the development of management skills for those who have progressed through the ranks of automotive fabrication into management role, with 30% moderately agreed and 15.9% disagreed (*M*=3.51*; SD*=0.90). This indicates that company promotes the development of management skills for those who have progressed through the ranks of automotive fabrication into management role. From table 4.7 above, majority of the respondents 164(72.2%) agreed that company motivates its staff through sector specific skill expansion, with 6.6% disagreed and 27.3% moderately agreed (*M=3.97; SD*=0.90). This implies that company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades. Most of the respondents 199(87.6%) agreed that apprenticeship system remains our company's preferred way of complementing skills formation, with 6.6% moderately agreed and 5.7% agreed (*M*=4.22*; SD*=0.80). This indicates that apprenticeship system remained bus vehicle structure construction companies' preferred way of complementing skills formation.

From the results of the analysis in Table 4.7 above, it was clear that the total average for responses to the 11 declarations for competency is 3.44. This indicates that most respondents moderately agreed with comments used to assess a bus' abilities. This has been apparent as management skills are emphasized, and businesses routinely send workers to seminars/work-shops to develop competencies to respond to dynamic developments in the sectors (every 6-12 months).

The company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training, company motivates its staff through sector specific skill expansion and apprenticeship system remains our company's preferred way of complementing skills formation. From the interview with bus vehicle structure construction firms, it was noted that bus vehicle builders' special skills and competencies required before recruitment of new staff include mechanical production technology, fitting and fabrication and be of grade tests minimum and with vast experience.

4.3.3 Engineering materials used in the manufacture of vehicle structure

The third objective sought to establish the influence of engineering materials on crashworthiness of a bus. There were a total of 21 statements that determined the engineering materials used on the school bus and the answers requested at a 5-point likert scale, as shown in table 4.8. Incase of fire or crush behavior, structural integrity of the stainless steel body is significantly longer than the carbon body's structural integrity, and still longer than that of an aluminum body, as decided by a plurality of respondents 193 (85.1 percent), with 11 percent somewhat agreed and 3.9 percent disagreed. This means that a body of stainless steel remains structural strength even longer than that of a carbon stainless steel body, and longer than the aluminum body, in the event of fire or crash behaviour.

Most 179 (78.9%) agreed to having a choice of constructing a stainless automobile car body to give consumers the value of a resilient structure, 9.3% agreed mildly and 9.3% agreed (M=4.05; SD=1.05). The customers opted to use this process. This means that the construction of stainless buses is selected to give the consumer the benefits of a resistant corrosion frame. A vast majority of respondents in 194 (81 percent) agreed with 11 percent mildly agreed and 7.9 percent discordant that the construction of a bus vehicle of stainless steel is still appealing over the entirety of its life (M=4.14; SD=0.97). This ensures that the bus body car made of steel remains an enticing look throughout its whole existence. Most respondents 140 (61.7%) agreed to minimize repair and services prices for stainless steel cars to ensuring that they are of high secondhand value, with a 9.7% fairly agreed and 7% disagreeable (M=4.16; SD=0.96). This shows that the body for vehicles made of stainless steel decreases repair and servicing costs and guarantees a high second hand value.

Table 4.8 Engineering materials used in the manufacture of vehicle structure

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	%	F	%	F	%	F	%	F	%		
In case of fire or crush behaviours, the structural integrity of a stainless-steel body remains intact.	110	48.5	83	36.6	25	11.0	8	3.5	1	.4	4.29	0.83
MIG material is high quality material applied in school / passenger vehicle body structure.	19	8.4	29	12.8	96	42.3	79	34.8	4	1.8	2.91	0.94
There is no much difference in the use of stainless steel to that of mild steel in school bus body building.	26	11.5	55	24.2	86	37.9	59	26.0	1	.4	3.20	0.97
Aluminum metal material is greatly applied on bus passenger vehicle body construction.	25	11.0	44	19.4	95	41.9	62	27.3	1	.4	3.13	0.95
Stainless steel is used for both underframe and bus passenger vehicle body to ensure a long life.	26	11.5	36	15.9	99	43.6	65	28.6	1	.4	3.09	0.96
Stainless vehicle body construction is chosen to give the customer the advantages of corrosion	93	41.0	86	37.9	21	9.3	21	9.3	6	2.6	4.05	1.05
Bus body vehicle that is made of stainless steel remains an attractive appearance for the whole life.	97	42.7	87	38.3	25	11.0	13	5.7	5	2.2	4.14	0.97
Stainless steel vehicle body reduces maintenance and service costs and high second – hand value.	97	42.7	92	40.5	22	9.7	10	4.4	6	2.6	4.16	0.96
The application or use of stainless steel can counter environmental challenges such as humid climate, cold places and salty waters.	59	26.0	108	47.6	32	14.1	19	8.4	9	4.0	3.83	1.03
Buses manufactured by stainless steel are lighter, require less maintenance and are more fuel efficient.	9	4.0	41	18.1	19	8.4	84	37.0	74	32.6	2.24	1.20
Our organization greatly uses / utilizes stainless steel panels for designing the school bus	12	5.3	26	11.5	22	9.7	82	36.1	85	37.4	2.11	1.18
This company totally uses stainless steel in building vehicle chassis and stainless-steel.	99	43.6	77	33.9	24	10.6	20	8.8	7	3.1	4.06	1.08
Stainless steel application for bus vehicle construction resists vibration.	115	50.7	56	24.7	14	6.2	36	15.9	6	2.6	4.05	1.20
In view of crashworthiness, stainless steel bears very high impact resistance that makes it a safer material in case of accidents.	27	11.9	124	54.6	51	22.5	19	8.4	6	2.6	3.65	0.89
In terms of floorings, footsteps, entrance and luggage carrier, it is worthwhile to use stainless steel in bus vehicle manufacture.	22	9.7	120	52.9	54	23.8	25	11.0	6	2.6	3.56	0.91
Roof for vehicle body buses need to be hugely made of stainless steel.	32	14.1	112	49.3	65	28.6	17	7.5	1	.4	3.69	0.82
Fasteners, hand rails and hand holds and guarding of step wells are more often than not made of stainless steel.	147	64.8	47	20.7	18	7.9	14	6.2	1	.4	4.43	0.91
Mild steel is the principal material used hugely in general bus vehicle body construction.	151	66.5	47	20.7	17	7.5	12	5.3			4.48	0.85
The chassis of school bus passenger vehicles are supplied by automobile manufacturers.	156	68.7	48	21.1	15	6.6	8	3.5			4.55	0.77
In most cases bus vehicle body is build by body builders as per the requirements of the schools/institutions or customer desire and specifications.	151	66.5	48	21.1	19	8.4	9	4.0			4.50	0.81
Bus vehicle body is painted as per the requirements of the customer.	64	28.2	112	49.3	32	14.1	19	8.4			3.97	0.87
Overall											**3.72**	**0.50**

Majority of the respondents 167(73.6%) agreed that application or use of stainless steel can counter environmental challenges such as humid climate, cold places and salty waters, with 14.1% moderately agreed and 12.4% disagreed (*M=3.83; SD*=1.03). This implies that application or use of stainless steel can counter environmental challenges such as humid climate, cold places and salty waters. Most of the respondents 176(77.5%) agreed that company totally uses stainless steel in building vehicle chassis and stainless-steel, with 10.6% moderately agreed and 11.9% disagreed (*M*=4.06*; SD=1.08*). This indicates that the company totally uses stainless steel in building vehicle chassis and stainless-steel.

Majority of the respondents 171(75.4%) agreed that stainless steel application for bus vehicle construction resists vibration, with 6.2% moderately agreed and 18.5% disagreed (*M=4.05; SD*=1.20). This implies that bus body vehicle that stainless-steel application for bus vehicle construction resists vibration. The 141 (66.5 percent) respondents were largely in agreement that stainless steel, a crashing tolerance with 22.5 percent of injury protection and 11 percent of injuries approved (M=3,65; SD=0,89), has a very high impact resistance. This reveals that stainless steel has exceptionally high impact resistance in view of crash resistance, which makes it a better substance in the event of collisions.

Most of the respondents 142(62.6%) agreed that in terms of floorings, footsteps, entrance and luggage carrier, it is worthwhile to use stainless steel in bus vehicle manufacture, with 23.8% moderately agreed and 13.6% agreed (*M*=3.56*; SD*=0.91). This indicates that floorings, footsteps, entrance and luggage carrier is worthwhile to use stainless steel in bus vehicle manufacture. From table 4.8 above , it is evident that majority of the respondents 144(63.4%) agreed that roof for vehicle body buses need to be hugely made of stainless steel, with 7.9% moderately agreed and 7.9% disagreed

(*M=3.69; SD*=0.82). This implies that roof for vehicle body buses need to be hugely made of stainless steel. Most of the respondents 194(85.5%) agreed that fasteners, hand rails and hand hold and guarding of step wells are more often than not made of stainless steel, with 7.9% moderately agreed and 6.6% agreed (*M*=4.43*; SD*=0.91). This indicates that fasteners, hand rails and hand hold and guarding of step wells are more often than not made of stainless steel.

Of the respondents 198(87.2%) agreed that mild steel is the principal material used hugely in general bus vehicle body construction, with 7.5% moderately agreed and 5.3% disagreed (*M=4.48; SD*=0.85). This implies that mild steel is the principal material used hugely in general bus vehicle body construction. Most of the respondents 204(89.8%) agreed that chassis of school bus passenger vehicles are supplied by automobile manufacturers, with 6.6% moderately agreed and 3.5% disagreed (*M*=4.55*; SD*=0.77). This indicates that chassis of school bus passenger vehicles are supplied by automobile manufacturers.

Majority of the respondents 199(87.6%) agreed that in most cases bus vehicle body is build by body builders as per the requirements of the schools/institutions or customer desire and specifications, with 8.4% moderately agreed and 4% disagreed (*M=4.5; SD*=0.81). This implies that in most cases bus vehicle body is build by body builders as per the requirements of the schools/institutions or customer desire and specifications. Most of the respondents 176(77.5%) agreed that bus vehicle body is painted as per the requirements of the customer, with 14.1% moderately agreed and 8.4% disagreed (*M*=3.97*; SD*=0.87). This indicates that the bus vehicle body is painted as per the requirements of the customer.

Much of those polled disagreed (73.5%) with 9.7%, with 38 (16.8%) support (M=2.11; SD=1.18) and disagreed that their company requires / uses significant quantities of stainless steel to build a school bus. This reveals that the bus companies do not use steel panels for the school bus construction.

The research results in table 4.8 above shows that the average mean for responses to the 21 statements used to test material engineering was 3.72. This indicates that most respondents are in accordance with the statements used for calculating bus engineering content. The structural strength of an Edelstahl body, which is much longer than the carbon steel body and is longer longer than that of an aluminum body, and the Edelstahl-Body-Construction, to improve the benefits of a corrosion resistant structure, is apparent with the incase of fire or crush activities.

The bus carriage made of stainless steel is an appealing sight over its lifespan, and the carriage of stainless steel reduces the costs of repairs and maintains a high secondary benefit. In the fabrication of car frames and stainless steel, stainless stainlos steel is used or used by the environment such as wet weather, cold spaces and salty water. The automotive body of the rubber vehicle for bus construction avoids shock and crash tolerance. In the event of collisions, rubber stainless steel has a very high impact resistance that makes it safer. An interview with respondents from the bus production industry reveals that much of the car body chassis have been imported. The respondents added that local materials had been used to create the bus body.

From the observation results the materials used for school bus vehicle body construction are mostly locally available for example at Doshi steel industry. It was established that aluminum material is rarely used in the construction of school bus vehicle body building because it is very expensive. It was equally observed that stainless steel as an engineering material is rarely used because it is very expensive. GI (Galvanized iron sheet is the one mostly used to cover bus vehicle body structures a long side with mild steel.

4.3.4 Equipment used in the manufacture of vehicle structure

The fourth objective sought to establish the influence of equipment on crashworthiness of a bus. A total of 10 statements were used to determine the equipment and the responses elicited on a 5-point likert scale with as shown in table 4.9. IT was noted that a majority of the respondents 172(75.8%) agreed that their company has in house window frame fabrication and assembly, with 11.9% moderately agreed and 12.3% disagreed (*M=3.91; SD*=0.94). This implies that bus body construction companies have in house window frame fabrication and assembly. Most of the respondents 140(61.7%) agreed that their company has research and design unit equipped with Autocard and optimizer, softwares, with 29.1% moderately agreed and 9.3% agreed (*M*=3.65*; SD*=0.92). This indicates that the company has research and design unit equipped with Autocard and optimizer, softwares.

Majority of the respondents 156(68.7%) agreed that attempts are in place in their company for adequate insurance cover for the entire unit, including men and machines and work in progress, against all types of hazards, with 13.2% moderately agreed and 18.1% disagreed (*M*=3.60*; SD*=0.92). This indicates that attempts are in place in their company for adequate insurance cover for the entire unit, including men and machines and work in progress, against all types of hazards.

Table 4.9 Equipment used in the manufacture of vehicle structure

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	%	F	%	F	%	F	%	F	%		
Our company has in house window frame fabrication and assembly.	63	27.8	109	48.0	27	11.9	28	12.3			3.91	0.94
This company has research and design unit equipped with Autocard and optimizer, softwares.	29	12.8	111	48.9	66	29.1	21	9.3			3.65	0.82
Attempts are in place in our company for adequate insurance cover for the entire unit	24	10.6	132	58.1	30	13.2	39	17.2	2	.9	3.60	0.92
This company has 16m long paint spray booth cum heating oven.	30	13.2	123	54.2	34	15.0	40	17.6			3.63	0.92
In case of checking for bus vehicle body roof, our company has a roof leaking testing equipment.	32	14.1	125	55.1	32	14.1	37	16.3	1	.4	3.66	0.93
The company has under chassis inspection bay facility.	50	22.0	68	30.0	40	17.6	69	30.4			3.44	1.14
This company is an ISO 9001 Certified.	51	22.5	109	48.0	32	14.1	35	15.4			3.78	0.97
Our organization has a hydraulic shearing machine.	73	32.2	110	48.5	35	15.4	9	4.0			4.09	0.79
The company possesses a hydraulic bending machine.	59	26.0	93	41.0	40	17.6	29	12.8	6	2.6	3.75	1.06
This company prides in having a 15m long hydraulic stretching machine.	19	8.4	54	23.8	90	39.6	60	26.4	4	1.8	3.11	0.95
Overall											**3.66**	**0.60**

Majority of the respondents 153(67.4%) agreed that company has 16m long paint spray booth cum heating oven, with 15% moderately agreed and 17.6% disagreed (*M=3.63; SD*=0.93). This implies that company has 16m long paint spray booth cum heating oven. Table 4.9 further shows that most of the respondents 157(69.2%) agreed that in case of checking for bus vehicle body roof, their company has a roof leaking testing equipment, with 14.1% moderately agreed and 16.3% disagreed (*M*=4.22*; SD*=0.80). This indicates that in case of checking for bus vehicle body roof, their company has a roof leaking testing equipment. Most of the respondents 118(52%) agreed that their company has under chassis inspection bay facility, with 17.6% moderately agreed and 30.4% disagreed (*M*=3.44*; SD*=1.1.4). This indicates that companies had under chassis inspection bay facility.

Majority of the respondents 160(70.5%) agreed that their company is an ISO 9001 Certified, with 14.1% moderately agreed and 15.4% disagreed (*M=3.78; SD*=0.97). This indicates that the company is an ISO 9001 certified. Majority of the respondents 183(80.7%) agreed that their organizations has a hydraulic shearing machine, with 15.4% moderately agreed and 4% disagreed (*M=4.09; SD*=0.79). This implied that companies had a hydraulic shearing machine. Most of the respondents 152(67%) agreed that the company possesses a hydraulic bending machine, with 17.6% moderately agreed and 15.4% disagreed (*M*=3.79*; SD*=1.06). This indicates that companies possessed a hydraulic bending machine.

It was clear from the results of the analysis in Table 4.9 that the sum mean of the answers to 10 declarations used for measurement instruments and equipment was 3.66. This indicates that most interviewees complied with the declarations used to measure bus facilities and equipment. This is evident in company with machine automatic Autocard and optimizer in home window frame production and assembly and research and design. There are attempts at ample liability coverage for the whole unit, like men and equipment, in our organization and function on all sorts of hazards, company has 16m long paint spray booth cum heating oven and in case of checking for bus vehicle body roof, our company has a roof leaking testing equipment. Also, the company is an

ISO 9001 Certified, organization has a hydraulic shearing machine and company possesses a hydraulic bending machine.

From the interview with bus vehicle body construction firms, it was reported that with most of the work being manually done or with very limited use of mechanization, there is the challenge of quality control on bus body building. Limited level of mechanization leads to further delays in meeting targets for customer orders which can easily lead to customer disappointments in collecting their finished buses. Many of the respondents of the school bus vehicle body construction reported that they have challenges when it comes to industrial safety since 90% (ninety) percent of the work is manual. They further reported that there are unavoidable cuts occasioned by some workers reluctant to use safety gear. From the observation it was quite evident in most bus body construction companies that there was immense use of mild steel in school bus body building. It was established that there was limited state of the art equipment or use of machines. There was immense use of manual work or over use of hand work which impacted on time wastage.

4.3.5 Welding type in the manufacture of vehicle structure

The fifth objective sought to establish the influence of welding technology on crashworthiness of a bus. A total of 6 statements were used to determine the welding technology and responses elicited on a 5-point likert scale with as shown in table 4.10. Majority of the respondents 186(81.9%) agreed that used MIG to join aluminum bus body parts, with 8.8% moderately agreed and 9.2% disagreed (*M=4.22; SD*=0.96). This implies that the company uses MIG welding to join aluminum bus body parts.

Most of the respondents 184(81.1%) agreed that in some specific welding aspects their organization uses spot welding to join bus body frames steel structures, with 8.8% moderately agreed and 10.1% disagreed (*M*=4.1*; SD*=1.0). This indicates that the company had some specific welding aspects that use spot welding to join bus body frames steel structures. Of the respondents 46(20.3%) agreed that they apply MIG to weld continuous mild steel bus body structure, with 40.5% moderately agreed and 39.2% disagreed (*M*=2.85*; SD*=0.90). This indicates that the companies sometimes apply MIG to weld continuous mild steel for bus vehicle structure.

Table 4.10 further shows that of all the respondents 67(29.5%) agreed that their organization uses spot welding to fix bus vehicle body mild steel metal sheets, with 39.2% moderately agreed and 31.3% disagreed (*M*=3.04*; SD*=0.92). This indicates that their organizations sometimes use spot welding to fix bus vehicle body mild steel metal sheets. Of all the respondents 71(31.3%) agreed that used mild steel welding rods to weld bus vehicle body metal structures and sheets, with 44.5% moderately agreed and 24.2% disagreed (*M=3.18; SD*=0.93). This implies that companies sometimes use mild steel to weld bus vehicle body metal structures and sheets. At least 65(28.7%) of the respondents agreed that their organization uses arc welding to join bus vehicle body mild steel metal sheets and steel structures, with 44.5% moderately agreed and 26.9% disagreed (*M*=3.15*; SD*=0.99). This indicates that their organization sometimes uses arc welding to join bus vehicle body mild steel metal sheets and steel structures.

Table 4.10 Welding type in the manufacture of bus vehicle structure

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
			F	**%**	**F**	**%**	**F**	**%**	**F**	**%**		
I use MIG to join aluminum bus body parts	112	49.3	74	32.6	20	8.8	20	8.8	1	.4	4.22	0.96
I apply MIG to weld continuous mild steel bus body structure	14	6.2	32	14.1	92	40.5	85	37.4	4	1.8	2.85	0.90
Our organization uses spot welding to fix bus vehicle body mild steel metal sheets	16	7.0	51	22.5	89	39.2	69	30.4	2	.9	3.04	0.92
I use mild steel to weld bus vehicle body metal structures and sheets	25	11.0	46	20.3	101	44.5	54	23.8	1	.4	3.18	0.93
Our organization uses arc welding to join bus vehicle body mild steel metal sheets and steel structures	31	13.7	34	15.0	101	44.5	59	26.0	2	.9	3.15	0.99
In some specific welding aspects our organization uses spot welding to join bus body frames steel structures	93	41.0	91	40.1	20	8.8	18	7.9	5	2.2	4.10	1.00
Overall											**3.42**	**0.61**

It was clear from the study results on table 4.10 that the answers to the six statements used to test welding technologies had a combined average of 3.42. This indicates that most respondents were mild in their support of statements used to measure soldering systems on buses. With some unique features of weld, the company uses spot solding to join systems of steel and use MIG in the combination of aluminum bus body sections. This is obvious.

From the interview with bus vehicle body construction firms, it was reported that spot welding, arc welding and MIG welding are frequently used in school bus body welding applications. From the observation, it was established that the construction of school bus vehicle structure starts with the layout of the floor structures followed by side structures, followed by roof structures, front (driver structures) and finally rear end (back) structure. Welding of the school bus body vehicle structures is done by use of MIG welding and other sections by arc welding.

4.3.6 Bus Vehicle Structure Inspection Tests and Crashworthiness.

The sixth objective sought to establish the vehicle inspection tests on crashworthiness of a school bus. A total of 7 statements were used to determine the bus vehicle structure inspection tests and responses elicited on a 5-point likert scale with as shown in table 4.11. Majority of the respondents 179(78.9%) agreed that their buses have 100% roll over compliant providing more stability to the structure, with 12.3% moderately agreed and 8.8% disagreed (*M=4.06; SD*=0.98). This implies that the buses had 100% roll over compliant providing more stability to the structure. Most of the respondents 178(78.4%) agreed that organization performs impact tests on front and rear on the bus, with 13.2% moderately agreed and 8.4% disagreed (*M*=4.07*; SD*=0.98). This indicates that the company performs impact tests on front and rear on the bus.

Majority of the respondents 167(73.6%) agreed that their organization conducts water leakage on the bus using roof leaking testing equipment, with 15.9% moderately agreed and 10.6% disagreed (*M*=3.87; *SD*=1.02). This indicates that the company conducts water leakage on the bus using roof leaking testing equipment. Most of the respondents 152(66.9%) agreed that their company has under chassis inspection bay facility, with 14.5% moderately agreed and 18.5% disagreed (*M*=3.8; *SD*=1.1.8). This indicates that the company has under chassis inspection bay facility.

Table 4.11 Bus Vehicle structure Inspection Tests

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**		
All our buses have 100% roll over compliant providing more stability to the structure.	86	37.9	93	41.0	28	12.3	15	6.6	5	2.2	4.06	0.98
Our organization performs impact tests on front and rear on the bus	88	38.8	90	39.6	30	13.2	14	6.2	5	2.2	4.07	0.98
Our organization conducts water leakage on the bus using roof leaking testing equipment	64	28.2	103	45.4	36	15.9	15	6.6	9	4.0	3.87	1.02
Our organization conduct welding tests on the bus	11	4.8	31	13.7	20	8.8	98	43.2	67	29.5	2.21	1.15
Our organization do not perform quality control tests on the bus	7	3.1	30	13.2	27	11.9	85	37.4	78	34.4	2.13	1.12
Our company has experienced quality assurance team	80	35.2	72	31.7	33	14.5	34	15.0	8	3.5	3.80	1.18
The company has under chassis inspection bay facility.	107	47.1	56	24.7	28	12.3	30	13.2	6	2.6	4.00	1.17
Overall											**3.45**	**0.67**

Majority of the respondents 113(71.8%) agreed that the company has under chassis inspection bay facility, with 12.3% moderately agreed and 15.8% agreed (*M*=4.0; *SD*=1.17). This indicates that the companies sometimes apply MIG to weld continuous mild steel bus body structure. Majority of the respondents 165(72.7%) disagreed that their organization conducts welding tests on the bus, with 8.8% moderately agreed and 42(18.5%) agreed (*M=2.21; SD*=1.15). This implies that their organization do conducts welding tests on the bus. Most respondents 163(71.8%) disagreed that their organization do not perform quality control tests on the bus, with 11.9% moderately agreed and 16.3% agreed (*M*=2.13*; SD*=1.12). This indicates that their organization performs quality control tests on the bus.

Results from the analysis in table 4.11 show that the answers to the seven statements used to measure inspection vehicles had an aggregate average of 3.45, indicating that more participants agreed with statements used to measure inspection vehicles on a school bus. This was obvious in the situation that all buses had 100% roll over, giving more flexibility to the frame and the company carries out impact checks both at the front and back of the vehicle. Organizations conduct water leakage on buses using roof-leakage monitoring devices.

From the interview with bus vehicle structure construction firms, it was noted that they had challenges when it comes to crash testing of a school bus. The provision for crash test of any bus is only accessible to very few industries (companies in Kenya) with majority recommending/suggesting that the Kenyan government should consider in future providing a crash test. The body builders use KS372/2014 KEBS standard manual and NTSA policy guideline, while considering the designs and fabrication of any bus construction. School bus vehicle structure building companies reported that limited testing was done to finished bus body.

Rain water testing equipment is mostly used in finished school bus body vehicles and that most equipment for testing are not readily available. The interviews with school bus vehicle body construction indicated that used a standard manual as prescribed by

KEBS KS372/2014 and also policies as guided by NTSA and other relevant stakeholders such us KABM. The bus vehicle structure construction industry has challenges to do with unauthorised bus vehicle structure builders (Jua Kali) who are a threat to bus body industry with no standards to comply with.

From the interview with the NTSA, it was noted that officers of KABM adhere to KEBS KS372/2014 standard which stipulates the lighting and illumination conditions of the vehicle, driver's work place, sizes of emergency exit and window frames positioning. Other specified elements include overhead luggage racks and a host of other facets concerning the exterior body projections and interior fittings. Under the new code, NTSA authorized KABM to carry out bus vehicle structure integrity inspections. Kenya has about fifteen (15) licensed bus vehicle body builders.

From the interview, the NTSA stated that as a regulator it ensures that no school bus will be licensed to operate on the Kenyan roads, unless they have satisfied an inspection by Kenya Bureau of Standards (KEBS) at the port or approved to comply after inspection by KABM if they conform to the manufacturing standard specification. The NTSA officer stated that they do inspect school buses annually. In other words, the NTSA expects school bus managers to avail school buses at the vehicle inspection centers after every ten to 12 months. When conducting a school bus vehicle body inspection, the key word is school bus compliance with body parts expected to be up to standard. There should be no damages; writings on the body are not also allowed, only yellow colour and name of school. The NTSA further reported that there is a new set of regulation in place and which tests environmental issues such as emissions.

From the observation, it was also noted that due to lack of standardization there is no control on specification of the best suited roll over protection bars thus quality and strength of materials used are compromised therefore not effective in protection from crumbling during an accident. This can be improved if this procedure is legislated in Kenya as it will ensure standardization after trial and testing through the Kenya Bureau of Standards, National Transport and Safety Board among other relevant bodies.

From the interview, the NTSA respondents reported that the NTSA officers are deployed on the ground alongside with NPS (National Police Traffic Service) to check on compliance in view of school bus vehicle body safety standard and school bus body building. NTSA respondents reported that the NTSA by use of National Police Service, KEBS and also KABM (Kenya Association of Bus Manufacturers) are able to enforce the rule of law in bus body construction for crashworthiness. In order to enforce the rule of law on school bus drivers in view of road safety, the drivers must have or wear a badge, have more than 4 years driving experience, be licensed to drive, be in possession of good conduct report, have a good medical report, driver should have refresher training, drivers not engage in drink driving and drive within limited 8 hours driving per day. The National Police Service work alongside with the NTSA in view of the foregoing.

The interviews with the NTSA officers indicate challenges they face in respect to school bus body safety standards. The challenge pertains to compliance issues for example schools that buy old vehicles. Such old buses involved purchasing from public transport vehicles that are over used or worn out. The said vehicles could be even more that 15 years old, not compliant at all, full of emissions, although painted to appear new but quite old. Further from the interview, the NTSA officer reported that as a way forward into the future, there is a new development in terms of new school bus regulation. The NTSA further reported that the new regulation deal with school bus body standards, school bus transport safety and a further testing on school bus emissions and a raft of other issues pertaining to inspection of school buses. NTSA officer stated that the

KABM works closely with the KEBS to ensure that the standards for school bus body are observed. The KRA according to NTSA are to ensure that the right spare parts for bus components are imported.

From the interview with school principals, it was reported that they have to comply with the ministry of education guidelines in view of vehicle inspections which is normally done yearly or 12 months. The ministry of education has guidelines on school bus management and transportation of students. They further indicated that the guidelines specify that students must not travel after six o'clock. In other words, the driver and students to sleep at a point where darkness falls or near a police station. Further that there should be no overloading, pupils/ students to observe safety by belting up, no peeping heads by students outside the windows, no horseplay by students while in the bus travelling and that the driver to give clear signals while on the road.

From the interviews with the National Police Service, they noted that the design of roads in some parts of the country has a potential effect on accidents. Some roads were meandering; full of bumps and of rugged terrain hence causing some road safety challenges. The Police Traffic Servicemen experience a challenge of weather. Many National Traffic Police Servicemen indicated that ever since the advent of devolved traffic command structure, there has been a challenge in terms of law enforcement, in other words the National Police Traffic Commandant at the national headquarters cannot summon a County Traffic Officer.

From the interview with school principals it was established that the yellow school bus should be given priority or better still school bus (Yellow buses) should be given a special lane in future in the event of heavy traffic jam in cities. There was a general consensus from many school respondents that in order to maintain road safety while transporting students, the school bus has to be roadworthy meaning the school bus should be well serviced and that the driver should always observe highway rules (code).

4.3.7 Customer needs for manufacture of school bus vehicle structure

A total of 8 statements were used to determine the customer needs on the bus and responses elicited on a 5-point likert scale with as shown in table 4.12. Majority of the respondents 198(87.2%) agreed that their school buses are all fitted with safety belts, with 7% moderately agreed and 5.7% disagreed (*M=4.30; SD*=0.84). This implies that buses are all fitted with safety belts. Of the respondents 74(32.6%) agreed that their buses are assembled in compliance with KEBS standards, with 37% moderately agreed and 30% disagreed (*M*=3.16*; SD*=1.02). This indicates that the buses are assembled in compliance with KEBS standards.

At least 77 (33.9%) agreed that they consider school / customer needs / specifications while accepting their orders of buses, with 39.6% moderately agreed and 26.4% disagreed (*M*=3.22*; SD*=1.01). This indicates that they consider school / customer needs / specifications while accepting their orders of buses. Of the respondents 49 (21.5%) agreed that their buses are designed and build to meet the environmental terrain of this country, with 44.9% moderately agreed and 20.2% disagreed (*M*=3.26*; SD*=0.92). This indicates that school buses are designed and build to meet the environmental terrain of this country. Majority of the respondents 197(86.8%) agreed that their organization maintains close contact with school management, ensuring in-depth understanding of their expectations of the bus, with 9.7% moderately agreed and 3.5% disagreed (*M=4.35; SD*=0.80). This implies that companies maintain close contact with school management, ensuring in-depth understanding of their expectations of the school bus vehicle structure customer needs. At least 75(33%) agreed that they provide updates of major milestones and outcomes to school management in view of bus needs, with 39.2%

moderately agreed and 27.7% disagreed (M=3.16; SD=0.96). This indicates that they provide updates of major milestones and outcomes to school management in view of bus needs.

Table 4.12 Customer needs used in the manufacture of school bus vehicle structure

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	%	F	%	F	%	F	%	F	%		
Our buses are all fitted with safety belts	111	48.9	87	38.3	16	7.0	13	5.7			4.30	0.84
Our buses are assembled in compliance with KEBS standards	32	14.1	42	18.5	84	37.0	68	30.0	1	.4	3.16	1.02
We consider school / customer needs / specifications while accepting their orders of buses.	34	15.0	43	18.9	90	39.6	59	26.0	1	.4	3.22	1.01
Our buses are designed and built to meet the environmental terrain of this country.	26	11.5	53	23.3	102	44.9	45	19.8	1	.4	3.26	0.92
We provide updates of major milestones and outcomes to school management in view of bus needs.	25	11.0	50	22.0	89	39.2	62	27.3	1	.4	3.16	0.96
The organization maintains close contact with school management, ensuring in-depth understanding of their expectations of the bus.	118	52.0	79	34.8	22	9.7	8	3.5			4.35	0.80
We engage a strategic planning committee that is in touch with school management	154	67.8	46	20.3	20	8.8	7	3.1			4.53	0.78
We design bus according to customer needs/requirements/tastes/ as regards to placement of school bus orders.	18	7.9	18	7.9	7	3.1	125	55.1	59	26.0	2.17	1.14

Overall		3.52	0.54

From table 4.12 above, it is evident that most of the respondents 200(88.1%) agreed that they engage a strategic planning committee that is in touch with school management, with 8.8% moderately agreed and 3.1% disagreed (*M=4.53; SD*=0.78). This implies that the companies engage strategic planning committees that is in touch with school management. Majority of the respondents 184(81.1%) disagreed that they design a bus according to customer needs as regards to placement of school bus orders, with 3.1% moderately agreed and 15.8% agreed (*M=2.17; SD*=1.14). This implies that the company does not design bus according to customer needs/requirements/tastes/ as regards to placement of school bus orders.

Furthermore, from the analysis of the analysis on Table 4.12 above, the average mean for responses to the eight declarations used for the assessment of consumer needs is 3,52. This indicates that most respondents comply with the claims used to assess consumer specifications. This was apparent with the organization's close communication with school management and ensuring that its bus anticipation is well recognized, a strategic planning committee in contact with the management of the school was formed, and the buses are all equipped with security belts.

From the interview with bus vehicle structure construction companies, it was reported that customers were placing orders for bus vehicle especially school buses. The customers have a say on the bus designs and in addition, customers have the freedom to suggest designs for school bus frontal and rear outlooks. Bus vehicle body builders recommend that for the growth of a school bus vehicle, policies should be developed by manufacturers, NTSA and industry players on bus design uniformity. They further argued that customers should not dictate or order bus with diverse designs but rather stick to some form of bus model(s). Diverse bus vehicle structure designs have costs implications to both the manufacturer and even to the potential buyer or customer.

From the interview with the NTSA officers it was reported that emergency institution like the St. John Ambulance, the Red Cross, hospitals and the National Police Service assist the NTSA in collecting and managing accident data. The NTSA respondents reported that as their mandate, it is their duty to ensure road safety in view of road carnage prevention. As an elaborate measure to curb road carnage, NTSA further reported that there is a public education on road safety. There is training of drivers generally and more specifically school bus drivers through school associations of Nairobi City County. There was motor vehicle inspection to ensure the vehicle is roadworthy, Road safety audits and advice given to road agencies correctly. Moreover, there is driver training and testing and licensing. In view of the above, the right drivers get licensed. The NTSA works closely with the National Police Service to ensure enforcement. The NTSA further works with emergency response for example the St. John's, the Red Cross to handle emergencies.

From the interview with the National Police Traffic, it was reported that corruption was a problem that hampers law enforcement. They were of the view that a change of mind set among the general public, the Police and any other professional can do better to avoid any form of extortion. Lack of capacity and inadequate number of Police force leads to limited law enforcement. There was need to introduce an examinable subject in schools on road safety. This will go a long way to sensitize the masses and enhance road safety.

From the interview with school managers (principals) it was noted that while ordering a school bus, a major consideration was the load carrying capacity of students preferably (60 – 72 bus seater). Most of the school respondents reported that while ordering for a school bus, school managers engage students to participate in the shape (design) of the school bus outlook (school bus body shape), this further suggests that their preference is a new bus as opposed to buying an old bus.

The interview with school managers further indicated that they relied on school bus driver's trust, work ticket and minimal accident cases. Many schools hired school drivers mostly from the NYS (National Youth Service) who have some basics of mechanics and therefore in the event of buses developing some mechanical problems, the drivers are able to solve basic problems and even advice school managers on way forward. In view of drivers being able to communicate effectively with different persons such as students and policemen among others, they empower them with through seminars and workshops for drivers on road safety.

From the observation made in bus construction industry, it was evident that design shapes of the school buses at the front and rear have a cost implication. There are numerous designs used for both front and rear designs. It was established that the numerous designs on school bus vehicle bodies make the industry appear confused, lack of uniformity as in models and this has a way of policy needs to be regulated or addressed. This is caused by largely customer varied desires and changing tastes.

There are four major stakeholders when it comes to bus vehicle structure quality control checks. Namely; the NTSA (Bus body regulator), KEBS (Standards custodian), KENAS and the KABM (Kenya Association of Bus Manufacturers). There has been an upgrade on the KEBS standards bus specifications since 2014. The most current is the one released January 2019. About 30,000 or more buses currently on the Kenyan roads are likely to be recalled for revalidation of specifications so as to conform to the current 2019 standards specifications. This is due to the errors of commission or omission done before 2019 during bus vehicle structure construction.

From interview with the school principals, it was noted that the challenge faced by public schools is an overwhelming number of students to be transported over the weekends. In most cases, weekends for public schools are punctuated with a lot of extra-curriculum activities such as games, drama festivals and other functions. In view of the large number of students, the buses are limited thereby forcing public school managers (principals) to hire from other schools as funds to buy new buses are unavailable. One of the school principals stated that a school bus is a major boost to academic excellence.

4.3.8 Crashworthiness of school bus vehicle structure

The dependent variable was crashworthiness of a school bus vehicle structure. A total of 9 statements were used to determine the crashworthiness of a school bus and responses elicited on a 5-point likert scale with as shown in table 4.13. Table 4.13 below show that a majority of the respondents 191(84.2%) agreed that their buses have strong roof structures for rollover protection, with 6.6% moderately agreed and 9.3% disagreed (*M=4.19; SD*=0.92). This implies that buses have strong roof structures for rollover protection.

Of the respondents 49 (21.5%) agreed that their bus structures have ability to deform plastically, yet stiff front structures, in a short period of time, with 44.1% moderately agreed and 34.3% disagreed (*M*=2.89*; SD*=0.80). This indicates that the bus structures have ability to deform plastically, yet stiff front structures, in a short period of time. Of all the respondents 53(23.4%) agreed that their bus structures are light and able to be economically mass-produced, with 39.6% moderately agreed and 37% disagreed (*M*=2.93*; SD*=0.92). This indicates that the bus structures are light and able to be economically mass-produced.

Table 4.13 Crashworthiness of School bus vehicle structure

Statements	Strongly agree		Agree		Moderately agree		Disagree		Strongly disagree		Mean	SD
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**		
Our bus structures have the ability to deform faster with stiff front structures,	6	2.6	43	18.9	100	44.1	77	33.9	1	.4	2.89	0.80
Our bus structures are light and able to be economically mass-produced.	17	7.5	36	15.9	90	39.6	83	36.6	1	.4	2.93	0.92
We tune our structural stiffness for ride and handling	16	7.0	32	14.1	106	46.7	73	32.2			2.96	0.86
We ensure that noise vibration and harshness in our buses is compatible with other vehicles.	19	8.4	38	16.7	105	46.3	63	27.8	2	.9	3.04	0.90
The buses have properly designed side structures and doors to intrusion in side impact and prevent doors opening due to crash loads	16	7.0	45	19.8	106	46.7	60	26.4			3.07	0.86
Buses have strong roof structure for rollover protection	14	6.2	36	15.9	114	50.2	62	27.3	1	.4	3.00	0.84
Accommodate various chassis designs for different power train locations and drive configurations.	13	5.7	65	28.6	98	43.2	50	22.0	1	.4	3.17	0.85
Deformable rear structure to maintain integrity of the rear passenger compartment and protect the fuel tank.	24	10.6	55	24.2	108	47.6	40	17.6			3.28	0.88
Our buses have strong roof structures for rollover protection	100	44.1	91	40.1	15	6.6	21	9.3			4.19	0.92
Overall											**3.17**	**0.59**

Of all the respondents 48(21.1%) agreed that they tune their bus body structural stiffness for ride and handling, with 46.7% moderately agreed and 32.2% disagreed

(*M=2.96; SD*=0.86). This implies that companies tune their buses structural stiffness for ride and handling. At least 57(25.1%) of the respondents agreed they ensure their noise vibration and harshness in our buses is compatible with other vehicles, with 46.3% moderately agreed and 28.7% disagreed (*M*=3.04*; SD*=0.90). This indicates that the organizations ensure that noise vibration and harshness in their buses is compatible with other vehicles.

Table 4.13 above shows that all respondents61(26.8 percent), 46.7 percent agreed to be moderately agreed, with 26.4 percent disaccorded (M = 3.07; SD= 0.86), agreed that busses have well-designed lateral systems, and doors for lateral impact to discourage doors from opening as a result of crash loads. This reveals that the buses have lateral frameworks and doors built to penetrate the side-impact and avoid the opening of doors due to crash loads. Of all respondents, 50 (22,1 percent) agreed with 50% and 27,7 percent disagree (M=3,0; SD=0,84), that buses have a roof structure which is strong for rollover safety. This means that busses provide a good roof protection structure.

At least 78 (34.3%) respondents accepted that the chassis designs would suit the different powertrain sites, with a modest 43.2% agreement and a disagreement of 22.4% (M=3.17; SD=0.85, respectively). This shows they fit different types and drive configurations of chassis for multiple power train locations. In all the respondents, 69 (34.8 pp), 47.6 ppm was moderately accepted and 17.6 ppm was not agreed (M=3.28; SD=0.88), with deformable back configuration to retain the rear passenger comppartment integrity and cover the fuel tank. This assumes that the deformable rear frame maintains stability and protecting the fuel tank in the rear passenger cabin.

From the findings of the study on table 4.13 above, it was evident that responses to the 9 statements used to measure crashworthiness of a bus had an overall mean of 3.17. This show that majority of the respondents moderately agreed with the statements that were used to measure crashworthiness of a bus. This was evident with buses having strong roof structures for rollover protection, deformable rear structure to maintain integrity of the rear passenger compartment and protect the fuel tank and accommodate various chassis designs for different power train locations and drive configurations. This implies that the respondents were not sure on the crashworthiness of a bus.

Based on the remarks made during the bus business, it was clear that the use or use of the dual frame (square tube) was a significant strengthening of the front rear of the bus driver during the building of school bus structures. The typical center of the bus was another dual frame. Lastly, at around 95 percent behind the truck, another double frame was found, designed for crashing strengthened vehicles in the case of a rear collision. In terms of safety and accident in the driver's front, the double frame cannot be convenient. The height of the bus (bus seat) determines the metal tube size

4.4 Reliability Analysis

A research tool is accurate if clear outcomes are obtained despite being applied to various classes of respondents. To test the internal consistency or homogeneity of the products, the Cronbach Alpha Coefficient was used. For engineering materials with a coefficient of 0.860, the highest Cronbach alpha was observed, and the lowest coefficient was training (0.695) as shown by Table 4.14. Crashworthiness component had a coefficient of 0.850, consumer requires 0.714, welding technologies had 0.708 and automotive maintenance testing had a coefficient of 0.729, and machinery / equipment had a coefficient 0.833.

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Table 4.14 Reliability Statistics

	Cronbach's Alpha	Number of Items
Locally designed	.695	4
Competency skills	.795	11
Engineering materials	.860	21
Equipment	.833	10
Crashworthiness	.850	9
Customer needs	.714	8
Welding technology	.708	6
Vehicle inspection tests	.729	7
Overall	**.955**	**76**

4.5 Validity of the Constructs

Validity refers to the degree to which the test instrument calculates what it wanted to measure (Zikmund, Babin, Carr & Griffin 2010). Before using the data collection questionnaire, the researcher debated it with the managers and colleagues. The views of the respondents during the pilot study were used to refine the test instrument for the final study. In addition, Kaiser-Mayor-Oklin sampling adequacy measures (KMO) and Bartlett's sphericity test were used to test whether there was a relationship between the sample variables. Kaiser-Mayor-Oklin was used as a test of sampling adequacy and a value of >.5 and a p-value of <0.5 was appropriate.

In this respect, factor analysis was used to better define the exact number of variables that ultimately evaluated each construct as interpreted by the respondents. The validity of the instrument was assessed by Bartlett's Sphericity Test. The Bartlett Sphericity Test was used to test the adequacy of the correlation matrix by checking the null hypothesis that the correlation matrix has all diagonal elements as 1 and non-diagonal elements as 0. If the test value is high and the significance amount is minimal, the null hypothesis that the variables are independent can be dismissed.

On all variables, component factor analysis with varimax rotation was done to remove factors from the scales of each construct. All things loading below 0.50 were removed based on the previous works (Hair, Black Anderson & Tatham, 2006) and those with greater than 0.50 load factor were kept. All objects were well loaded into their separate variable dimension structure underlying them.

In this analysis, factor analysis was used to verify whether the products were loaded into the intended categories in each segment. To verify the four variables that are different, Varimax rotation was used. As postulated by Hair et al, the key component analysis and Varimax rotation were removed in all products with factor loadings smaller than 0.50, as postulated by Hair et al (2006). The statement responses were summed up to build a score and subjected to inferential analysis after completing the factor analysis of each variable.

4.5.1 Locally designed school bus vehicle structure.

The findings of the factor analysis of the locally built school bus vehicle layout showed that the KMO was 0.575 and the sphericity test of Bartlett was significant ($p<.05$) and the chi square was 244.727. (Table 4.15). The rotated theory part of Varimax resulted in two loading factors on the locally built vector, illustrating 81,388 percent of variance with Eigen values greater than 1. All statements were maintained, calculated and renamed for further review locally planned.

Table 4.15 Rotated Component Matrix of Locally designed school bus

	Component	
	1	2
School bus/ passenger vehicles in our organization are constructed and can readily face the harsh Kenyan environment.	.902	
Our locally build school bus / passenger vehicles have a lower failure rate compared to an imported manufactured product.	.900	
Locally produced school bus/ passenger vehicles have a quality reputation and enjoy a competitive advantage.		.886
School bus / passenger vehicle manufacturing often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials.		.883
KMO	.575	
Approx. Chi-Square	244.727	
Bartlett's Test of Sphericity (P<0.001) df=6		
Eigenvalues	2.091	1.165
% of Variance (81.388%)	41.400	39.989

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

4.5.2 Competency Skills of School Bus Vehicle structure technicians.

Factor research was subjected to competency skills statements and three components with Eigen values greater than 1 were derived, cumulatively describing 61,693 percent of variance as seen in (Table 4.16). The competency ability shows that the KMO was 0.776 and that the sphericity measure of the Bartlett was important (p<.05) and chi square (828.493). No statements were omitted and all eight statements were maintained for further review with computed and renamed competency.

Table 4.16 Rotated Component Matrix of Competency skills of Technicians

	Component		
	1	2	3
This organization takes a keen interest in technical skills and knowledge in electronic component sensitivity.		.844	
The organization values innovation in employees.		.867	
While welding during bus vehicle manufacture, I/we use MIG welding in fastening / joining of specific metals.			
MIG welding is a popular welding method used in our organization.		.851	
The organization emphasizes foundation skills, for adapting to dynamic industry changes.			.651
During recruitment of new employees, the organization is mostly keen to take note of language, literacy, numeracy and digital skills.			.621
The company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades.	.709		
This company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training.	.683		
Our company promotes the development of management skills for those who have progressed through the ranks of automotive fabrication into management role.	.741		
The company motivates its staff through sector specific skill expansion.	.748		
The apprenticeship system remains our company's preferred way of complementing skills formation.	.589		
KMO	.776		
Approx. Chi-Square	828.493		
Bartlett's Test of Sphericity (P<0.001) df=55			
Eigenvalues	3.768	1.810	1.209
% of Variance (61.693%)	24.673	22.464	14.557

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

4.5.3 Engineering Materials used on School Bus Vehicle Structure

The findings of the factor analysis of engineering materials showed that the KMO was 0.828 and the sphericity test of Bartlett was important (p<.05) and the chi square was 3057.67. (Table 4.17). The rotated theory part of the Varimax resulted in five factors loading on the vector of materials that described 71,154% of variance with Eigen values greater than 1. For further review, computed and renamed materials were kept for all claims.

Table 4.17 Rotated Component Matrix of Engineering materials

	Component				
	1	2	3	4	5
In case of fire or crush behaviours, the structural integrity of a stainless steel body remains intact.		.767			
GI material is high quality material applied in school / passenger vehicle body structure.			.677		
There is no much difference in the use of stainless steel to that of mild steel in school bus body building.				.712	
Aluminum metal material is greatly applied on bus passenger vehicle body construction.				.768	
Stainless steel is used for both underframe and bus passenger vehicle body in the manufacturing process to ensure a long life.				.833	
Stainless vehicle body construction is chosen to give the customer the advantages of corrosion – resistant framework.	.829				
Bus body vehicle that is made of stainless steel remains an attractive appearance for the whole of its life.	.772				
Stainless steel vehicle body reduces maintenance and service costs and ensures a high second – hand value.	.810				
The application or use of stainless steel can counter environmental challenges such as humid climate, cold places and salty waters.	.751				
Buses manufactured by stainless steel are lighter, require less maintenance and are more fuel efficient.			.849		
Our organization greatly uses / utilizes stainless steel panels for designing the school bus vehicle bodies.			.853		
This company totally uses stainless steel in building vehicle chassis and stainless-steel.	.747				
Stainless steel application for bus vehicle construction resists vibration.	.801				
In view of crashworthiness, stainless steel bears very high impact resistance that makes it a safer material in case of accidents.	.667				
In terms of floorings, footsteps, entrance and luggage carrier, it is worthwhile to use stainless steel in bus vehicle manufacture.	.523				
Roof for vehicle body buses need to be hugely made of stainless steel.					.697
Fasteners, hand rails and hand holds and guarding of step wells are more often than not made of stainless steel.		.734			
Mild steel is the principal material used hugely in general bus vehicle body construction.		.767			
The chassis of school bus passenger vehicles are supplied by automobile manufacturers.		.828			
In most cases bus vehicle body is build by body builders as per the requirements of the schools/institutions or customer desire and specifications.		.723			
Bus vehicle body is painted as per the requirements of the customer.					.712
KMO	.828				
Approx. Chi-Square	3057.67				
Bartlett's Test of Sphericity ($P<0.001$) df=210					
Eigenvalues	7.119	3.464	1.834	1.335	1.191
% of Variance (71.154%)	22.823	18.822	10.780	10.329	8.400

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

4.5.4 Equipment used on School Bus vehicle Structure.

Factor analysis was conducted on equipment statements and two components were derived with Eigen values greater than 1, which cumulatively clarified 57.694 percent of variance as seen in (Table 4.18). The devices shows that the KMO was 0.826 and the sphericity measure of the Bartlett was significant (p<.05) and chi square (856.884). Our company has two statements with a research and design unit fitted with Autocard and optimizer, program and company prides in making a 15m long hydraulic stretching system removed and all eight statements for further study were kept, computed and renamed equipment.

Table 4.18 Rotated Component Matrix of Equipment used on School Bus vehicle Structure.

	Component	
	1	2
Our company has in house window frame fabrication and assembly.	.762	
This company has research and design unit equipped with Autocard and optimizer, softwares.		
Attempts are in place in our company for adequate insurance cover for the entire unit, including men and machines and work in progress, against all types of hazards.	.716	
This company has 16m long paint spray booth cum heating oven.		.821
In case of checking for bus vehicle body roof, our company has a roof leaking testing equipment.	.736	
The company has under chassis inspection bay facility.		.729
This company is an ISO 9001 Certified.		.890
Our organization has a hydraulic shearing machine.	.549	
The company possesses a hydraulic bending machine.	.717	
This company prides in having a 15m long hydraulic stretching machine.		
KMO	.826	
Approx. Chi-Square	856.884	
Bartlett's Test of Sphericity (P<0.001) df=45		
Eigenvalues	4.191	29.549
% of Variance (57.694%)	1.579	28.144

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

4.5.5 Customer needs of School bus

Factor analysis was conducted on the consumer needs statements and two components were derived with Eigen values greater than 1, which cumulatively clarified 72.53 percent of variance as seen in (Table 4.19). The client announced that the KMO was 0.819 and the sphericity test of the Bartlett was relevant (p<.05) and chi square (920.275). For more review, all claims were maintained, calculated, and renamed client.

Table 4.19 Rotated Component Matrix of Customer needs of school bus

	Component	
	1	2
Our buses are all fitted with safety belts		.814
Our buses are assembled in compliance with KEBS standards	.880	
We consider school / customer needs / specifications while accepting their orders of buses.	.869	
Our buses are designed and build to meet the environmental terrain of this country.	.871	
We provide updates of major milestones and outcomes to school management in view of bus needs.	.875	
The organization maintains close contact with school management, ensuring in-depth understanding of their expectations of the bus.		.798
We engage a strategic planning committee that is in touch with school management		.851
We design bus according to customer needs/requirements/tastes/ as regards to placement of school bus orders.		-.748
KMO	.819	
Approx. Chi-Square	920.275	
Bartlett's Test of Sphericity (P<0.001) df=28		
Eigenvalues	3.298	2.505
% of Variance (72.53%)	40.05	32.48

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

4.5.7 Welding type on School Bus Vehicle Structures

The welding technology factor analysis results showed that the KMO was 0.712 and the sphericity test of Bartlett was important (p<.05) and the chi square was 384.9412. (Table 4.20). The rotated principal portion of Varimax resulted in two loading factors on the vector of c welding technology that explained 66.957 percent of variance with Eigen values greater than 1. For more review, both claims were kept, measured and renamed for welding.

Table 4.20 Rotated Component Matrix of Welding type

	Component	
	1	2
I use of MIG to join aluminum bus body parts		.864
I apply MIG to weld continuous mild steel bus body structure	.677	
Our organization uses sport welding to fix bus vehicle body mild steel metal sheets	.816	
I use mild steel to weld bus vehicle body metal structures and sheets	.817	
Our organization uses arc welding to join bus vehicle body mild steel metal sheets and steel structures	.850	
In some specific welding aspects our organization uses larger welding to join bus body frames steel structures		.824
KMO	.712	
Approx. Chi-Square	384.941	
Bartlett's Test of Sphericity (P<0.001) df=15		
Eigenvalues	2.635	1.382
% of Variance (66.957%)	42.319	24.638

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

4.5.8 School Bus Vehicle Structure Inspection Tests

The claims of the school bus vehicle structure inspection tests were subjected to factor analysis and two components were derived with Eigen values greater than 1, which cumulatively clarified 74.75% of variance as seen in (Table 4.21). The vehicle inspection tests revealed that the KMO was .762 and that the sphericity test of the Bartlett was significant ($p<.05$) and chi square (880.473). For further review, all claims were maintained, calculated, and renamed terminal.

Table 4.21 Rotated Component Matrix of vehicle structure inspection tests

	Component	
	1	2
All our buses have 100% roll over compliant providing more stability to the structure.	.854	
Our organization performs impact tests on front and rear on the bus	.860	
Our organization conducts water leakage on the bus using roof leaking testing equipment	.728	
Our organization conducts welding tests on the bus		.921
Our organization performs quality control tests on the bus		.898
Our company has experienced quality assurance team	.841	
The company has under chassis inspection bay facility.	.881	
KMO	.762	
Approx. Chi-Square	880.473	
Bartlett's Test of Sphericity (P<0.001) df=21		
Eigenvalues	3.548	1.684
% of Variance (74.751%)	49.849	24.902

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

4.5.5 School Bus Vehicle structure and Crashworthiness of school bus

The crashworthiness factor analysis findings showed that the KMO was 0.826 and the sphericity test of Bartlett was important ($p<.05$) and a chi square of 853.2588 was significant (Table 4.22). Two factors loaded on the crashworthiness variable resulted in the Varimax rotated theory portion, which clarified 61,541 percent of variance with Eigen values greater than 1. For further review, both claims were preserved, measured and renamed for crashworthiness.

Table 4.22 Rotated Component Matrix of school bus Crashworthiness

	Component	
	1	2
Our bus structures have ability to deform plastically, yet stiff front structures, in a short period of time	.683	
Our bus structures are light and able to be economically mass-produced.	.806	
We tune our structural stiffness for ride and handling	.841	
We ensure that noise vibration and harshness in our buses is compatible with other vehicles.	.809	
The buses have properly designed side structures and doors to intrusion in side impact and prevent doors opening due to crash loads	.773	
Buses have strong roof structure for rollover protection	.772	
Accommodate various chassis designs for different power train locations and drive configurations.	.636	
Deformable rear structure to maintain integrity of the rear passenger compartment and protect the fuel tank.	.541	-.539
Our buses have strong roof structures for rollover protection		.899
KMO	.826	
Approx. Chi-Square	853.258	
Bartlett's Test of Sphericity (P<0.001) df=36		
Eigenvalues	4.408	1.131
% of Variance (61.541%)	48.95	12.591

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

4.6 Correlation Analysis

Having described the study variables using descriptive statistics the researcher sought to establish the bivariate nature of both dependent and independent variables. The researchers can either apply correlations in order to ascertain the intensity of the interaction between the dependent and the independent variable in the Kothari (2007) estimation of the bivariate existence of two variables. The magnitude and direction of the relation between research variables are seen by the correlation coefficient.

In order to assess if there is any interaction between varibles, the researcher uses the correlation matrix before performing the regression analysis. In order to meet this association of Pearson's product moment, all the variables were in the interval range. To investigate whether there is a relationship between bus design and crashworthiness, Pearson's product moment associations were used. This was important because Tabachnick and Fidell (2013) claimed that regression can be done only after validation of correlations.

The findings of the correlations presented in Table 4.23 indicate a strong positive association between the independent variable and the dependent variable. The research results found that the locally built effect on the crashworthiness of a bus was significant (r=0.505, p=0.00). This suggests that an improvement in the use of a locally built bus has resulted in an increase in a bus's crashworthiness. There was a significant positive relationship between competency skills of bus body builders and crashworthiness of a bus (r= 0.775, p =0.000). Therefore, competency skills increase the crashworthiness of a bus.

On the engineering materials, the study findings showed that there was a significant positive influence of engineering materials on crashworthiness of a bus (r =0.611, p=0.000). This implies that the rise in the use of engineering materials led to more crashworthiness of a bus. There was a significant positive influence of equipment and tools on crashworthiness of a bus (r =0. 634, p=0.000). This indicated that the more there was equipment and tools the crashworthiness of a bus increased.

A significant positive influence of welding technology on the crashworthiness of a bus (r =0.772, p=0.000). This implies that the more welding technology is used the crashworthiness of a bus increased. There was a significant positive vehicle inspection tests on crashworthiness of a bus (r =0. 454, p=0.000). This showed that the more the vehicle inspection tests are done the crashworthiness of a bus increased.

On the customer needs, the study findings showed that there was a significant positive influence of customer needs on crashworthiness of a bus (r =0.552, p=0.000). This implies that the customer needs increased the more crashworthiness of a bus.

Table 4.23: Correlation Results of dependent and independent variables

		Crash worthiness	Locally	Competency	Materials	Equipment	Welding	Vehicle inspection tests	Customer
Crash worthiness	Pearson Correlation	1	.505**	.775**	.611**	.634**	.772**	.454**	.552**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000
Locally	Pearson Correlation	.505**	1	.462**	.491**	.415**	.538**	.282**	.452**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000
Competency	Pearson Correlation	.775**	.462**	1	.629**	.775**	.732**	.353**	.533**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.000
Materials	Pearson Correlation	.611**	.491**	.629**	1	.603**	.832**	.820**	.539**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.000
Equipment	Pearson Correlation	.634**	.415**	.775**	.603**	1	.614**	.309**	.476**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000
Welding	Pearson Correlation	.772**	.538**	.732**	.832**	.614**	1	.574**	.538**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.000
Vehicle inspection tests	Pearson Correlation	.454**	.282**	.353**	.820**	.309**	.574**	1	.417**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.000
Customer needs	Pearson Correlation	.552**	.452**	.533**	.539**	.476**	.538**	.417**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).
b. Listwise N=227

4.7 Multiple Regressions Assumptions

The declarations for the dependent and independent variable were coded and entered in SPSS (Version 22). Consequently, the assumptions for these variables were tested using criteria for normality, linearity, homoscedasticity,

autocorrelation and multicollinearity for multiple regression analysis (Tabachnick & Fidell, 2013).

4.7.1 Normality

The assumption is based on the standard distribution form and provides scientists with information on the expected values (Keith, 2006). This assumption was tested by the investigator in several pieces: visual inspection of data plots, skewing, curtosis and P-plots (Osborne & Waters, 2002). Data cleaning was necessary for the detection of outliers to validate this presumption. The regular residual histograms have been further tested for normality (Stevens, 2009). Histogram is a

bar graph with residuals that has been summarized in Figure 4.1 with a superimposed normal curve.

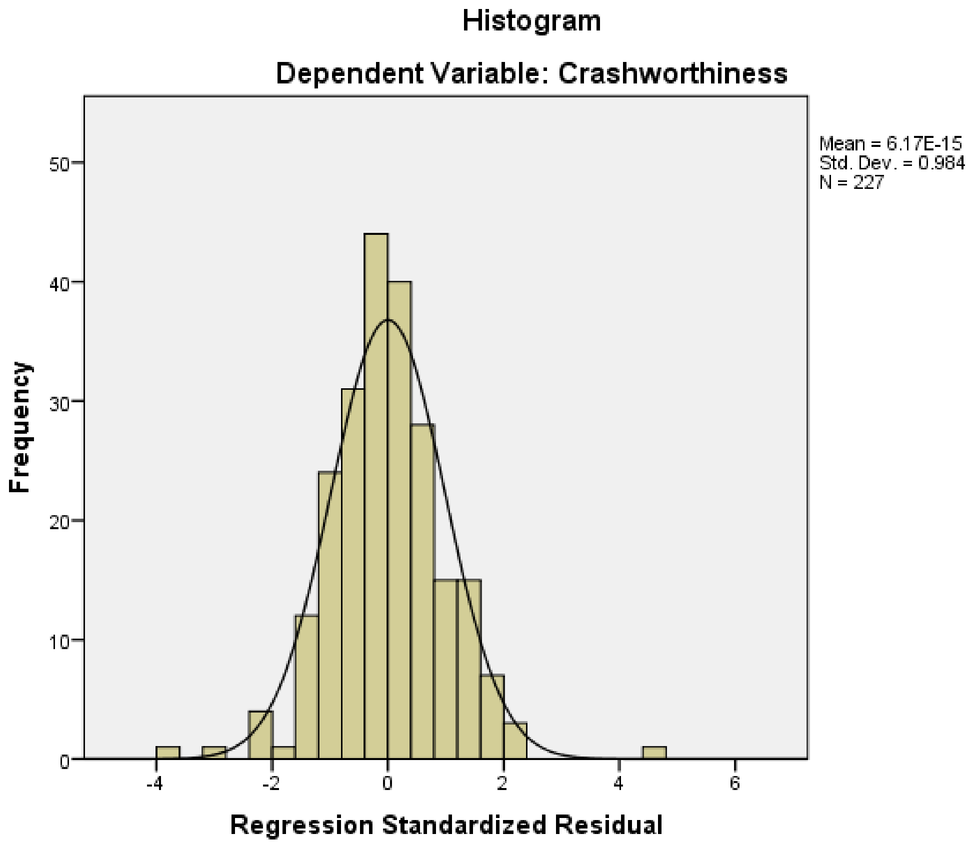

Figure 4.1 Normality

4.7.2 Linearity

Linearity is the concept that two variables are connected in a straight line (Tabachnick & Fidell, 2013). Linearity checking was found important as linearity is an expectation that must be fulfilled. A deeper study of the residual sections and scatter plots of most automated statistical packages suggests linear vs. curvilinear relationships (Keith, 2006; Osborne & Waters, 2002). Residual plots with uniform residual relative to expected values helped to find infringements of linearity (Stevens, 2009). Any organizational trend or clustering of the waste indicates an infringement (Stevens, 2009). Residual plots showing the standardized residuals and the predicted values were used to establish linearity as shown in Figure 4.2.

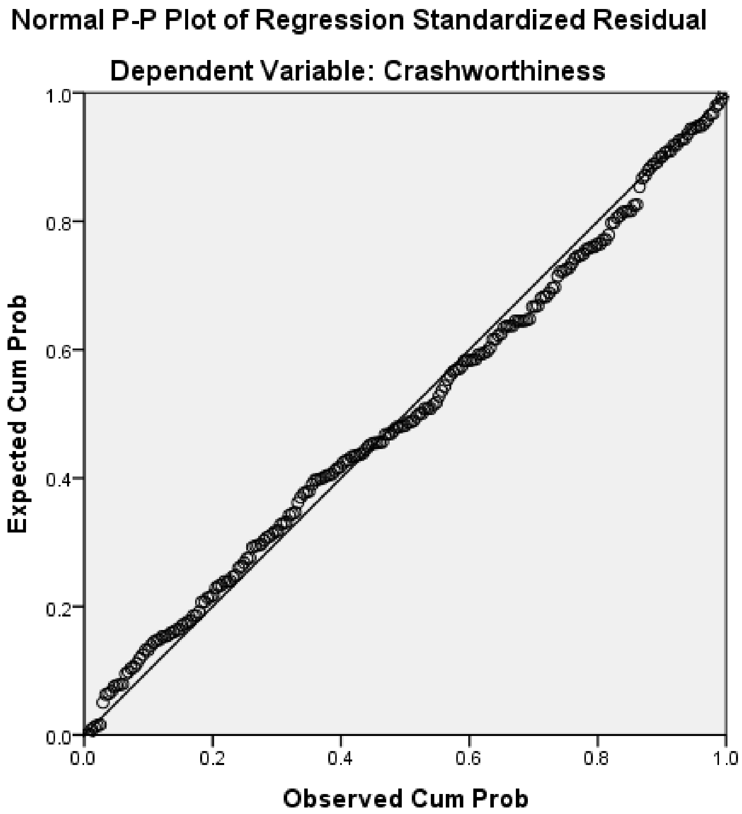

Figure 4.2 Linearity

4.7.3 Homoscedasticity

Homoscedasticity applies to multiple regressions which suggests uniform variability of ratings for dependent variables in comparison to independent variables as set out by Tabachnick and Fidell (2013). For all types of independent variables, the assumption of homoscedasticity shall be the same error variance (Osborne & Waters, 2002). This implies that errors were distributed evenly by variables in the analysis (Keith, 2006). In specific, to verify this assumption, the

SPSS statistician package scatters residues using independent variables (Keith, 2006). A formal dispersion plot was used to assess homoscedasticity (Figure 4.3).

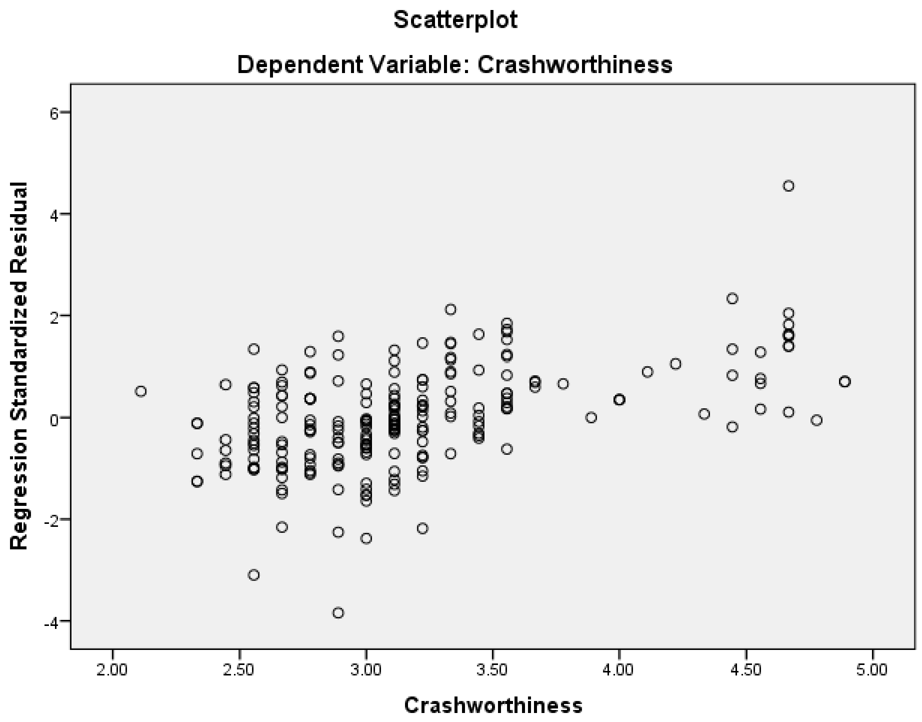

Figure 4.3 Homoscedasticity

The main inferential statistical method was testing for homoscedasticity, by using the hierarchical multiple regression. Variables were supposed to yield oval or elliptic dispersion plots to fulfill this statement. Results shown in Figure suggest the non-violation of homoscedasticity criteria in all cells that resulted in oval scatter plots.

4.7.4 Autocorrelation

The interaction between residual regressions is a measure of the autocorrelation as described in Tabachnick and Fidell (2013). Many times, as considerations such as time and distance correspond to the order in which cases are adopted, the assumption of independence from errors is violated. The independence of errors was then tested using the figures from Durbin-Watson, intended to calculate the autocorrelation of errors in cases that take account of the order of the cases (Tabachnick & Fidell, 2013).

The essential values of 1.5 < d < 2.5 were used in this analysis to determine whether autocorrelation occurs. Consequently, in the Multiple Linear Regression Data a Durbin-Watson statistical was found to be a lack of first class linear auto-correlation. Table 4.24 reveals that there was no auto-correlation in the Durbin-Watson statistics d=1,846 between the two critical values.

Table 4.24 Autocorrelation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.863[a]	.744	.736	.30161	1.846

a. Predictors: (Constant), Customer needs, Vehicle inspection tests, Locally designed, Equipment, Welding technology, Competency skills, Engineering materials

b. Dependent Variable: Crashworthiness

4.7.5 Multicollinearity

Multicollinearity is characterized by high correlations (Vatcheva, Lee, McCormick & Rahbar) between independent variables or predictors (2016). In that case there are multiple variables in the regression model that are bound not only to the equation but to each other as well. Vatcheva et al. (2016) suggested that multi-linearity could contribute to unpredictable and unbiased norm errors, which would result in unsustainable and irrational interpretations. In addition, logically, it cannot be inferred in the presence of multi-columnarities that the interpretation of the regression coefficient is based on one variable, while holding others constant because of the information that could be overlapping.

The variance inflation factor (VIF) is known to assess the increase in the variance of the predicted regression coefficient for the multicollinearity measure, where there is a correlation between the predictors (Tabachnick & Fidell, 2013). As seen in Table 4.25, the rule of thumb for a broad VIF value is 10 and the tolerance should be greater than 0.2 (Keith, 2006). The findings revealed that all VIF values were below the threshold value of 5, suggesting that there was no problem with multicollinearity in the current sample.

Table 4.25 Collinearity Diagnostics

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Equipment	.346	2.893
	Locally designed	.651	1.537
	Competency skills	.283	3.535
	Engineering materials	.109	9.135
	Welding technology	.216	4.623
	Vehicle inspection tests	.245	4.084
	Customer needs	.610	1.640

a. Dependent Variable: Crashworthiness

4.8 Multiple Regression Analysis

To test the hypotheses, multiple linear regression analysis was used. The presence of a causal interaction between the individual bus crashability predictors was therefore important to affirm by testing the hypotheses formulated in this study. The crashworthiness of the bus was limited to the six architecture determinants learned under this method. The idea was to analyze the effects on each indicator's bus crashworthiness. To evaluate the first six null theories, the researchers used multiple regression tests.

To test the hypotheses, multiple linear regression analysis was used. The presence of a causal interaction between the individual bus crashability predictors was therefore important to affirm by testing the hypotheses formulated in this study. The crashworthiness of the bus was limited to the six architecture determinants learned under this method. The idea was to analyze the effects on each indicator's bus crashworthiness. To evaluate the first six null theories, the researchers used multiple regression tests.

4.8.1 Model Summary Results

The coefficient of determination (R squared) of.744 shows that 74.4 percent of the variation in bus crashworthiness can be clarified by vehicle design structures and components dependent on the regression test. The adjusted R square of.736 shows that the discrepancy in bus crashworthiness of 73.6 percent of the remaining percentage can be clarified by other variables excluded from the model as illustrated in Table 4.26 for all vehicle construction structures and components except the constant variable. The R shows the correlation coefficient of the combined effects of vehicle construction systems and components, and R= 0.863 shows a clear positive relationship between them between vehicle design structures and materials. The standard error of estimate (.302) shows a small deviation of the independent variables from the line of best fit.

Table 4.26 Model Summary on Crashworthiness of a bus

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.863[a]	.744	.736	.30161	.744	91.057	7	219	.000	1.846

a. Predictors: (Constant), Customer needs, Vehicle inspection tests, Locally designed, Equipment, Welding technology, Competency skills, Engineering materials
b. Dependent Variable: Crashworthiness

4.8.2 ANOVA of Crashworthiness of a school bus vehicle structure

The regression model of vehicle construction designs and materials as a predictor was important (F=91.06, p value=0.000) shows that there is a significant association between the configuration of the vehicle design and the crashability of a bus and that at least the slope (β coefficient) is not null as seen in Table 4.27. This also means that there is a major link between the layout of the vehicle configuration and the crashworthiness of a bus.

Table 4.27 ANOVA of Crashworthiness of a school bus vehicle structure

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	57.983	7	8.283	91.057	.000[b]
	Residual	19.922	219	.091		
	Total	77.906	226			

a. Dependent Variable: Crashworthiness
b. Predictors: (Constant), Customer needs, Vehicle inspection tests, Locally designed, Equipment, Welding technology, Competency skills, Engineering materials

4.8.3 Crashworthiness of a bus Coefficients

In addition, in order to test the study's hypotheses, β coefficients were developed from the model for vehicle structure designs and materials as an independent variable. The t-test was used as a metric to identify whether a substantial

improvement to the model was made by the bus vehicle architecture architectures and materials predictor. The β-value estimates and the contribution of each predictor to the model were given in table 4.28.

Table 4.28 Coefficients of Crashworthiness of a bus

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.252	.175		1.435	.153
	Locally designed	.089	.036	.104	2.460	.015
	Competency skills	.429	.069	.400	6.218	.000
	Engineering materials	-.725	.122	-.613	-5.939	.000
	Equipment	.127	.057	.130	2.243	.026
	Welding technology	.575	.071	.595	8.101	.000
	Vehicle inspection tests	.321	.060	.368	5.329	.000
	Customer needs	.094	.047	.087	1.980	.049

a. Dependent Variable: Crashworthiness

The β-value for engineering products, had a negative relationship, while tools, locally built bus vehicle structure, competency abilities, welding technologies, vehicle inspection tests and consumer needs had a positive coefficient, depicting positive relationship with crashworthiness of a bus as summarized in the model as:

$Y=0.252+0.089X_1+0.429X_2-0.725X_3+0.127X_4+0.575+X_5+0.321X_6+0.094X_7+\varepsilon$….

………………………………………………………………………Equation 4.1

Where:

Y = crashworthiness, X_1 = locally designed bus vehicle structure, X_2 = competency skills X_3 = engineering materials, X_4 = equipment, X_5 = welding technology, X_6 = vehicle inspection tests, X_7 = Customer needs and ε = error term

The t-test correlated with β-values was important from the results and the structures and materials of the vehicle structure were a predictor that made a significant contribution to the model. The research hypothesized that the locally built school car has no major impact on the crashworthiness of a bus. The results of the analysis revealed that there was a significant association between the school bus vehicle locally built and the bus crashworthiness ($\beta1= 0.089$ and p value <0.05). The further school buses built locally led to an increase in a bus's crashworthiness. It dismissed the null hypothesis (Ho1). The locally designed school vehicle had a significant positive relation with crashworthiness of a bus.

The research proposed that competency capabilities had little major impact on the crashworthiness of a bus. The results of the analysis found that there was a positive substantial effect of competence abilities on a bus's crashworthiness ($\beta2=0.429$ and $p<0.05$). Competency capabilities have therefore improved a bus's crashworthiness. The null hypothesis was denied (Ho2). Competency qualities have a positive effect on a bus's crashworthiness. The research results found that there was a substantial negative association between engineering materials and a bus's crashworthiness ($\beta3= -0.725$ and p value<0.05). A decline in engineering materials thus corresponds to an increase in a bus's crashworthiness. The null hypothesis (**Ho$_3$**) was rejected. The use of engineering materials had a negative significant influence on crashworthiness of a bus.

The results found that equipment and instruments had a positive substantial effect on the crashworthiness of a bus ($\beta4=0.127$ and $p<0.05$). An rise in the use of equipment and tools by the unit contributed to an improvement in the bus's crashworthiness. It dismissed the null hypothesis (Ho4). Thus, equipment and instruments have a beneficial impact on a bus's crashworthiness. The results of the study found that there was a positive significant correlation between welding technology and bus crashability ($\beta5 = 0.575$ and $p = 0.05$). An rise in welding technology has led to an increase in a bus's crashworthiness. The null hypothesis was discarded (Ho5). Welding technology has had a huge effect on a bus's crashworthiness.

The results of the analysis found that terminal tests (vehicle inspection tests) had a positive significant impact on bus crashworthiness ($\beta 6 = 0.321$ and $p = 0.05$). Increased terminal testing (vehicle inspection testing) has resulted in an improvement in the crashability of the truck. The null hypothesis was denied (Ho6). The terminal examination had a big impact on the bus's crashworthiness. Customer requirements have a positive significant effect on a bus' crashworthiness ($\beta 7 = 0.094$ and $p = 0.05$). An rise in consumer requirements has led to an increase in a bus's crashworthiness. The null hypothesis (**Ho_7**) was rejected. Customer needs had a significant influence on crashworthiness of a bus.

While on the survey research, the researcher was able to visit numerous school bus vehicle body construction companies. In view of the visitation, the researcher was able to administer the research questionnaires, do some selected oral interviews and finally do some observations. While making observations on the activities at the bus vehicle structure construction industries, the researcher was equally able to take some photographs as shown in Appendix XIII.

3.9 Chapter Summary

This chapter presented the findings of the study with respect descriptive analysis, reliability and validity results, correlation and regression representing the inferential analysis on the relationships. The findings of the study was summarized according to the study objectives.

CHAPTER FIVE

DISCUSSIONS

5. 1 Introduction

This chapter presents the discussion of findings based on the following specific objectives; the influence of locally designed bus vehicle structure on crashworthiness, competency skills of bus vehicle structure builders on crashworthiness, engineering materials used on bus vehicle structures, crashworthiness of school bus, equipment and crashworthiness of school bus, welding technology and crashworthiness of school bus, bus vehicle structure inspection tests and crashworthiness. Determine the relationship between bus vehicle structure designs and materials on crashworthiness of school bus.

5.2 Effect of locally designed school bus vehicle structure on crashworthiness.

The first objective of the current study sought to establish the effect of locally designed bus vehicle on crashworthiness of a school bus. The school bus was build based on the harsh Kenyan environmental rugged terrain. The findings showed that locally designed school bus vehicle had a significant positive relation with crashworthiness of a bus. This is in accordance with Gakuu (2014) and includes: roll-over security, longitudinal impact safety, lateral impact protection, cross members, a gangway and seat design, sidewall diagonals, passenger gate gates, passenger benches, front grille and rear steps, as well as: roll-over protection, front shielding protection, side shielding, seated configurations, lateral wall diagonal structures. According to specialists, busses can still follow minimum requirements including: protection from rolls; protection from frontal impacts; and protection from side impacts.

5.3 Competency skills of school bus vehicle structure builders and crashworthiness.

The second objective sought to establish the relationship between competency skills of bus body builders and crashworthiness of a bus. The findings showed that the competency skills positively influence on crashworthiness of a bus. Arul & Kavi (2002) agree that technical skills are needed in different areas of auto mechanical service, such as engine control, repair and maintenance, car body design, car electricians, volcanoes, steering and suspension systems, braking systems and automobile air conditioning.

Employability capabilities, also referred to as non-technical skills and talents, play a significant role in people's active and successful presence in contemporary work (Common wealth of Australia, 2006). This skill is seen to disconnect the engine, correctly extract or mount the cylindrical head, flywheel operation, remove and install an oil pump, properly clean up a cooling system, check the internal and external leakage of the cooling system, and so on, based on the technical know-how needed for a small automotive workshop.

The outcomes of the management skills needed to set up a small car workshop demonstrated a very strong need for job preparation, operation monitoring and tracking, coordination assignments, decision-making, communication and leadership. In support of this opinion, Osuala (2004) said that the role of management is to provide a company establishment with leadership and guidance.

5.4 The use of engineering materials influence on crashworthiness of a bus

The third objective sought to establish the influence of engineering materials on crashworthiness of a bus. The results revealed a substantial negative impact on the crash tolerance of a bus while using engineering equipment. Steel and various other materials are used to produce the frame and body. When the car body collides, the car's deformity must be mitigated by transforming as much cinematic energy as necessary. This is sufficient for Gliner (2011), so that the mechanical properties are not compromised in joints sold on those steels that use relatively low soldering energy. Various experimental prototypes (DOEs) like Taguchi have been employed by several researchers to work on various material form using different types of lasers.

In automobile body style, sheet steel is customary in various grades. For highly stressed building materials, the high-strength, low alloy (HSLA) sheet steel is used. The increase in thickness of these components (Geoff, 2003). High-solid steels now include very light materials as well as titanium, magnesium, ceramics and carbon-reinforced materials. These new high-tech materials contain parts that are up to 60% lighter than those made of ordinary steel, whose use is significantly reduced.

The improvement of the components and the processing processes used for these products is one of the most important technologies for the construction of bus vehicles. Smaller materials can increase mobility, quality and performance. Material and technical knowledge in development is an essential strategic element (Bosch, 1993). The most significant factor in the manufacture of school busses is iron, the iron alloy and the small amount of carbon. Achebo (2011) showed optimization by choosing input parameters such as soldering current, tensile voltage and speed and time to react to the ultimate tensile strength of steel with the support of Taguchi Process. This means the organisation, coordination and supervision of all operations and the handling of persons, in order to enable effective use of materials and human capital achievement of planned objectives.

5.5 Equipment and tools effect on crashworthiness of a bus positively.

The fourth objective sought to establish the influence of equipment on crashworthiness of a bus. The availability of equipment and tools affect crashworthiness of a bus positively. FDOT (2007), Bojanowski (2009) and Bojanowski, Kwasniewski and Wekezer (2013) believe that a lot of focus should be paid to choosing the best performing coaches that have the most injuries and the better atmosphere for their passengers. This also resulted in a Florida standard for Paratransit bus crashworthiness and safety evaluation (Bojanowski, Wekezer, Kwasniewski and Kownacki, 2009).

A well-equipped tool case containing hammers and squashers, punching, files, hacksaws, pliers and other materials, including their different types and dimensions, was found to be available for the car body and auto mechanics stores based on the findings on basic machinery, supplies and services. Machinery and machinery, such as welding machines, grinders, workshops, repair pits, are also necessary to function effectively. Where applicable, a wide range of quality services are available in support of this Elobuike (2004), making work more effective. Proper tools complement the huge range of challenges readily encountered by car mechanics.

5.6 Welding Technology vehicle structure Influence on crashworthiness of a school bus

The fifth target was to determine the effect of welding technology on a bus's crashworthiness. The findings showed that welding technology had a big impact on a bus's crash resistance. The method, welding parameters, are the most critical components that affect the welding joints' performance, productivity and expense, and this is in line with Karadeniz et al (2007). The effect of different process parameters such as soldering current, arc tension, arc velocity, solder location, gas flow rate, composition of gas shielding was investigated and its impact on various materials such as parameters of tensile strength and hardness efficiency was investigated.

The accurate performance with high production can be achieved by properly tuning the process parameters of MIG welding. The Wahab and Khuder (2011) accept that the measurements of spot weld and shear force are increased as the soldering current is increasing, whereas the shear strength is diminishing as the welding time is increased. This also correlates with Uslu et al. (2010) in the evaluation of the arc and welding bath and in the knowledge of its shift during the process, in order to achieve optimal results.

5.7 School bus vehicle Inspection test influence on crashworthiness

The sixth objective sought to establish the influence of terminal test on crashworthiness of a bus. The findings showed that terminal test had a significant influence on crashworthiness of a bus. The other most important idea is that the body must be tested to measure the stiffness and strength to increase the safety for the bus occupants. Each bus were tested in order to ensure stiff and strong structures are used to ensure and to provide reliable safety, comfort and durable structure for the bus owners and passengers.

The mandatory requirements for buses are intended to bring together the Standards, procedures, specifications and transport regulations for the purpose of regulating and determining the rules for the manufacture, construction and registration of a bus in any country. An significant part of consolidating compulsory criteria is focused upon years of domestic research, development and running buses, road crash investigation reports, etcetera whose aim is to increase passenger and road transport safety standards. Bojanowski and Kulak (2011) accept that sidewall and front cap structures are the most important components of a bus construction which alters the objective functions. The goal of establishing the code of practice leads to improved layout of buses, passenger safety and convenience, technical advancement and reduced number of bus owners and insurance companies cost of maintenance, reduced property and life loss.

5.8 Influence of Customer Needs on crashworthiness of a school bus

The seventh objective sought to establish the influence of customer terminal needs. The findings showed that customer needs had a significant influence on crashworthiness of a bus. That coincide with the fact that consumer ties with the selected product, the product maker and the distributor provide customer service after purchase, Dant, (2004) Sheller, (2004). Sheller, (2004) bought goods. The contributors to an attachment have been shown to be linked to the excellent functionality of a device during the life span of the product, Mugge, Schifferstein & Schoormans (2010).

An examination of various vehicle attributes should be presented with detailed descriptions with a matching degree of detail in order to ensure correct understanding of the evaluated attributes. The separation of the consumer path into phases helps one to consider how, with time and through knowledge of operating the vehicle, the value of certain characteristics varies. This may have consequences on which characteristics in the marketing collateral and distributor experiences should be illustrated. The relevance of these characteristics can also vary across various customer groups and across different segments of the vehicle industry.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter deals with the summary of findings, the conclusions reached, recommendations to be implemented and areas that require further research.

6.2 Summary of the Findings

The study sought to establish the relationship between bus vehicle structure designs and materials and crashworthiness of school bus. From the findings of the study, it shows that school bus vehicle had a strong roof structure protection. The deformable rear structure to maintain integrity of the rear bus vehicle compartment and protect the fuel tank and accommodate various chassis designs for different power train locations and drive configurations. The organizations maintain close contact with school management and thereby ensuring in-depth understanding of their expectations of the bus. The companies engage strategic planning committees that were in touch with school management and the buses are all fitted with safety belts. In this section, research findings were summarized as per each research objective.

6.2.1 Effect of Locally Designed School bus Vehicle structure on Crashworthiness.

The first objective of the current study sought to establish the effect of locally designed bus vehicle structure on crashworthiness of a bus. The school bus in company organizations are constructed and can readily face the harsh Kenyan environment. The locally build school buses have a lower failure rate compared to imported manufactured products. The locally produced school buses have a quality reputation and enjoy a competitive advantage.

The school bus manufacturing companies often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials. There was a significant relationship between locally designed school bus vehicle and crashworthiness of a bus (β_1= 0.089 and p value <0.05). The more the locally designed school vehicle led to an increase in crashworthiness of a bus. The null hypothesis (**Ho_1**) was rejected. The locally designed school vehicle had a significant positive relation with crashworthiness of a bus.

6.2.2 Relationship between Competency skills of bus body builders and crashworthiness of a bus

The second objective sought to establish the relationship between competency skills of bus vehicle builders and crashworthiness of a bus. Majority of the respondents moderately agreed that organization emphasizes foundation skills. For adapting to dynamic industry changes, company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades. The company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training.

The company motivates its staff through sector specific skill expansion and apprenticeship system remains companies preferred way of complementing skills formation. There is no significant influence of competency skills on crashworthiness of a bus. The study findings depicted that there was a positive significant influence of competency skills on crashworthiness of a bus (β_2=0.429 and p <0.05). Thus, competency skills increased crashworthiness of a bus. The null hypothesis (**Ho_2**) was rejected. Competency skills positively influence on crashworthiness of a bus.

6.2.3 Engineering Materials Influence on Crashworthiness of a school bus vehicle structure.

The third target was to determine the effect of engineering materials on a bus's crashworthiness. The majority of respondents decided that the structural integrity of the stainless steel body remains intact for longer than that of the carbon steel body in the event of fire or crush behaviour. To offer the consumer the benefits of corrosion resistance structure, the longer even than that of an aluminum body and stainless vehicle body construction is picked.

The stainless steel bus body vehicle remains an appealing presence for its entire life and the stainless steel vehicle body lowers the cost of repair and operation and guarantees a high second-hand value. The use or use of stainless steel will overcome environmental issues such as wet weather, cold places and saline oceans, and the company uses stainless steel and stainless steel entirely in the design of vehicle frames.

The use or use of stainless steel will overcome environmental issues such as wet weather, cold places and saline oceans, and the company uses stainless steel and stainless steel entirely in the design of vehicle frames. Stainless steel bears very high impact resistance, which makes it a better substance in case of collisions, the body vehicle that uses stainless-steel application for bus vehicle construction avoids vibration and crashworthiness. There was a major negative association between engineering materials and bus crashworthiness ($\beta 3= -0.725$ and <0.05 p value). A decline in engineering materials thus corresponds to an increase in a bus's crashworthiness. The null hypothesis (**Ho_3**) was rejected. The use of engineering materials had a negative significant influence on crashworthiness of a bus.

6.2.4 Influence of Equipment on Crashworthiness of a school bus vehicle structure

The fourth objective sought to establish the influence of equipment on crashworthiness of a bus. From the findings of the study, it was evident that majority of the respondents agreed that the company had an in-house window frame fabrication and assembly and research and design unit equipped with AutoCAD and optimizer, software's. Attempts are in place in their company for adequate insurance cover for the entire unit, including men and machines and work in progress, against all types of hazards.

The company has 16m long paint spray booth cum heating oven and in case of checking for bus vehicle body roof. The company has a roof leaking testing equipment. Also, the companies are an ISO 9001 Certified organizations. The organizations had a hydraulic shearing machine and companies possess a hydraulic bending machine. There was a positive significant influence of equipment and tools on crashworthiness of a bus ($\boldsymbol{\beta_4}$=0.127 and $p < 0.05$). A unit increase in the use of equipment and tools led to an increase in crashworthiness of a bus. The null hypothesis (**Ho$_3$**) was rejected. Thus, equipment and tools affect crashworthiness of a bus positively.

6.2.5 Influence of Welding Technology on Crashworthiness of a school bus vehicle structure.

The fifth target was to determine the effect of welding technology on a bus's crashworthiness. The majority of the respondents moderately agreed with the claims used to assess a bus vehicle's welding technologies. With precise welding using spot welding in some companies, this was apparent in connecting steel frameworks of bus body frames and using MIG to connect aluminum bus body parts. There was an important positive association between welding technologies and bus crashability (β5 = 0.575 and p = 0.05). An rise in welding technology has

led to an increase in a bus's crashworthiness. The null hypothesis was discarded (Ho5).

6.2.6 School bus Vehicle inspection tests and crashworthiness.

The sixth objective sought to establish the vehicle inspection tests on crashworthiness of a school bus vehicle structure. Majority of the respondents agreed that all buses have 100% roll over compliant providing more stability to the structure. The organization performs impact tests on front and rear on the bus. The organization conducts water leakage on the bus using roof leaking testing equipment.

The companies have experienced quality assurance team and further companies have under chassis inspection bay facility. The study findings depicted that there was a positive significant influence of terminal test (vehicle inspection tests) and crashworthiness of a bus ($\boldsymbol{\beta_6}$ = 0.321 and p =0.05). An increase in terminal test led to an increase in crashworthiness of a bus. The null hypothesis (**Ho_6**) was rejected. Terminal test had a significant influence on crashworthiness of a bus.

6.2.7 Influence of customer needs on crashworthiness of a bus

The seventh objective sought to establish the influence of customer needs on crashworthiness of a bus. The findings indicated that the vehicle structure designs and materials was significant predictors of crashworthiness of a bus. Therefore, an increase in customer needs increases crashworthiness of a bus. Based on the regression model, the coefficient of determination (R squared) of .744 showing that 74.4% of the variation in crashworthiness of a bus can be explained by bus vehicle structures designs and materials. The regression coefficient β-value for engineering materials had a negative and significant influence on crashworthiness of a bus.

The equipment, locally designed bus vehicle structure, competency skills, welding technology, vehicle inspection tests and customer needs had a positive significant influence on crashworthiness of a bus. This showed that the presence of roll over protection bars in the bus body are essential as they protect the occupants from severe injuries due to their resistance to roof crumbling and snapping of the upper part of the bus body. This concept is not a requirement in the traffic act and KEBS KS 372:2014 and may require legislation for it to be enforced.

6.3 Conclusion

The study concluded that the locally designed bus vehicle structures, competency skills, engineering materials, equipment, welding technology, vehicle inspection tests and customer needs had a significant influence on the crashworthiness of school bus.

Absence of proper national standard/code of practice for bus body building design and approval to regulate and control the builders. Thus, setting and implementing the rules for the bus vehicle structure builders corrects the existing challenges and helps to manufacture quality products which are economical, safe and comfortable.

In addition, proper design which includes complete technical specifications, general drawings of bus structure along with complete dimensions, its components, seats, interior/ exterior fittings, electrical systems, wiring harness, photometric items and other accessories along with complete details of materials used, their specification, manufacturing tolerances should be provided.

6.4 Recommendation

The Government of Kenya should take a keen interest in developing policy guidelines aimed at giving detailed school bus construction designs and material application. The Government of Kenya should give manufacturers and importers of bus construction materials tax waivers or incentives to avail advanced materials to manufacture school buses that have increased bus vehicle structure crashworthiness.

The Government of Kenya should through its multi –agency departments focus more on school bus vehicle body construction standards requirements with a view to demand samples of materials used and final testing of a completed bus based on outlined policy criteria. The Government of Kenya should consider developing a policy geared towards encouraging school bus manufacturers in the use of advanced engineering materials such as stainless steels for enhanced/ improved school bus body crashworthiness. The Government of Kenya should develop a policy guideline to invoke a bus body recall in view of improved vehicle standards so as to conform to the new changing bus vehicle structure standards dynamics.

The ministry of industrialization should provide incentives to the school bus manufacturing company to locally build school bus that have a lower failure rate compared to an imported manufactured product. Also, the government should enable school bus manufacturing company access supplies of locally designed components such as glass, chrome and other materials. The management of school bus manufacturing company should periodically (every 6-12) months sends employees to workshops for competence skills upgrades.

The management of bus vehicle structure construction companies should always develop skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training. The company should always motivate its staff through sector specific skill expansion. The management of school bus companies need to conduct all the terminal test (vehicle inspection tests) needed before releasing the vehicle in order to enhance crashworthiness of a bus.

The Transport authority should examine and check the mandatory requirements and periodically amend them in accordance with the safety, engineering and ecological standardization. The committees of experts should be convened, to represent various bodies dealing with buses, which include representatives of the Vehicles Department in the Ministry of Transport, representatives of local bus manufacturers, public transport cooperatives and bus importers.

6.5 Suggestion for Further Studies

This study focused on the relationship between bus vehicle structure designs and materials on crashworthiness of school bus. The vehicle designs and materials were limited to locally designed vehicle, competency skills, engineering materials, equipment, welding technology and vehicle inspection tests. Future studies should focus on the relationship between vehicle design and materials on crashworthiness of sport utility vehicles (SUV) and use experiments to determine the crashworthiness of the school buses. The future studies should focus on other types of vehicles in order to make comparison on their crashworthiness. Other areas of further research to be considered can be material sourcing and testing for vehicle bodies and industrial safety in the bus vehicle manufacturing industry.

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APPENDICES
APPENDIX I: QUESTIONNAIRE

Dear Respondent

I am a post graduate student at the University of Eldoret undertaking research leading to a Doctorate degree. In response to the above, I humbly request that you kindly assist in the noble exercise of filling or responding to this questionnaire for your generous effort will hugely be appreciated. I promise to protect your identity and keep all the information supplied quite confidential. This research or exercise is purely for academic purposes and I promise to provide the outcome of the findings at your request upon successful completion of the thesis writing.

I thank you most sincerely for your immense cooperation and assistance.

Section A: Demographic Information

1. What is your gender?

Male ☐ Female ☐

2. How long have your been in the bus passenger vehicle body building company?

Under 5 years ☐ 6-10 years ☐

11-15 years ☐ over 15 years ☐

3. What is your job category?

Technician officer ☐

Supervisor ☐

Manager ☐

4. What is your highest level of Education?

Primary level ☐

Secondary level ☐

Certificate technician level ☐

Diploma certificate ☐

Bachelor degree ☐

Any other (please specify) …………………………………………………………

5. Any other professional training or affiliation……………………………………..

6. Years of experience in service (current position) …

(5-10) ☐ (11-20) ☐ (20-30) ☐ (31-45) ☐ over 45.

7. When was the company established (state the year) ---------------

Section B: Locally designed school/ passenger vehicles

9. In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Locally designed school/ passenger vehicles

. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

B.	Statements	SD	D	U	A	SA
1	School bus/ passenger vehicles in our organization are constructed and can readily face the harsh Kenyan environment.					
2	Our locally build school bus / passenger vehicles have a lower failure rate compared to an imported manufactured product.					
3	Locally produced school bus/ passenger vehicles have a quality reputation and enjoy a competitive advantage.					
4	School bus / passenger vehicle manufacturing often have challenges in accessing supplies of locally designed components such as glass, chrome and other materials.					

Section C: Competency skills of bus vehicle body builders

9. In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Competency skills of bus vehicle body builders. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

C	Statements	SD	D	U	A	SA
1	This organization takes a keen interest in technical skills and knowledge in electronic component sensitivity.					
2	The organization values innovation in employees.					
3	Welding during bus vehicle manufacture, I/we use MIG welding in fastening / joining of specific metals.					
4	MIG welding is a popular welding method used in our organization.					

5	The organization emphasizes foundation skills, for adapting to dynamic industry changes.					
6	During recruitment of new employees, the organization is mostly keen to take note of language, literacy, numeracy and digital skills.					
7	The company periodically (every 6-12) months sends employees to refresher / seminar / workshops for competence skills upgrades.					
8	This company hugely develops the skills and knowledge of its employees to work on new vehicle technologies, including manufacturer – specific training.					
9	Our company promotes the development of management skills for those who have progressed through the ranks of automotive fabrication into management role.					
10	The company motivates its staff through sector specific skill expansion.					
11	The apprenticeship system remains our company's preferred way of complementing skills formation.					

Section D: Materials Engineering

9. In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Materials Engineering.

Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

D	**Statements**	SD	D	U	A	SA
1	In case of fire or crush behaviours, the structural integrity of a stainless-steel body remains intact.					
2	MIG material is high quality material applied in school / passenger vehicle body structure.					

3	There is no much difference in the use of stainless steel to that of mild steel in school bus body building.					
4	Aluminum metal material is greatly applied on bus passenger vehicle body construction.					
5	Stainless steel is used for both underframe and bus passenger vehicle body to ensure a long life.					
6	Stainless vehicle body construction is chosen to give the customer the advantages of corrosion					
7	Bus body vehicle that is made of stainless steel remains an attractive appearance for the whole life.					
8	Stainless steel vehicle body reduces maintenance and service costs and high second – hand value.					
9	The application or use of stainless steel can counter environmental challenges such as humid climate, cold places and salty waters.					
10	Buses manufactured by stainless steel are lighter, require less maintenance and are more fuel efficient.					
11	Our organization greatly uses / utilizes stainless steel panels for designing the school bus					
12	This company totally uses stainless steel in building vehicle chassis and stainless-steel.					
13	Stainless steel application for bus vehicle construction resists vibration.					
14	In view of crashworthiness, stainless steel bears very high impact resistance that makes it a safer material in case of accidents.					
15	In terms of floorings, footsteps, entrance and luggage carrier, it is worthwhile to use stainless steel in bus vehicle manufacture.					

16	Roof for vehicle body buses need to be hugely made of stainless steel.					
17	Fasteners, hand rails and hand holds and guarding of step wells are more often than not made of stainless steel.					
18	Mild steel is the principal material used hugely in general bus vehicle body construction.					
19	The chassis of school bus passenger vehicles are supplied by automobile manufacturers.					
20	In most cases bus vehicle body is build by body builders as per the requirements of the schools/institutions or customer desire and specifications.					
21	Bus vehicle body is painted as per the requirements of the customer.					

Section E: Equipment/ Tools For Bus Vehicle Body Building

In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Equipment/ Tools For Bus Vehicle Body Building . **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

E	Statements	SD	D	U	A	SA
1	Our company has in house window frame fabrication and assembly.					
2	This company has research and design unit equipped with Autocard and optimizer, softwares.					
3	Attempts are in place in our company for adequate insurance cover for the entire unit					
4	This company has 16m long paint spray booth cum heating oven.					

5	In case of checking for bus vehicle body roof, our company has a roof leaking testing equipment.					
6	The company has under chassis inspection bay facility.					
7	This company is an ISO 9001 Certified.					
8	Our organization has a hydraulic shearing machine.					
9	The company possesses a hydraulic bending machine.					
10	This company prides in having a 15m long hydraulic stretching machine.					

Section F: Vehicle body inspection tests

In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Vehicle inspection tests. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

F	Statements	SD	D	U	A	SA
1	All our buses have 100% roll over compliant providing more stability to the structure.					
2	Our organization performs impact tests on front and rear on the bus					
3	Our organization conducts water leakage on the bus using roof leaking testing equipment					
4	Our organization conduct welding tests on the bus					
5	Our organization do not perform quality control tests on the bus					
6	Our company has experienced quality assurance team					
7	The company has under chassis inspection bay facility.					

Section G: Welding technology on bus vehicle body

In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing welding technology. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

G	Statements	SD	D	U	A	SA
1	I use MIG to join aluminum bus body parts					
2	I apply MIG to weld continuous mild steel bus body structure					
3	Our organization uses spot welding to fix bus vehicle body mild steel metal sheets					
4	I use mild steel to weld bus vehicle body metal structures and sheets					
5	Our organization uses arc welding to join bus vehicle body mild steel metal sheets and steel structures					
6	In some specific welding aspects our organization uses spot welding to join bus body frames steel structures					

Section H: Customer Needs

In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Customer Needs. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

H	**Statements**	SD	D	U	A	SA
1	Our buses are all fitted with safety belts					
2	Our buses are assembled in compliance with KEBS standards					
3	We consider school / customer needs / specifications while accepting their orders of buses.					
4	Our buses are designed and build to meet the environmental terrain of this country.					
5	We provide updates of major milestones and outcomes to school management in view of bus needs.					
6	The organization maintains close contact with school management, ensuring in-depth understanding of their expectations of the bus.					

7	We engage a strategic planning committee that is in touch with school management					
8	We design bus according to customer needs/requirements/tastes/ as regards to placement of school bus orders.					

Section I: Bus body crashworthiness

In the scale given below, *please tick* **[√]** *in the appropriate space* indicating your level of agreement with the following statements describing Customer Needs. **Key: 1 = Strongly Disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree**

I	Statements	SD	D	U	A	SA
1	Our bus structures have ability to deform plastically, yet stiff front structures, in a short period of time					
2	Our bus structures are light and able to be economically mass-produced.					
3	We tune our structural stiffness for ride and handling					
4	We ensure that noise vibration and harshness in our buses is compatible with other vehicles.					
5	The buses have properly designed side structures and doors to intrusion in side impact and prevent doors opening due to crash loads					
6	Buses have strong roof structure for rollover protection					
7	Accommodate various chassis designs for different power train locations and drive configurations.					
8	Deformable rear structure to maintain integrity of the rear passenger compartment and protect the fuel tank.					
9	Our buses have strong roof structures for rollover protection					

APPENDIX II: INTERVIEW SCHEDULE FOR SCHOOL BUS BODY BUILDING (INDUSTRY) MANAGER / SUPERVISOR

1. What is the difference between school bus vehicle body and a general bus vehicle body?

2. What do you consider in terms of designs and fabrication of any bus constructions?

3. What is the role of customers in your task of bus vehicle construction?

4. Do you consider customers requests in the design and construction of the school bus?

5. Which is the most ideal engineering material to use in a school bus / passenger vehicle body?

6. Which methods are used in the testing of a build bus vehicle for crashworthiness?

7. What are the equipment used in bus vehicle testing of vehicle bodies?

8. Do you use a standard manual while designing and constructing a school bus vehicle?

10. What are the special skills / competencies required before one joins bus body Construction Company as an employee?

11. What is the minimum level of education required before a new employee can be recruited to your company?

12. What are the recommended types of welding in your industrial bus body joinery?

13. What are the personal safety considerations to be observed while building a school / bus passenger vehicle?

14. During the construction of bus passenger vehicle body/fabrication, what safety aspects are considered in view of crashworthiness?

15. What are the challenges faced in school bus body construction?

16. What are your future prospects in school bus body building?

APPENDIX III: INTERVIEW SCHEDULE FOR NATIONAL TRANSPORT AND SAFETY AUTHORITY (NTSA) MANAGER/ SUPERVISOR

1. How often do you inspect school buses?
2. What aspects of the vehicles do you check on?
3. What are the safety standards that your organization prescribes for school buses body building?
4. How does NTSA enforce the rule of law in bus body construction for crashworthiness?
5. How does NTSA enforce the rule of law on school bus drivers in view of road safety and the Highway Code?
6. Does NTSA collect and manage accident data? .
7. What is the role of NTSA in accident / road carnage prevention / reduction?

8. What mechanism have the NTSA instituted to educate the general public / school bus drivers on road safety? Please explain

……………………………………………………………………………………………

……………………………………………………………………………………………

9. Is there accident data available for school buses in Kenya?

……………………………………………………………………………………………

……………………………………………………………………………………………

10. What challenges does your organization face in view of school bus body safety standards?

11. What are your future prospects in the improvement of school bus body safety standards?

APPENDIX IV: INTERVIEW SCHEDULE FOR KENYA BEREAU OF STANDARDS (KEBS)

1. Does your organization have KEBS for school bus vehicle body building?

No ( ) Yes ( )

If Yes please explain ………………………………………………

2. How does the KEBS enforce the standards of school bus body building while in industry?

Is it during or (ii) after tail end

Please explain

………………………………………………………………………………………

3. What are the penalties meted out incase of failure to observe bus body building standards. Please explain

………………………………………………………………………………………

………………………………………………………………………………………

4. How does KEBS enforce the use of correct / quality / ideal use of engineering materials? Please explain

5. How does KEBS enforce the use of proper engineering drawing designs? Please explain

………………………………………………………………………………………

………………………………………………………………………………………

6. What guarantees does KEBS provide to interested parties in terms of certification in view of standards conformance? Please explain

………………………………………………………………………………………

………………………………………………………………………………………

7. Who develops school bus body design drawings? Is it KEBS or the manufacturer? Please explain

………………………………………………………………………………………

8. What are the challenges faced in the maintenance of standards for school bus body building?

………………………………………………………………………………………

9. What are the future plans / prospects for the improvement of school bus body building?

………………………………………………………………………………………

APPENDIX V: INTERVIEW SCHEDULE FOR SCHOOL MANAGERS/PRINCIPALS/DEPUTY PRINCIPAL

1. Which mode of transport do you use in your institution? (i) Van (ii) School bus
2. How often do you use your buses (i) every day (ii) occasionally during external events?
3. Do your buses ferry students every day to school? Yes ( ) No ( )
4. If yes, what is the average passengers ferried every morning and evening?
5. What consideration do you base while ordering for a bus? Please explain
6. Does your school have certain bus body specification (size) before placing an order for manufacture? Please explain
7. How does your organization (school) ensure that school bus drivers have a record of accident free vehicles? Please explain
8. Any training (further upgrades) for school bus drivers periodically for enhanced road safety. Please explain
9. For the sake of vehicle roadworthiness, how often do you take your school bus for motor vehicle inspection checks?

   i) After every six months ii) one year iii) Any other………….
10. How does the organization (school) ensure that drivers work or observe work ethics? I.e. Professionalism? Please explain.
11. In the event of vehicle mechanical failure, how has the school management prepared drivers on simple basic mechanical repair and fault detection? Please explain?
12. Any provision for drivers for short courses on vehicle repair and fault detection and manufacturer's guidelines?
13. How are your school driver(s) empowered with communication skills so as to be effective while interacting with different people on the road?
14. Is there Ministry of Education policy / guidelines on the management and transportation of pupils/students?
15. What challenges are you facing as an institution while transporting students to schools? Please explain
16. What are your recommendations or suggestions on how best to maintain road safety while transporting students to schools?

APPENDIX VI: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. THOMAS MONGARE BOSIRE
of UNIVERSITY OF ELDORET, 0-30100
ELDORET,has been permitted to conduct
research in *Nairobi County*

Permit No : NACOSTI/P/18/19095/25740
Date Of Issue : 18th October,2018
Fee Recieved :Ksh 2000

on the topic: *VEHICLE SAFETY DESIGN STRUCTURES AND MATERIALS FOR IMPROVED SCHOOL BUS PASSENGER VEHICLE BODY CRASHWORTHINESS IN KENYA: A CASE OF NAIROBI CITY COUNTY*

for the period ending:
17th October,2019

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. **The License is valid for the proposed research, location and specified period.**
2. **The License and any rights thereunder are non-transferable.**
3. **The Licensee shall inform the County Governor before commencement of the research.**
4. **Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.**
5. **The License does not give authority to transfer research materials.**
6. **NACOSTI may monitor and evaluate the licensed research project.**
7. **The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.**
8. **NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.**

National Commission for Science, Technology and innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 21336

CONDITIONS: see back page

APPENDIX VII: RESEARCH AUTHORIZATION (NACOSTI)

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/18/19095/25740**

Date: **18th October, 2018**

Thomas Mongare Bosire
University of Eldoret
P. O. Box 1125-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Vehicle safety design structures and materials for improved school bus passenger vehicle body crashworthiness in Kenya: A case of Nairobi City County"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **17th October, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

8/11/2018

The County Director of Education
Nairobi County.

APPENDIX VIII: RESEARCH AUTHORIZATION (MOE)

Republic of Kenya

MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING & BASIC EDUCATION

Telegrams: "SCHOOLING", Nairobi
Telephone; Nairobi 020 2453699
Email: rcenairobi@gmail.com
cdenairobi@gmail.com

When replying please quote

REGIONAL COORDINATOR OF EDUCATION
NAIROBI REGION
NYAYO HOUSE
P.O. Box 74629 – 00200
NAIROBI

Ref: RCE/NRB/GEN/VOL.1

DATE: 8th November, 2018

Thomas Mongare Bosire
University of Eldoret
P O Box 1125-30100
ELDORET

RE: RESEARCH AUTHORIZATION

We are in receipt of a letter from the National Commission for Science, Technology and Innovation regarding research authorization in Nairobi County on **"Vehicle safety design structures and materials for improved school bus passenger vehicle body crashworthiness in Kenya: A case of Nairobi County"**

This office has no objection and authority is hereby granted for a period ending **17th October, 2019** as indicated in the request letter.

Kindly inform the Sub County Director of Education of the Sub County you intend to visit.

REGIONAL COORDINATOR OF EDUCATION NAIROBI
08 NOV 2018
MINISTRY OF EDUCATION

DRUSCILLA MOSIORI
FOR: REGIONAL COORDINATOR OF EDUCATION
NAIROBI

c.c.

Director General/CEO
National Commission for Science, Technology and Innovation
NAIROBI

APPENDIX IX: INTRODUCTORY LETTER (UOE)

University of Eldoret
flame of knowledge and innovation

P.O. Box 1125-30100, ELDORET, Kenya
Tel: 053-2063111 Ext. 242
Fax No. 20-2141257

SCHOOL OF EDUCATION
TECHNOLOGY EDUCATION DEPARTMENT

11th February, 2019

TO WHOM IT MAY CONCERN

SUBJECT: PROGRESS REPORT: BOSIRE THOMAS MONGARE
REG NO: EDU/PHD/TE/002/14

The above named person is a continuing PhD Postgraduate student at the Department of Technology Education. He successfully defended his research proposal in 2018 with the title "Vehicle Safety Design Structures and Materials for Improved School Bus Passenger Vehicle Body Crashworthiness in KENYA: A Case of Nairobi City County.

He is progressing well and currently undertaking field research. He is expected to complete his program this year.

Any assistance accorded to him will be highly appreciated.

UNIVERSITY OF ELDORET
Head Dept. Of Technology Education
P.O. Box 1125 Eldoret-30100

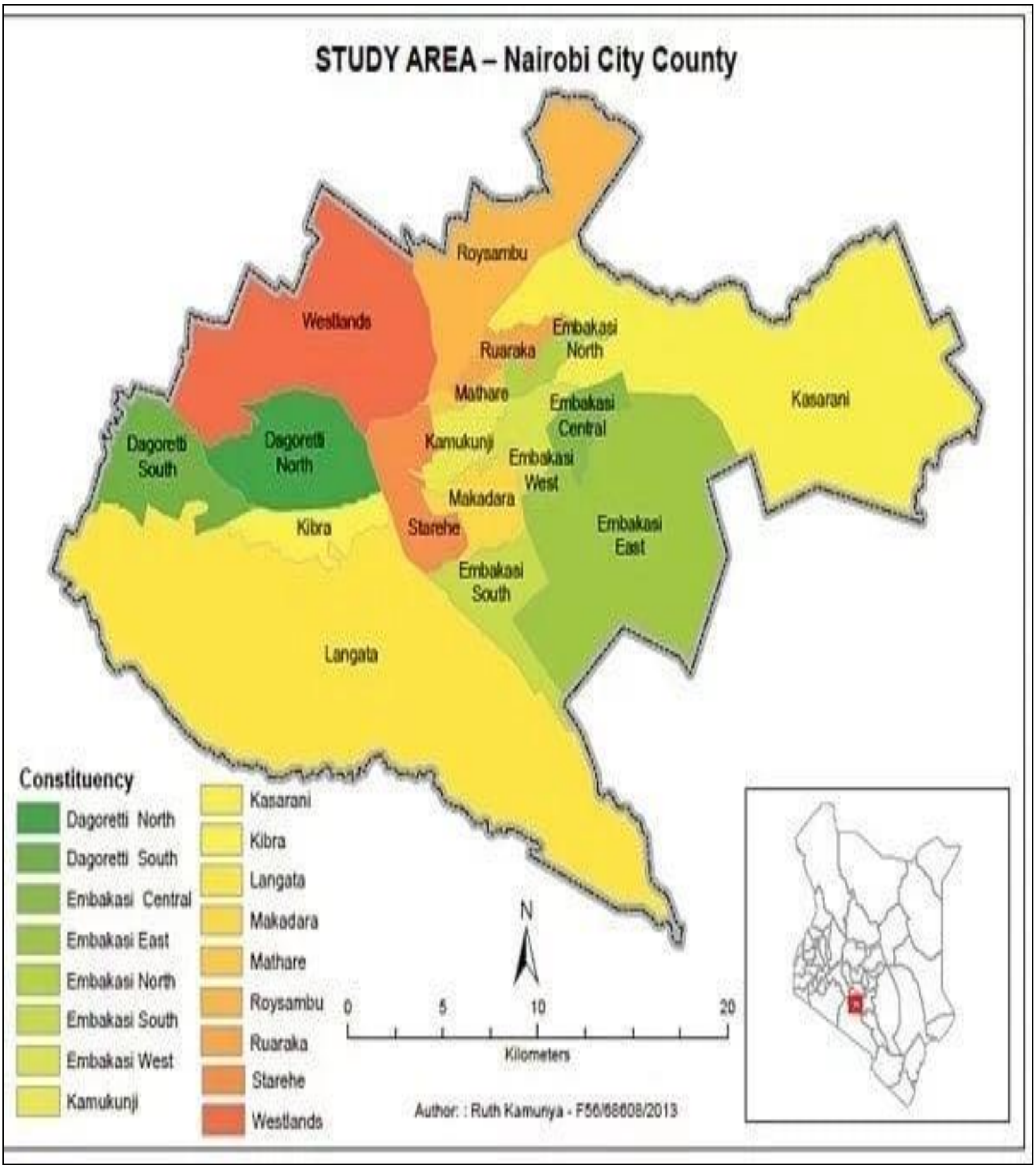
DR. HOSEAH KIPLAGAT
HEAD, TECHNOLOGY EDUCATION DEPARTMENT

University of Eldoret is ISO 9001: 2015 Certified

KEBS

APPENDIX X: MAP OF NAIROBI COUNTY (STUDY AREA)

(Source : Google Map)



APPENDIX XI: STAGES OF SCHOOL BUS VEHICLE BODY DESIGNS

APPENDIX XII: CRASHWORTHINESS OF SCHOOL BUSES INVOLVED IN ACCIDENT

APPENDIX XIII: SIMILARITY INDEX REPORT

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EDU/PhD/TE/ 002/14 By Thomas Bosire M.

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